Workforce Foresighting Hub

Build Sectorial Quantum Expertise.

A Workforce Foresighting study to support decarbonisation and build resilient and efficient networks.

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CATAPULT Digital

Acknowledgements

The Workforce Foresighting process integrates data from the following international data sets:

Skills England (formerly IfATE – Institute for Apprenticeships and Technical Education, England)

ESCO – European Skills, Competencies, Qualifications & Occupations, EU

ONet – Occupational Networks Online, USA

In accordance with licence and publishing requirements of these organisations for the use of their data sets, the Workforce Foresighting Hub team states that:

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The method and process used in the Workforce Foresighting process is under development and there may be errors and omissions in the data provided.

This report was produced following workshops undertaken December 2025 to March 2026 using the data set and tools available at that time.

Executive Summary

This report outlined findings from the Workforce Foresighting cycle focusing on **Build sectoral quantum expertise (across Energy, Telecoms and Transport) to support decarbonisation and build resilient and efficient networks**. This industry challenge was sponsored by the National Physical Laboratory (NPL) and study conducted by the Digital Catapult in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative.

Workforce foresighting is a systemic approach to forward planning that anticipating future skills and capability needs associated with new technologies and government transformation targets. It involves identifying and understanding the skills required for tomorrow's jobs, ensuring our education and training systems are prepared so that our workforce is ready to adopt new technologies and support future industrial growth.

This report sets out the findings of the workforce foresighting study and suggests the next recommended actions required by various stakeholders to create a workforce that is prepared to effectively implement these new technologies in the sector.

Strategic context and purpose for Workforce Foresighting

The United Kingdom established the world's first national quantum programme, the UK National Quantum Technologies Programme (NQTP) (NQTP, 2026) , in 2014. This 10-year, £1 billion initiative was designed to bridge the gap between academic research and industrial commercialisation. Following this, the National Quantum Strategy was published including a set of long-term quantum missions to galvanise technology development towards ambitious outcomes.

The Department for Science, Innovation and Technology on the 17th of March 2026 announced up to £2 billion to establish the UK as a world leader in quantum, from skills and talent to research and procurement programmes (gov.uk, 2026). A report from Oxford Economics (Oxford Exonomics, 2026) estimates Quantum could boost productivity by 7% in the next two decades, creating more than 100,000 jobs in the process. To realise this, future roles must be mapped and the associated skills requirements for the future workforce. Hence the need for this workforce foresighting cycle.

Participants and Stakeholders

Technology Participants	Industry Participants	Skills Participants
IBM	BP	National Physical Laboratory
AnchoredIn	Transport for London	Cambridge University
Digital Catapult	Department for Transport	Heriot-Watt University
RethinkPNT		Anglia Ruskin University
Sunderland Software City		

Quantum computing offers a new paradigm compared to classical computation, and both new and existing skillsets will need to be supported so that key sectors can take full advantage of the technology. The UK was uniquely placed, supported by a strong academic background in quantum computing and multiple university spin-out companies. This cycle did not focus on skillsets supporting quantum computing hardware development as these areas are currently served well in the UK's academic and industrial landscape. Instead, the

analysis focused on the skills and roles required to develop and deploy quantum computing use cases across the Energy, Telecoms and Transport sectors.

Though the cycle a set of key future occupation profiles (FOPs) was identified and future capabilities matched to each role. When these profiles and capabilities were aligned against current Skills England[1] education provision, coverage was found to be very limited. This matching reflects the emerging nature of quantum technologies, resulting in a lag from discovery and innovation to education. A key next step is to identify the current courses and training programmes which have yet to be tailored or created, especially for early careers. Doing this would improve the coverage across the identified capabilities and provide greater momentum for the UK future quantum workforce.

Exploration of the topic through this cycle revealed that the future development and adoption of quantum computing technologies across the Energy, Telecoms & Transport sectors will require strong **foundations in core quantum disciplines** (e.g. quantum mechanics and quantum computing), alongside a wide range of adjacent and supporting capabilities (e.g. quantum algorithm design, high-performance computing, and hybrid quantum–classical system integration). These were identified as needing to be **complemented by broader technical skills** (e.g. software engineering and systems maintenance) and **business-oriented capabilities** (e.g. data analytics, strategic planning, and innovation management).

Across the supply chain, system integrators were expected to require a broad and diverse capability base. Quantum computing may not be the core of an integrator's skill portfolio. Though the cycle, key capabilities and a role proficiency level were identified to ensure these roles are ready to adopt quantum computing. This included benchmarking against classical systems, optimisation of hybrid workflows, and mitigation of noise and error in near-term quantum devices. Given the early-stage maturity of quantum computing technologies and the timescales considered, a significant proportion of capabilities are concentrated in design, prototyping, and the development of sector-specific use cases for Energy systems, Telecommunications networks, and Transport optimisation.

Next Steps

Through this cycle, a set of next steps was identified to address the gaps and challenges outlined in this report:

- Engage with NPL and Institute of Physics (IOP) to explore what a publicly accessible centralised repository of education resources related to quantum computing could offer the ecosystem and future workforce.
- Identify sector specific career pathways where shorter modules and upskilling workshops can be introduced to degrees, apprenticeships and continuous professional development courses to build a **quantum aware workforce**.
- Look to input into UK Quantum Skills working group and other forums to validate findings on skills needed for the future workforce.
- Disseminate findings across all three target sectors.
- **Given the UK's 'Quantum Leap'** (gov.uk, 2026) **announcements in funding for quantum computing, it is important we examine any measures and cross reference job creation across the cycle timeline.**

[1] Apprenticeship search / Skills England

Glossary

Term	Definition
Challenge Response	Specific intervention aimed at the challenge
Capability (Organisation)	The collective abilities, and expertise of an organisation to carry out a function, because provision and preparation have been made by the organisation
Capability Classification	Classification provides a common, structured vocabulary to define capability
Capability Statements	Description of the depth and nature of each capability within an organisation
Capability Syntax	Common language to describe each capability application within organisation type
Carbon Accounting	The process of measuring, tracking, and reporting greenhouse gas emissions produced by an organisation or activity
Competencies (Workforce / Individual)	Proficiency, aptitude, capacity, skill, technique, experience, expertise, facility, fitness related to capability
Competency definition 'KSBs' (Knowledge, Skills and Behaviours)	Knowledge, Skills, and Behaviours are the elements used to express the required competencies for each Role Group
Competency Domain	Used during foresighting analysis to provide focus on existing and emerging competency needs
CPD	Continued Professional Development
FOP	Future Occupational Profile
Foresight Cycle	Set of workshops, analysis and reporting that implements the Foresight Process for each subject
Foresight Process	A series of activities which are convened to understand future competence needs, the opportunities available and actions required to deliver the right skills at the right time and place
Foresighting Champion	An individual nominated within a new user organisation of foresighting to facilitate and lead the use of foresighting processes and tools with the support of the Project Team
Foresighting Subject	The application of specific technologies in the context of a given challenge and which are candidates for foresighting
Future Competency Set	The KSB output from the Educator workshop for each Role Group
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
Organisation Type	Simple description of nature of organisation for which capability is required
Participants	Technologists, Educators, Employers
Proficiencies	Proficiencies differentiate the degree of competencies required from differing Role Groups to support capabilities
Project Sponsor	Typically, a stakeholder in the challenge being successfully met who requires information to under-write plans to act
Roadmaps	Sector, Industry, Regional view of emerging opportunities and their market entry
Role Group	Role groups are a collective of roles that exist in a typical manufacturing business / industrial sector
Technologies	The technologies that could be used to address the challenge
Working Scenario	To provide further context in relation to the subjects and used to position participants thinking during the detailed identification of future capabilities
Workshops	Online sessions used to undertake each step in the foresight process

Table 1 Glossary

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Figures and Tables

1. Introduction

1. Introduction

1.1 Introduction to Workforce foresighting

Workforce foresighting is essential in addressing the skills challenge, by aligning the skills value chain from early education through to advanced training—with the demands of emerging technologies. By identifying future occupation profiles (FOPs) and the capabilities required for new roles, foresighting enables educators, employers, and policymakers to proactively adapt curricula, qualifications, and training pathways. This ensures the workforce is not only prepared for technological change but also equipped to drive innovation and productivity. In doing so, it transforms the skills gap from a reactive challenge into a strategic opportunity for national growth and resilience.

This report outlined findings from a Workforce Foresighting cycle focused on: **Build sectoral quantum expertise (Energy, Telecoms and Transport**) to support decarbonisation and build resilient and efficient networks. The study was sponsored by NPL, and conducted by Digital Catapult, in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative. This report was designed to support and inform strategic decision making and inform the next steps on the Skills Value Chain from convening around future workforce needs through to curating provision and catalysing delivery at scale.

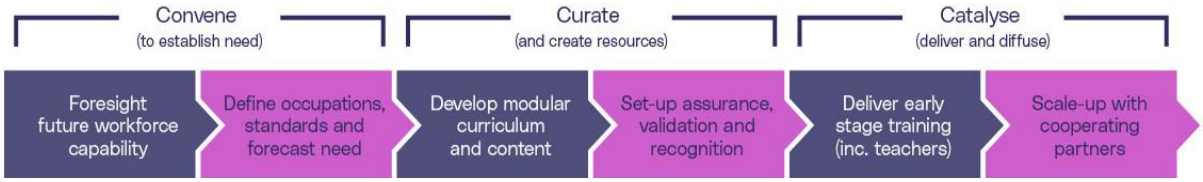

Figure 1: The Skills Value Chain (SVC)

1.2 Defining the Workforce Foresighting Topic

Quantum-ready cloud platforms—which may provide hybrid quantum/classical solvers for network optimisation, solutions for material and chemical simulation, quantum machine learning (QML) for demand forecasting, QML for anomaly detection, cloud environments for scalable experimentation, and QML for generating test data and scenarios—provide secure, on-demand access to quantum computers and simulators without the need for specialised hardware. These platforms enable professionals to test quantum algorithms and hybrid workflows using real network data, building practical skills and confidence in identifying quantum use cases across Energy, Telecoms, and Transport sectors. QML enhances traditional machine learning by creating synthetic datasets and simulating rare events, improving model accuracy for network optimisation and resilience. These technologies are prioritised for their high relevance to network challenges and their potential for near-term impact as quantum hardware and software mature, ensuring UK professionals are equipped to scope, test, and deploy quantum solutions for early adoption in this transformative field.

1.3 Contributing Participants

The organisations below contributed their time and commitment to providing insights and data for this study, in the hope that this process will have a significant impact on the target sectors.

Technology Participants	Industry Participants	Skills Participants
IBM	BP	National Physical Laboratory
AnchoredIn	Transport for London	Cambridge University
Digital Catapult	Department for Transport	Heriot-Watt University
RethinkPNT		Anglia Ruskin University

Table 2: Contributing Participants

This represents the second quantum workforce foresighting cycle to which Digital Catapult has contributed, following an earlier cycle focused on quantum sensing for the transport sector. Across both cycles strong engagement from the quantum ecosystem has been evident demonstrating sustained enthusiasm to contribute and shape the future quantum workforce.

2. Findings & Insights

2. Findings and Insights

This report outlines a three-step foresighting process to understand how emerging technologies will reshape supply chain capabilities and workforce needs.

- **Industry** - First, the report explores how organisational capabilities must evolve to enable the adoption and/or deployment of new and emerging technologies, identifying which supply chain partner and functions will be most impacted.
- **Workforce -** Next, these capabilities are grouped into Future Occupational Profiles (FOPs), which show the occupations that will need to change.
- **Provision** - Finally, the FOPs are compared against current education and training provision—using Skills England occupational standards as a benchmark—to identify where existing programmes align and where gaps exist.

The report summarises priority capabilities, FOPs, and knowledge, skills, and behaviours (KSBs). Full details of the data and findings are available in the appendix and visualisation tool.

Introduction to the Visualisation Tool

The Workforce Foresighting Hub's Visualisation Tool is a powerful, innovative system, which will enable the reader to explore and analyse foresighting data to determine the capabilities required for future roles. Links throughout this report make it easy to identify existing standards which meet the needs of these future roles and pinpoint where new standards are necessary to develop a skilled workforce equipped to adopt new technologies.

The data is generated by the foresighting cycles, integrating the expertise of technologists/domain specialists, employers, and educators. The data can be used to inform the development of future curricula and course content as determined by the action plan. Using AI tools validated by human oversight, and by linking to external data sources, the Visualisation Tool identifies differences at the level of occupation/role as well as detailed changes required to help update and/or refresh knowledge, skills and behaviours, delivering insights for learners, providers, creators, and assurers of skills.

Link to **Visualisation Tool**[2]

Detailed instructions on how to use the Visualisation Tool can be found in the Appendix A. (**Appendix A**)

[2] https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?_environment=production&token=d19ed99c3bc6a3345f60de0bf32d46df

2.1 Industry - Identified Organisational Capabilities

Capabilities Identified

Exploration of organisational changes provides insights into how organisations will need to adapt their current capabilities to implement the solutions that respond to the challenge addressed by the foresighting project.

66 organisational capabilities were identified, which would need to be adapted before implementation, as some are cutting edge and not currently served by existing capabilities. Following the first set of industry workshops, it was identified that quantum computing hardware development skills would be descoped from this cycle, as these capabilities are being addressed by both UK academic and industry strategies. The focus was instead placed on identifying the capabilities required in the next two to five years to enable the target sectors to fully adopt and exploit quantum computing.

Insight:

The identified sectors being Energy, Telecoms and Transport each offer exciting opportunity to adopt quantum computing and are known early adopters of the technology. Each sector has skills bases in physics and mathematics. These bases allow easier adoption of key capabilities such as use case identification and translating problems such that quantum computing offers a possible solution. Beyond this cycle it is important we explore how other sectors may need further support in developing these capabilities.

2.1.1 Future Supply Chain

To understand how supply chains must evolve in response to emerging technologies, a forward-looking view of what future supply chain operations will look like, compared with how they functioned at the time of analysis. This comparison highlighted the areas where change was needed to meet new demands and opportunities.

Throughout the process, participants to identified which supply chain partners will be affected by the technology in question. This ensures that the analysis was grounded in real-world contexts and considers the full ecosystem of organisations involved. The supply chain partners related to the analysis are as follows:

1. **Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s**
2. **Quantum Application and Consulting**
3. **RTO/COI - Research & Innovation Organisations**
4. **Regulatory Organisations**
5. **Quantum Service Providers**

Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s

OEMs integrate quantum capabilities into existing infrastructure by co-designing quantum–classical interfaces and secure cloud connectors. Quantum-compatible hardware modules were developed alongside seamless installation and maintenance of hybrid systems, enabling large-scale deployment across Energy, Telecoms, and Transport networks.

Quantum Application and Consulting (Including End User Organisations)

Quantum Application and Consulting services provide the specialised expertise required to translate complex business or scientific challenges into practical quantum solutions. These partners bridged the gap between emerging quantum capabilities and real-world applications by assessing user needs, designing tailored architectures, and integrating quantum components into existing workflows. Support spanned the full solution lifecycle, from problem framing and algorithm selection to hardware alignment and implementation planning.

Typical examples include:

- Algorithm designers and software specialists for developing quantum algorithms, optimisation routines, and hybrid quantum classical workflows.
- Consultancies and systems integrators that guide organisations with strategy, readiness assessments, solution design, and integration with classical systems.
- These partners ensure that organisations can adopt quantum technologies effectively, efficiently, and with a clear path to measurable value.

Research & Technology Organisation, and Centres of Innovation – RTO & COI

These hubs drive quantum adoption by developing algorithms, hybrid architecture, and quantum machine learning models for sector-specific challenges. They create testbeds and integration frameworks that bridge research with industry, enabling scalable experimentation through quantum-ready cloud platforms.

Regulatory Organisations

Regulators and standards organisations develop and enforce frameworks for quantum technology adoption in critical infrastructure. Certify quantum systems for safety, security, and interoperability, monitor compliance, and ensure ethical deployment across Energy, Telecoms, and Transport sectors.

Quantum Service Providers

These organisations deliver quantum-ready cloud services, APIs, and integration tools, enabling secure and scalable access to quantum computing resources. Supporting enterprise integration and managing hybrid IT environments to ensure reliable deployment of quantum-enabled solutions

The foundation of this analysis is an information architecture built around five core functional domains common to any business: **Design, Implement, Logistics, Support, and Enterprise**. These functions provide a structured lens through which capabilities shifts is assessed.

Insight: The 66 capabilities are distributed across the 5 domains as shown in the graph below. The dominance of Design and Implement capabilities indicates that quantum computing remains at a formative stage, where organisational value is driven by use case creation and deployment rather than operational optimisation. This suggests a near-term skills demand focused on development, integration, and system design, with other capability domains likely to mature later as adoption scales.

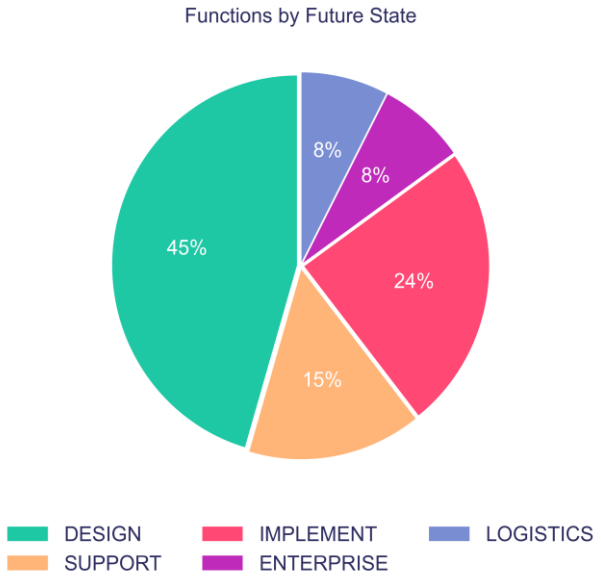

Figure 2: Future – Whole Supply Chain - Capability Function Distribution

Link to visualisation tool for **66 capabilities**[3]

[3] Capabilities hvmcatapultforesighting.retool.com/embedded/public/f56f84e9-8ab8-414f-aa1a-0b42ab5c71df?token=d19ed99c3bc6a3345f60de0bf32d46df

Insight: In Figure 3: Distribution of Functions across each Supply Chain partner below show the dominance of Design and Implement capabilities across the supply chain indicates that **quantum adoption remains at a formative stage**, where success depends on early-phase system design and deployment rather than optimisation. The relative **emphasis on Support within regulatory organisations** reinforces the need for early, coordinated engagement with regulators and RTOs to manage compliance risk and guide effective workforce upskilling.

By mapping supply chain partners against five functional domains, enables identification where capability change was required and which organisations would need to adapt, whether through new skills, new roles, or new ways of working.

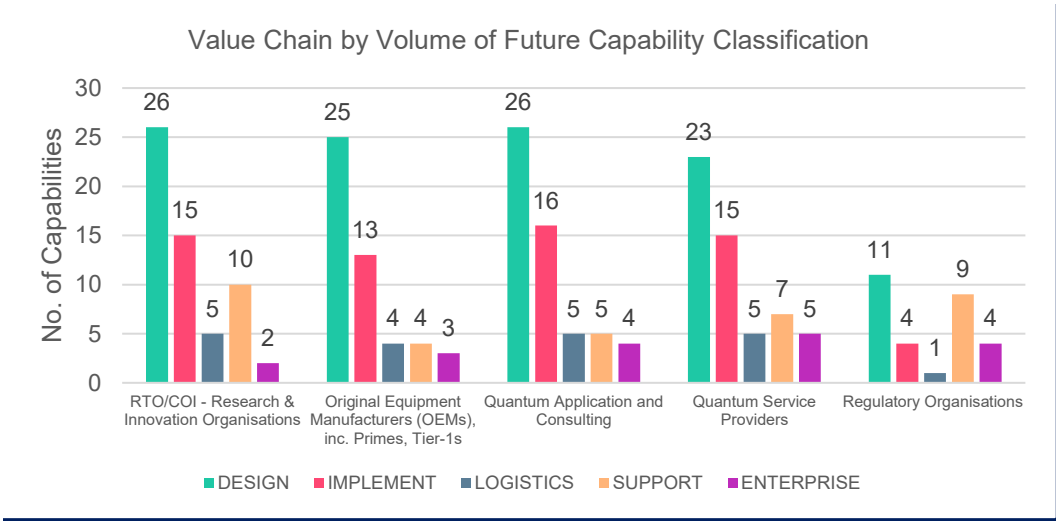

Figure 3: Distribution of Functions across each Supply Chain partner

The graph illustrates the distribution of capabilities by function across the supply chain partners. These capability groupings were used to form the development of FOPs within each role level.

Links: Link to visualisation tool for **5 supply chain partners**[4]

2.1.2 Functional Cycle Capabilities Currently Not Served

Out of the 66 future capabilities needed to adopt this technology across the supply chain, 52 are not currently well matched with any duty statements found in existing apprenticeship standards for Skills England. This could be indicative of a potential gap across all levels of education provision, highlighting the need to develop both short and long-term training solutions to upskill the current workforce and prepare new entrants. The 52 unmatched capabilities are listed in Appendix (**Appendix B. List of Cycle Capabilities Currently Not Served by Skills England Provision**).

[4] https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=d19ed99c3bc6a3345f60de0bf32d46df

The capability mapping highlights that successful quantum adoption requires synchronous development of advanced algorithmic R&D, hybrid integration architectures, sector specific optimisation expertise-, robust regulatory and ethical frameworks, and the workforce, platforms, and leadership systems needed to operationalise quantum technologies at scale.

The organisational capability potential gap identified overarching capability themes:

- Quantum R&D and algorithmic development
- Integration & systems architecture
- Regulation, standards & ethical governance
- Adoption, skills, deployment & operational readiness

Within each supply chain partners, a set of potential capability priorities are identified, including:

- **Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s:** systems integration, operations optimisation, hardware-adjacent quantum applications
- **Quantum Application and Consulting services:** algorithm design, QML models, use-case development
- **RTO/COI:** deep R&D, validation, benchmarking
- **Regulatory Organisations**: standards, ethics, safe-deployment frameworks
- **Quantum Service Providers**: quantum cloud connectors, interfaces, architecture support, secure comms

2.1.3 Prioritised Capability Themes

Following a review conducted with expert participants, the following initial capability themes was identified as critical for the adoption of this technology. These capabilities were subject to further analysed.

In this instance prioritisation was based on the capabilities identified as the most essential for adoption, as captured in Survey B. Participants reviewed a defined subset of capabilities and ranked each one a four-point scale: Essential, Desirable, Not necessary, or Don't know. These rankings were used to identify priority capabilities, alongside areas where no corresponding Skills England education provision currently exists. In addition, capabilities could be prioritised based on the Future Occupational Profiles (FOP) distribution, i.e. which capabilities are used most across the identified FOPs:

Top 5 Priority Themes (Ranked by Frequency in FOPs)

1. Quantum computing use case identification, discovery and development
2. Hybrid architecture and Software engineering
3. System Benchmarking
4. Strategic Decision-Making & System Integration
5. Regulatory Alignment & Ethical Innovation

Analysis against Skills England data[5] only 21.2% (14 of 66) of the identified capabilities are currently matched to an existing educational provision. However, some of these matches are very loose and would require significant changes to truly serve the desired capability, especially within the desired context.

At the start of this process, apprenticeships and other schemes included in the Skills England database were found offer only a very small part of the education routes for the field

[5] **Analysis and Comparison Date** The analysis for this cycle was conducted on **09/03/2026.**The date of the Skills England data used for comparison was **24/02/2026**.

of quantum computing, as the majority of current roles require a PhD or a master's level degree (level 7&8). Though there are some apprenticeships at this level, there are none currently relevant to this field. The UK offers many Masters and PhDs in quantum computing and similar undergraduate courses; this could serve a further 21.2% (14/66) of the identified capabilities, such as those related to quantum computing algorithm research and development.

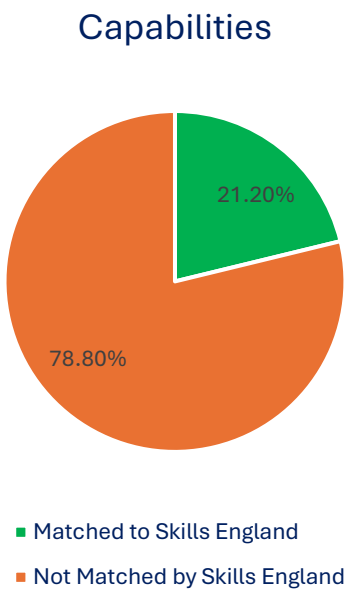

Figure 4: Capabilities matched to education provision analysed (Skills England)

2.2 Workforce Insight

2.2.1 Future Occupational Profiles (FOPs)

Future Occupational Profiles (FOPs) indicated how roles in the target sectors were expected to evolve as the sectors becomes more productised, systemised, and technology driven. They define the key responsibilities and the knowledge, skills, and behaviours required for each role, ensuring alignment with each sector transformation.

The FOPs defined for this cycle do not capture the full extent of a current or future job role. Instead, they reflect the capability changes and new requirements identified through this workforce foresighting cycle that will be required with the identified future occupations to enable future technology adoption.

Link to **FOP Matrix**[6]

2.2.2 Role Levels

Organisations rely on structured role levels to manage talent, drive performance and support sustainable growth. A clear hierarchy from entry level to executive leadership ensures that responsibilities are well defined and that expectations are aligned. Each level builds on the last in terms of complexity, autonomy and impact, enabling effective collaboration and accountability.

[6] https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=d19ed99c3bc6a3345f60de0bf32d46df

Within Workforce Foresighting process a consistent set of role levels was applied across all five supply chain partners for the technology examined within this cycle. This shared role level framework underpinned the capability assessment and supported consistency, clarity in the definition of FOPs and associated capability development within and between sectors. Each workforce foresighting cycle defined role levels to the requirements of the challenge and sector.

Role Levels (RL) selected for this cycle are:

1. **Professional and Delivery**
   Execution and tactical delivery including analysis within defined systems
2. **Strategic and Operational Management**
   Leadership includes leading teams, assessing systems, designing solutions and managing resources.
3. **Enterprise/Strategic Leader**
   Drives enterprise foresight, policy, and transformational strategy.

2.2.3 Future Occupational Profiles results

To enable the mapping of the future workforce, 11 FOPs (Future Occupational Profiles) were identified. These FOPs can be seen below listed by Role Level and across the supply chain partners identified.

Table Key

1. **Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s**
2. **Quantum Application and Consulting**
3. **RTO/COI - Research & Innovation Organisations**
4. **Regulatory Organisations**
5. **Quantum Service Providers**

RL	FOP	1	2	3	4	5
1	Computer Analysts and Scientists	✓	✓	✓	✓	✓
	Engineering Lead/Quality Assurance Professional	✓	✓	✓	✓	✓
	IT Solutions Architects and Designers	✓	✓	✓	✓	✓
	Molecular Chemists Computational Modelling		✓			✓
	Network Optimisation Specialist	✓	✓	✓		✓
	Software Developers	✓	✓	✓	✓	✓
2	Managers & Directors in the management of energy	✓	✓	✓	✓	✓
	Transport Planners	✓	✓	✓	✓	✓
	Cyber Security Management and Governance Specialists	✓	✓	✓	✓	✓
3	Research and Development (R&D) Directors	✓	✓	✓	✓	✓
	Information Technology Technical Directors	✓	✓	✓	✓	✓

Table 3: Future Occupational Profiles by Supply Chain Partner

2.2.4 Priority FOPs

The FOPs were reviewed by expert cycle participants against three criteria: importance to the sector; level of demand; and mapping against current Skills England provision. Cycle participants identified five priority FOPs as critical future roles for industry transformation and quantum computing across Energy, Telecoms, and Transport.

As part of our strategic workforce planning, undertaken through the cycle, FOPs were identified and prioritised against a set of defined criteria. A Priority FOP is defined as a role critical to any UK businesses future organisational success and must be developed ahead of others to meet evolving business needs.

These roles are prioritised because they:

- Were strategically important to the sectors' long-term goals
- Faced current or anticipated capability gaps
- Had a high impact across multiple functions
- Required early talent planning and pipeline development
- Needed to be ready within a defined timeframe

The Priority FOPs are as follows:

- FOP 1 Cyber Security Management and Governance Specialists
- FOP 2 Computer Analysts and Scientists
- FOP 3 IT Solutions Architects and Designers
- FOP 4 Research and Development (R&D) Directors
- FOP 5 Software Developers

Insight The fact that all identified Future Occupational Profiles already exist indicates that quantum computing will be incorporated into existing roles, either as an incremental enhancement or as a fundamental shift, depending on organisational context. The primary workforce challenge is not role creation, but the scale and depth of capability transformation required within existing roles.

2.3 Education & Training provision insights

Quantum computing education in the UK was increasingly aligned with the needs of Energy, Telecoms, and Transport because these sectors face complex optimisation, machine learning and simulation problems. University programmes and Centres for Doctoral Training (CDTs), often supported by organisations like the National Quantum Computing Centre (NQCC), train students in quantum algorithms and modelling techniques directly applicable to real-world systems. In the Energy sector, this includes optimising power grids and simulating new materials for batteries; in Telcom sector, optimising networks and deploying quantum networks with quantum-safe encryption schemes; and in Transport sector, solving routing and logistics problems at scale. Industry partners need to look to embed into these programmes, to ensure that graduates gain experience working on sector-specific challenges. Quantum computing will not be the only approach to solve these problems but may be the right solution in certain applications.

As a result, the UK's education system was not just producing theoretical knowledge but building a sector-ready workforce capable of supporting national infrastructure transformation. Training initiatives increasingly needed to incorporate practical exposure to industrial use cases. While most expertise still emerges at postgraduate level, the growing

integration of quantum skills into applied contexts reflects a strategic effort to future-proof these critical sectors and maintain UK competitiveness in emerging technologies. However, the lack of a public repository of resources and the pathways to upskill on quantum computing is a potential barrier.

2.3.1 Provision Analysis of FOPs and Capabilities

The tables below provided a comparison of each priority FOP against the highest scoring existing education provision. They highlight the highest-scoring standard for each and identify capabilities that are not currently addressed within the selected Skills England Apprenticeship standard. These unmet capabilities could be used to inform the development of future education and training provision, either through adapting existing programmes or through the creation of short CPD courses aimed at upskilling the existing workforce.

Links: Link to **FOP vs Provision** to see full list of capabilities in each FOP mapped to existing Skills England provision[7].

[7] FOP vs provision https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=d19ed99c3bc6a3345f60de0bf32d46df

FOP 1 Cyber Security Management and Governance Specialists

Cyber Security Management and Governance Specialists are responsible for overseeing an organisation's information security strategy, policies, and compliance frameworks. They ensure that systems, networks, and data are protected against cyber threats while aligning security practices with business objectives and regulatory requirements. The role will shift from fragmented security and compliance approaches to the coordinated, ethical and secure integration of quantum technologies across Energy, Telecoms, and Transport. It will involve designing secure data exchange architectures, implementing quantum enhanced encryption, and embedding ethical, regulatory and security principles into quantum deployments, aligned with international best practice. The role will also involve planning certification and assurance processes to manage risk, building societal trust, and ensuring that quantum innovation supports resilient, efficient and decarbonised critical infrastructure.

Aligned to supply chain partner: Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s, Quantum Application and Consulting, RTO/COI - Research & Innovation Organisations, Regulatory Organisations, Quantum Service Providers.

The FOP vs Provision analysis found no Skills England standards aligned with this FOP. The unmatched FOP capabilities that were not matched to existing provision are shown in the table below:

Function Area	Capability Statement
DESIGN	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.
DESIGN	Develop understanding of international best practice in regulation to ensure these are included in UK regulation.
DESIGN	Develop an understanding of the risks of inappropriate Quantum Innovation, so that these can be mitigated in regulation, for example export controls.
IMPLEMENT	Identify specific areas of processes that could benefit from quantum-enhanced solutions to provide organisational benefit.
SUPPORT	Draft ethical guidelines for quantum deployment to address societal implications and promote responsible innovation.
SUPPORT	Plan certification processes for quantum systems to establish trust and reliability in energy, telecoms, and transport applications.
SUPPORT	Develop ethical guidelines and security protocols to ensure responsible deployment of quantum technologies across critical infrastructure.
SUPPORT	Draft ethical guidelines for quantum deployment to address societal impacts and promote responsible innovation.
SUPPORT	Implement quantum-secured communication protocols to protect critical infrastructure from cyber threats.
ENTERPRISE	Implement quantum-enhanced encryption methods to protect data transmission across transport infrastructures.
ENTERPRISE	Develop ethical guidelines for quantum technology deployment to ensure responsible innovation and societal trust.

Table 4: Cyber Security Management and Governance Specialists capabilities not served by Skills England

FOP 2 Computer Analysts and Scientists

Computer Analysts and Scientists research, design, and improve computer systems and computational methods. They analyse complex problems and develop innovative solutions involving software, algorithms, and data processing.

The role will shift from being purely focused on classical techniques and data science with some potential awareness of quantum technologies, to active application of quantum research into deployable, sector-specific solutions for Energy, Telecoms, and Transport. It will involve assessing quantum algorithms, quantum-enhanced machine learning and hybrid quantum-classical architectures to improve forecasting, optimisation and network performance.

Aligned to supply chain partners: Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s, Quantum Application and Consulting, RTO/COI - Research & Innovation Organisations, Regulatory Organisations, Quantum Service Providers.

The FOP vs Provision analysis finds no Skills England standards aligned with this FOP. The FOP capabilities that were not matched to existing provision are shown in the table below:

Function Area	Capability Statement
DESIGN	Develop expertise in quantum entanglement to explore potential applications in the field of superconductivity
DESIGN	Develop quantum-enhanced machine learning models to improve network anomaly detection and resilience.
DESIGN	Integrate quantum computing solutions to optimise operational processes and decision-making in energy, telecoms, and transport industries.
DESIGN	Research and implement quantum computing algorithms for supply chain optimization.
DESIGN	Implement quantum machine learning models to improve demand forecasting in telecommunications networks, ensuring resilient and efficient services.
DESIGN	Develop specific quantum applications to solve industry relevant problems.
DESIGN	Integrate quantum and classical architectures to enhance computational performance in terms of accuracy, efficiency, and speed.
DESIGN	Identify promising quantum use cases to enhance computational efficiency.
DESIGN	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.
DESIGN	Verify results from quantum computations
IMPLEMENT	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.
IMPLEMENT	Implement quantum-classical interfaces to allow hybrid solution development.
LOGISTICS	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.
SUPPORT	Implement quantum-secured communication protocols to protect critical infrastructure from cyber threats.

Table 5: Computer Analysts and Scientists capabilities not served by Skills England

FOP 3 IT Solutions Architects and Designers

IT Solutions Architects and Designers plan and design technology systems that meet business needs. They ensure that IT infrastructure, applications, and integrations are efficient, scalable, and aligned with organisational goals. The role will shift from isolated cloud and quantum experimentation to the coordinated design and deployment of hybrid quantum–classical platforms across Energy, Telecoms, and Transport. It will involve advising on optimised quantum workflows, building secure and energy efficient cloud environments, and designing hybrid and cloud service architectures that improve network resilience and support decarbonisation. The role will also develop deployment strategies and organisational methodologies to accelerate adoption of quantum technologies aligned with evolving technology roadmaps.

Aligned to supply chain partners: Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s, Quantum Application and Consulting, RTO/COI - Research & Innovation Organisations, Regulatory Organisations, Quantum Service Providers.

In FOP vs Provision there was a 15% fit with Skills England Artificial intelligence (AI) data specialist. The FOP capabilities that were not matched to existing provision are shown in the table below:

Function Area	Capability Statement
DESIGN	Support commissioning of early-stage quantum solutions to accelerate adoption in energy, telecoms, and transport sectors.
DESIGN	Design hybrid quantum classical architectures to optimise network efficiency and resilience.
DESIGN	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.
DESIGN	Integrate quantum-enabled tools with client systems to enhance network resilience and efficiency.
DESIGN	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.
DESIGN	Interpret hardware roadmaps to align organisational technology strategies with market developments.
DESIGN	Develop specific quantum applications to solve industry relevant problems.
DESIGN	Integrate quantum and classical architectures to enhance computational performance in terms of accuracy, efficiency, and speed.
DESIGN	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.
DESIGN	Verify results from quantum computations
DESIGN	Develop specific skill sets for applying quantum technologies to address precise industry challenges
DESIGN	Develop specific value propositions to facilitate the adoption of quantum computing technologies.
DESIGN	Develop specific methodologies within the organisation to accelerate the adoption of new technologies and processes.
IMPLEMENT	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.
IMPLEMENT	Advise on configuring hybrid quantum-classical workflows to optimise experimentation processes and recommend trusted platforms.
IMPLEMENT	Train team members to manage specific quantum computing applications and systems.
IMPLEMENT	Build cloud environments for quantum access to support decarbonisation efforts in energy, telecoms, and transport.
SUPPORT	Provide training materials to end users to clarify optimal integration of quantum computing technologies in their workflows.
ENTERPRISE	Design cloud service architectures to optimise energy efficiency and support decarbonisation initiatives.

Table 6: IT solutions Architects and Designers capabilities not served by Skills England

FOP 4 Research and Development (R&D) Directors

R&D Directors lead innovation initiatives within an organization. They oversee research projects, guide technical teams, and ensure the development of new products, technologies, or processes that support long-term business growth. The role will shift from traditional R&D and technology planning to leading the development and deployment of quantum enabled solutions across critical sectors. It will involve applying emerging quantum algorithms in research projects, coordinating cross sector collaboration, shaping technology strategies through hardware roadmap insight, and advancing superconductivity research. The role will also optimise supply chains using quantum methods and establish organisational approaches that accelerate responsible adoption of new quantum technologies.

Aligned to supply chain partners: Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s, Quantum Application and Consulting, RTO/COI - Research & Innovation Organisations, Regulatory Organisations, Quantum Service Providers.

The FOP vs Provision analysis finds no Skills England standards aligned with this FOP.

Function Area	Capability Statement
DESIGN	Research and develop quantum computing algorithms to optimize the analysis of superconducting materials.
DESIGN	Collaborate with international partners to advance quantum technologies and enable commercial use cases.
DESIGN	Research and implement quantum computing algorithms for supply chain optimization.
DESIGN	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.
IMPLEMENT	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.
IMPLEMENT	Coordinate projects to improve collaboration and therefore adoption of quantum technologies.
LOGISTICS	Deliver evidence-based recommendations using digital twins to enhance operational performance of transport services and networks.
LOGISTICS	Analyse transport network data utilizing Artificial Intelligence and quantum computing to simulate and improve operational strategies.
SUPPORT	Draft ethical guidelines for quantum deployment to address societal implications and promote responsible innovation.
ENTERPRISE	Develop ethical guidelines for quantum technology deployment to ensure responsible innovation and societal trust.

Table 7: R&D Directors capabilities not served by Skills England

FOP 5 Software Developers

Software Developers design, build, test, and maintain software applications. They work across various platforms to create solutions that meet user needs and business requirements.

The role will shift from conventional software and systems development to engineering quantum enabled solutions that enhance performance across Energy, Telecoms, and Transport. It will involve applying advanced quantum algorithms, designing hybrid quantum–classical architectures, and developing applications, software development kits (SDKs) and interfaces that support sector wide optimisation. The role will also strengthen resilience by integrating quantum systems into networks, improving anomaly detection, enhancing cybersecurity, and advancing supply chain optimisation through quantum methods.

Aligned to supply chain partners: Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s, Quantum Application and Consulting, RTO/COI - Research & Innovation Organisations, Regulatory Organisations, Quantum Service Providers.

The FOP vs Provision analysis finds no Skills England standards aligned with this FOP.

Function Area	Capability Statement
DESIGN	Develop quantum software development kits to facilitate application creation for energy, telecoms, and transport sectors.
DESIGN	Integrate quantum technologies into telecommunications infrastructure to improve network resilience and efficiency.
DESIGN	Develop quantum-enhanced machine learning models to improve network anomaly detection and resilience.
DESIGN	Apply quantum computing techniques to optimise telecommunication network operations, increasing efficiency and reliability.
DESIGN	Design hybrid quantum classical architectures to optimise network efficiency and resilience.
DESIGN	Research and implement quantum computing algorithms for supply chain optimization.
DESIGN	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.
DESIGN	Integrate quantum-enabled tools with client systems to enhance network resilience and efficiency.
DESIGN	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.
DESIGN	Design user interfaces for quantum computing platforms to facilitate intuitive quantum experiment programming.
DESIGN	Develop specific quantum applications to solve industry relevant problems.
DESIGN	Identify promising quantum use cases to enhance computational efficiency.
DESIGN	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.
DESIGN	Verify results from quantum computations
IMPLEMENT	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.
IMPLEMENT	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.
IMPLEMENT	Implement quantum-classical interfaces to allow hybrid solution development.
SUPPORT	Provide training materials to end users to clarify optimal integration of quantum computing technologies in their workflows.
SUPPORT	Update APIs and integration protocols to enhance system resilience and support decarbonisation efforts.
ENTERPRISE	Configure APIs for secure data exchange to facilitate interoperability between diverse energy systems.

Table 8: Software Developer: capabilities not served by Skills England

FOPs with the biggest Education provision gaps
The table below lists the total FOPs defined for this foresighting cycle. It highlighted provision gaps in existing provision by identifying the best fit existing apprenticeship standard for each FOP, based on the Maximum Fit Factor. The Maximum Fit Factor was combined with the Surplus Factor to determine the Apprenticeship Suitability score of Low, Medium or High.

A detailed comparison of existing apprenticeship provision against the capability requirements of the identified FOPs was available in the data visualisation tool: **FOP vs Provision.**[8]

Table Key:
1. Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s
2. Quantum Application and Consulting
3. RTO/COI - Research & Innovation Organisations
4. Regulatory Organisations
5. Quantum Service Providers

Role Level	FOP Title	Required for Supply Chain Partners	Best Fit Apprenticeship Standard/s	Apprenticeship Suitability[9]
Professional & Delivery	Computer Analysts and Scientists	1,2,3,4,5	None	LOW
	Software Developers	1,2,3,4,5	None	LOW
	Network Optimisation Specialists	1,2,3,5	None	LOW
	Engineering Lead/Quality Assurance Professionals	1,2,3,4,5	None	LOW
	IT Solutions Architects and Designers	1,2,3,4,5	Artificial intelligence (AI) data specialists	LOW
	Molecular Chemists Computational Modelling	5	None	LOW
Strategic & Operational Management	Managers & Directors in the management of energy	1,2,3,4,5	Nuclear scientist and nuclear engineers (integrated degree)	LOW
	Transport Planners	1,2,3,4,5	Transport planners (integrated degree)	MEDIUM
	Cyber Security Management and Governance Specialists	1,2,3,4,5	None	LOW
Enterprise Leadership	Research and Development (R&D) Directors	1,2,3,4,5	None	LOW
	Information Technology Technical Directors	1,2,3,4,5	Digital and technology solutions specialists (integrated degree)	LOW

Table 9: FOP vs Closest Existing Apprenticeship (Skills England) Provision

Links: Link to **FOP Distribution**[10]

[8] FOP vs Provision https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=d19ed99c3bc6a3345f60de0bf32d46df
[9] Suitability (or Fit) Factor was determined based on semantic matching between the capability statements within a FOP and the duty statements within an apprenticeship standard. 100% score would indicate all capabilities within the FOP exceed the defined linguistic matching threshold,
[10] FOP Distribution https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=d19ed99c3bc6a3345f60de0bf32d46df

2.3.2 Knowledge, Skills, and Behaviour tags and its observations.

For each capability in a foresighting cycle, a team of expert educators determined the relevant knowledge, skills, and behaviours (KSBs) required by the workforce to deliver that capability. This approach enables two key use cases.

1. **Informing / Guiding the alignment between future-state capability requirements and current educational provision.**
2. **Driving action by equipping educators to embed these capabilities into their curriculum.**

While capabilities define what organisations need to thrive in the future, KSBs provided a practical framework for how education must evolve to support that transformation. Capability tags that align well with existing educational provisions may also reveal shifts in KSBs requirements. Capabilities introduced during the cycle will were similarly also with relevant tags that will support educators to integrate those capabilities into curriculum effectively.

This intersection between capability relevance and KSB evolution is critical for identifying where curriculum updates are needed to keep pace with industry transformation.

Application

The complete list of KSBs associated with each capability is available within the visualisation tool, alongside all other relevant contextual information.

The application of this data can be broadly divided into two key areas:

1. **Macro Trend Analysis**
   By examining KSB tags at an aggregate level across all capabilities, educators can identify major shifts in demand. This high-level view helps narrow the focus to areas where change is most significant or emerging.

2. **Detailed Research**
   Once priority areas are identified through the macro lens, educators can drill down into specific capabilities or explore the detailed KSBs linked to a particular tag. This supports more targeted curriculum development and informed decision-making.

This report presents a selection of aggregated insights intended to illustrate potential use cases. Readers are strongly encouraged to explore **Cycle Visualisation Tool**[11] for a more detailed and interactive engagement with the data. (**Table 12: A1 Online Data visualisation Tool**) The tool offers deeper context, flexible filtering, and access to the full range of capabilities and KSB tags, enabling users to tailor their exploration to specific interests or needs.

[11]Cycle Visualisation Tool https://hvmcatapultforesighting.retool.com/embedded/public/676d513d-cfa2-4198-b6b4-8773863bf746?token=d19ed99c3bc6a3345f60de0bf32d46df

2.3.3 Most *frequent* tags

The following tables highlights the most frequently used tags across all capabilities in the foresighting cycle. These tags reveal macro trends that can guide the focus of training provisions.

Insight: The variation in quantum requirements across Future Occupational Profiles indicates a need for tiered education pathways differentiated by both knowledge depth and applied skill development:

a) **Knowledge** – Education provision should support graduated levels of quantum literacy, ranging from awareness-level understanding of quantum concepts and implications to advanced theoretical knowledge of quantum computing and quantum mechanics for specialist roles.

b) **Skills tags** – Skills development should focus on role-specific application, combining quantum techniques with complementary technical skills (such as high-performance computing, software engineering, or systems integration), with specialist pathways for roles requiring hands-on expertise in quantum applications and algorithm development.

Most frequent Knowledge Tags

Tag	Tag Frequency
Quantum Computing	40
Quantum Mechanics	8
Energy Management	7
Energy Engineering	7
Transport Planning	6
Mathematical Optimisation	6
System Integration	5
Information Security	4
High Performance Computing	4
Energy Management System	4
Software Development	3

Table 10: Most frequent Knowledge Tags

Most frequent Skills Tags

Tag	Tag Frequency
Optimise network performance	9
Research engineering applications of emerging technologies	8
Optimise energy use through active design solutions	8
Integrate systems and software	8
Apply advanced math's in AI and data science	7
Design smart grids	6
Develop guidelines for system implementation	5
Use safety critical communication protocols	4
Develop software applications	4
Design cloud infrastructure	4

Table 11: Most frequent Skills Tags

This data serves as a starting point to identify emerging knowledge and skills areas that may not be typical within the industry but are gaining traction due to the adoption of new technologies. It also highlights expected tags that rank lower than anticipated, potentially indicating a decline in demand. Using this insight, readers can explore the **visualisation tool**[12] enabling more informed decision.

2.4 Priority evaluation of underserved and high demand capability themes

Educators conducted a targeted review of capability statements and FOPs to identify areas where there is:

- High forecasted demand for specific capabilities in the future workforce, and
- Low current curriculum coverage, meaning these capabilities are not adequately addressed in existing educational programmes.

By focusing on this intersection—high demand but underserved provision—educators were able to pinpoint critical capability gaps that may hinder workforce readiness if left unaddressed. This approach supports strategic curriculum development by highlighting which capabilities should be prioritised for inclusion or enhancement in training programmes.

Discussion on Noteworthy Observations
Three main themes emerged from the clustering of capability statements with high demand and low provision, reflecting areas where current educational offerings may not sufficiently prepare learners for future roles, particularly in sectors undergoing rapid transformation. The following clusters represent key capability gaps and proposed solutions:

1. **Use Case Translation and Identification**
2. **System Architecture and Integration**
3. **Ethical Innovation and Adoption**

These themes highlight a shift in workforce capability needs toward quantum translators allowing strategic thinking and interdisciplinary collaboration, as well as further collaboration with the future supply chain. Addressing these gaps will require coordinated efforts between educators, industry partners, and curriculum designers, to ensure future professionals are equipped for evolving occupational demands.

2.5 Summary of Key Recommendations

Educators identified several capability gaps where curriculum provision does not currently meet forecasted workforce demand. To address these gaps, the following headline recommendations were proposed:

- **Centralised repository of training and educational courses** – There is a high barrier to entry to upskill on quantum computing, however the UK already offers multiple courses and resources to tackle this. A centralised catalogue of what courses offered by universities and RTOs would allow organisations to more easily identify which provisions can help upskill the future workforce.

- Identify Hybrid roles - **Develop leadership training** for ethical strategy in quantum computing adoption and application, targeting senior professionals.

[12]Cycle visualisation tool https://hvmcatapultforesighting.retool.com/embedded/public/8634650f-9700-4627-8431-068b4b764222?token=d19ed99c3bc6a3345f60de0bf32d46df

- Identify sector specific career pathways where shorter modules and upskilling workshops can be introduced to degrees, apprenticeships and continuous professional development course **to build a quantum aware workforce.**

These recommendations reflected a shift toward **interdisciplinary, ethically responsible education**, aligning technical expertise with emerging regulatory, environmental, and operational priorities. They also highlighted the need for **closer collaboration between industry and academia** to ensure that future professionals are equipped with relevant, applied capabilities.

3. Conclusion & Next Steps

3. Conclusions and Next Steps

Work conducted as part of this workforce foresighting cycle revealed that the future development and adoption of quantum computing technologies for Energy, Telecoms, and Transport would require strong foundations in core quantum disciplines (e.g. quantum mechanics and quantum computing), alongside a wide range of adjacent and supporting capabilities (e.g. algorithm design, high-performance computing, and hybrid quantum–classical system integration). These must be complemented by broader technical skills (e.g. software engineering, systems integration and maintenance) and business-oriented capabilities (e.g. data analytics, strategy, ethical innovation and risk management).

Across the supply chain, system integrators were expected to require a broad and diverse capability base. This reflects the current need for experimentation and validation of quantum computing applications, including benchmarking against classical systems, optimisation of hybrid workflows, and mitigation of noise and error in NISQ-era devices. Due to the early-stage maturity of quantum computing technologies within the two-to-five-year horizon, a significant proportion of capabilities were concentrated in design, prototyping, and use-case development.

The predominant role level remained centred on engineering and technical expertise, consistent with the current maturity of quantum computing. Advanced research skills—typically at PhD level—are critical for the development of core technologies such as quantum algorithms and error correction, often reflected in roles such as research scientists and fellows. Alongside this, a wide range of engineering roles are required to translate research into practical applications, including quantum software engineers, systems architects, and integration specialists. As a result, FOPs are heavily clustered around engineering disciplines, spanning areas such as software development, systems integration, and computational modelling. Technical support roles are also important, including testing, validation, and operational maintenance functions within hybrid computing environments.

The relatively weak alignment between current educational provision (Skills England) and future workforce needs reflects the emerging and rapidly evolving nature of quantum computing. While specialised degree programmes and training pathways are still developing, the overall fit remains relatively high, indicating that many of the required skills can be sourced from existing disciplines such as computer science, physics, and engineering. However, these skills often need to be recombined and supplemented with targeted training in quantum-specific concepts, tools, and applications to fully address capability gaps.

To drive meaningful transformation across the target sectors, strong leadership, strategic investment, and a deep understanding of emerging innovations are essential. The foresighting analysis underscores the importance of aligning workforce development with future demands, particularly through the adaptation of apprenticeship and degree programmes and the creation of flexible CPD opportunities. These efforts will ensure that individuals are equipped with the skills and knowledge required to navigate evolving technologies and practices.

3.1 Key Findings & Conclusions

From the Workforce Foresighting Cycle the following data points were identified and focus areas were developed.

Key Findings

Future Capabilities & Roles: 66 **future capabilities** were identified, leading to 11 **Future Occupational Profiles** (FOPs) across 5 **supply chain partners**.

Priority Capabilities Themes:
These capability themes were prioritised because they directly address the most pressing challenges and opportunities in the process **of building sectoral quantum expertise (Energy, Telecoms, and Transport) to support decarbonisation and build resilient and efficient networks:**

- **Use Case Translation and Identification**
- **Digitalisation, AI & Data-Driven Optimisation**
- **Hybrid System Architecture and Integration**
- **Strategic Decision-Making & Automation Integration**
- **Regulatory Alignment & Ethical Innovation**

High-Priority Roles:
The following roles will be instrumental in driving industry-wide change by facilitating informed decision-making and ensuring the compliance and economic viability of new technologies:

- **Cyber Security Management and Governance Specialists**
- **Computer Analysts and Scientists**
- **IT Solutions Architects and Designers**
- **Research and Development (R&D) Directors**
- **Software Developers**

Education provision gaps:
As identified through this programme, there are currently no matching current Skills England provisions for the future workforce needs. However, many existing provisions address these capabilities. Further work is required to enhance these provisions to include quantum computing and make them available through a public central repository/catalogue. This would enable employers and educators to direct individuals (employees) to the appropriate materials/resources as they seek to upskill.

Key Conclusions

In conclusion, while quantum computing presents significant long-term opportunities for the Energy, Telecoms, and Transport sectors, its near-term adoption will be constrained less by awareness and more by the ability of organisations to develop and access the right combination of skills. The challenge was not solely the availability of highly specialised expertise in areas such as Quantum Computing, but the integration of these capabilities with established disciplines including Computer Science, Engineering, and domain-specific knowledge.

Over the next two to five years, progress will depend on building multidisciplinary teams that can bridge the gap between theoretical potential and practical implementation. In particular, there will be a growing need for “translational” roles—individuals who can connect quantum technologies to real-world industry problems, support experimentation, and guide early-stage deployment through hybrid quantum–classical approaches.

Although current educational pathways are not yet fully aligned with these emerging needs, the underlying skill base already exists across adjacent fields. With targeted upskilling, stronger collaboration between industry and academia, and the development of tailored training programmes, organisations can begin to close these gaps. Those that invest early in workforce development, partnerships, and capability building will be better positioned to exploit quantum advantage as the technology matures, while those that delay risk falling behind in both innovation capacity and competitive positioning.

3.2 What this means for Industry

The three sectors identified at the start of the report are all early adopters of quantum computing. This cycle concluded that the largest gap within industry end users was use case identification as most end user organisations will not have dedicated “quantum” roles; instead, existing roles will have to adapt to incorporate quantum computing.
For industry, this means that quantum computing was not yet a “plug-and-play” technology but instead represents a capability-building challenge as much as a technical one. Organisations in the Energy, Telecoms, and Transport sectors needed to shift from viewing quantum computing as a future procurement decision to treating it as a strategic priority for workforce and innovation.

To help address these, Industry could consider:

- Upskilling existing teams (e.g. engineers, data scientists) though engagement programmes hosted by key RTOs.
- Identifying how roles and responsibilities map to those identified in this cycle for leaders, engineers, and technical teams.
- Discussing the business case for quantum computing and further innovation and workforce development. Engage with pilot programmes and early use case discovery.
- Hiring hybrid talent with backgrounds in Computer Science, physics, and domain expertise.

3.3 What this means for Educators

For the education sector, the rise of quantum computing had major implications, as the current talent pipeline is insufficiently aligned with industry needs. Therefore, universities,

training providers, and vocational programmes must rethink curricula, teaching methods, and industry engagement.

Throughout the cycle, existing education and training provisions listed within Skills England was found not to map directly to the required capabilities. However, provision relevant to many of the identified capabilities did exist, it was often fragmented, difficult to access or not packaged with the appropriate supporting resources for each of the FOPs identified in this cycle.

To help address these, educators could consider:

- Development of a public assessable, centralised catalogue of programmes and resources.
- Design of multi-disciplinary programmes, providing context to where quantum computing can be applied and where classical computing such as HPC may be the more suitable resource.
- Continuing expansion of continuing professional development (CPD) opportunities, including Summer Schools and short courses to support practical upskilling and application of quantum technologies.
- Promotion of deeper collaboration with industry to ensure relevance and impact. Co-developed modules on industry relevant applications. Provide internship and mentor opportunities.
- Identification of sector specific career pathways where shorter modules and upskilling workshops can be introduced to degrees, apprenticeships and continuous professional development course to build a quantum-aware workforce.

3.4 Summary of next steps:

Although this cycle focused on adoption of quantum computing within Energy, Telecoms, and Transport sectors, the findings were also relevant to other sectors. Further engagement is needed for input and to validate the findings for other sectors. Key actions identified at the end of the cycle included:

- Engagement with NPL and IOP (Institute of Physics) to explore what a public centralised repository of education resources related to quantum computing could offer the ecosystem and future workforce.
- Look to input into UK Quantum Skills working group to validate findings on skills needed for the future workforce.
- Disseminating findings across all three target sectors and engage and find learnings from sectors not originally considered in this cycle.

Given the announcements on UK's 'Quantum Leap' (gov.uk, 2026) and supporting funding for quantum computing, it is important we examine any measures and cross reference job creation across the cycle timeline.

Thus, as with the previous quantum cycle, it is important to coordinate with the DSIT Quantum Skills Taskforce wider challenges facing quantum skills and organisational capabilities in the UK, and how the findings from the cycle could inform future work in this regard.

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4. Appendix

Appendices

Appendix A Visualisation tool and instructions for use

The interested reader may wish to access the online data visualisation tool which provides several different ways to view the cycle data. Links to relevant parts of the tool are given with brief guidance below. This content is provided and maintained by the Workforce Foresighting Hub.

Visualisation Tool Section	What is it and what can it be used for?
Data Capture Overview	Provides a summary of the data captured across the foresight cycle, bringing together the work of the Technologists / Domain Specialists, Employers and Educators into one overview. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/676d513d-cfa2-4198-b6b4-8773863bf746?token=d19ed99c3bc6a3345f60de0bf32d46df
Supply Chain Capabilities	Provides an overview of the identified capabilities at a Supply Chain / Workflow Partner level. By selecting/deselecting each Supply Chain / Workflow Partner you can review the capabilities identified as required in that area of the Supply Chain / Workflow. This can be used to generate organisational capability profiles for each area of the workflow /supply chain to help prioritise and focus the acquisition of new capabilities that will be required in the future. It can also be used to generate combined organisational profiles, where an organisation may be involved in more than one area of the supply chain. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=d19ed99c3bc6a3345f60de0bf32d46df
FOP Detail	This page allows you to review a specific Occupational Profile, including the capabilities contained within it and the Knowledge, Skills & Behaviour (KSB) tags associated with the capability. You can select an individual Role Family and linked FOP in the two available dropdowns. The table in the lower section of the page will then be populated with all relevant capabilities. The search control above the table allows you to filter content of any of the columns of data. A key piece of functionality in this table is the presence of the KSB tags associated with the capabilities. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=d19ed99c3bc6a3345f60de0bf32d46df

Visualisation Tool Section	What is it and what can it be used for?
Future Occupational Profiles - FOP Matrix	Provides a detailed breakdown of future occupational profiles that could be required in the future workforce. These were generated using a combination of attributes collected through the workshops and an algorithm. These suggested profiles were then reviewed and ratified by small groups of employers who were able to add/remove capabilities and uprate/downrate proficiency levels required. You can view all the FOPs in a role family by selecting one (or more) of these from the drop down. This will then allow you to select the FOPs aligned to that role family. The populated table allows you to review and compare different FOPs within or across role families. You can view the capabilities in each FOP and the assigned proficiency levels. You can also toggle 'Hide Empty Capabilities' on/off to reduce the view down to only those capabilities included in the role family you are reviewing. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=d19ed99c3bc6a3345f60de0bf32d46df
Future Knowledge, Skill and Behaviours (KSBs) Summary	Not yet completed in this cycle. Provides a view of the complete set of capabilities within the cycle along with all of the associated KSB tags which are linked to them. It is, essentially, the superset of all details displayed on the FOP detail page. This is used to: • To review the identified Knowledge, Skill and Behaviour tags for a given capability, to support development of future education and learning material. • To review the requirements from a capability level, rather than a role family/occupational profile grouping. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/8634650f-9700-4627-8431-068b4b764222?token=d19ed99c3bc6a3345f60de0bf32d46df

Visualisation Tool Section	What is it and what can it be used for?
FOP Distribution	This page allows provides a breakdown of the Capabilities within the selected Cycle and how they are distributed across the FOPs with the addition of a distribution chart showing the required proficiency across those FOPs. Clicking the "View FOPs" button alongside each capability will provide a list of the proficiencies (EPA) with the FOPs that fall into them. The exported version of this data will include a full breakdown of the FOP IDs which contain the capability within a specific proficiency. This is used to: • understand the levels/volumes of common/crossover Capabilities, to support prioritisation of Capability Development • identify which Occupational Profiles contain these common/crossover capabilities, and so which may be prioritised for development activity Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=d19ed99c3bc6a3345f60de0bf32d46df
Capabilities Matched to Current Provision	This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard. You can select individual capabilities to review their specific matches. These matches are shown in the bottom panel, including the Standard, the Level and the Duty Statement this is matched to. You can filter in several ways to focus your review: • By the Capability Classification Framework (left-hand panel). • By capabilities that **are** served by the reference mapping framework – the default is Institute for Apprenticeships and Technical Education (Skills England Occupational Standards) provision. By capabilities that **are not** served by the reference mapping framework, e.g., Skills England Occupational Standards provision – these are capabilities required in the future that may require new/bespoke training and CPD materials to be developed to upskill/re-skill the workforce. This page can be used to identify where existing provision may exist across the broad spectrum of Occupational Standards, and not just within a narrow range of sector-specific Standards. The data also allows you to identify where provision may already exist to support specific capabilities. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/219ff6af-36ea-4b5e-bda1-b0b989c0e3f0?token=d19ed99c3bc6a3345f60de0bf32d46df

Visualisation Tool Section	What is it and what can it be used for?
Fit & Surplus Factors	This page allows you to review the 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (Skills England Occupational Standards). It is possible for the 'Fit' and 'Surplus' comparison to total over 100%, as they are two separate calculations based on a two-way comparison. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/c699e504-3f64-45a0-b52e-ad44a95f9aa4?token=d19ed99c3bc6a3345f60de0bf32d46df
Fit & Surplus Matrix	This page is a visual representation of the 'Fit and Surplus Factor' insight. You can visually review 'Fit' and 'Surplus' of Future Occupation Profiles (FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (Skills England Occupational Standards). This can help you identify which provision may align the strongest, or which may require adaptation, to provide the suitable provision fit for each future role. It will help you focus in on which provision to focus your attention for analysis. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/1c4e204b-3927-4226-9f8e-2f62ce0643c5?token=d19ed99c3bc6a3345f60de0bf32d46df
FOP Capability Matches	This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (Skills England Occupational Standards) Duty Statements. Clicking the arrow next to a number in the 'Matches' column will open a popup with more detail for each Capability. Each capability also includes Knowledge, Skill and Behaviour Tags, to support with scaffolding future education provision. You can review individual Future Occupational Profiles (FOPS) or review all FOPs under a Role Family, to give a more holistic view of Capabilities and Matches Where a future capability has been matched to existing provision (currently, by default, Skills England Occupational Standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements. This can be used to review the capability requirements for Role Families and FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/6a205e7e-8f33-4765-b39b-82f1f549217a?token=d19ed99c3bc6a3345f60de0bf32d46df

Visualisation Tool Section	What is it and what can it be used for?
FOP vs Provision	This page allows you to compare FOPs against existing Skills England Occupational Standards. The information here allows you to prioritise effort or action over the short, medium or long-term. This is displayed as a Matched/Not Matched Capability, comparing the Capability in a FOP to the Duties in a Standard. The left-hand side allows you to select the Role Family and FOP, while the right-hand modal allows you to compare against the top 10 matched Skills England Occupational Standards for that Occupational Profile. Where a future capability has been matched to existing provision (currently, by default, Skills England Occupational Standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=d19ed99c3bc6a3345f60de0bf32d46df
FOP Priorities	Provides a list of all the FOPs within the selected cycle with details of their fit and surplus factors. The information here allows you to prioritise effort or action over the short, medium or long-term. Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/ad0f6dcb-9535-4239-96a7-c8d0e005477a?token=d19ed99c3bc6a3345f60de0bf32d46df

Table 12: A1 Online Data visualisation Tool

Appendix B. List of Cycle Capabilities Currently Not Served by Skills England Provision

Table Key: Supply Chain Partners

1. **Original Equipment Manufacturers (OEMs), inc. Primes, Tier-1s**
2. **Quantum Application and Consulting (Inc. End User Organisations)**
3. **RTO/COI - Research & Innovation Organisations**
4. **Regulatory Organisations**
5. **Quantum Service Providers**

Function	Capability statement	1	2	2	3	5
DESIGN	Research and develop quantum computing algorithms to optimize the analysis of superconducting materials.		✓	✓		
DESIGN	Develop expertise in quantum entanglement to explore potential applications in the field of superconductivity.	✓	✓	✓		
DESIGN	Develop quantum software development kits to facilitate application creation for energy, telecoms, and transport sectors.	✓	✓	✓		✓
DESIGN	Plan quantum technology integration strategies to enhance energy, telecoms, and transport sector decarbonisation efforts.	✓	✓	✓	✓	✓
DESIGN	Integrate quantum technologies into telecommunications infrastructure to improve network resilience and efficiency.	✓	✓	✓	✓	✓
DESIGN	Collaborate with international partners to advance quantum technologies and enable commercial use cases.	✓		✓	✓	✓
DESIGN	Develop quantum-enhanced machine learning models to improve network anomaly detection and resilience.	✓	✓	✓		✓
DESIGN	Integrate quantum computing solutions to optimise operational processes and decision-making in energy, telecoms, and transport industries.	✓	✓	✓		✓
DESIGN	Apply quantum computing techniques to optimise telecommunication network operations, increasing efficiency and reliability.	✓	✓	✓		✓
DESIGN	Support commissioning of early-stage quantum solutions to accelerate adoption in energy, telecoms, and transport sectors.	✓	✓	✓	X	✓
DESIGN	Design hybrid quantum–classical architectures to optimise network efficiency and resilience.	✓	✓	✓		✓
DESIGN	Develop sustainable transport strategies for supply chain operations.		✓		✓	
DESIGN	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.	✓	✓	✓	✓	✓
DESIGN	Research and implement quantum computing algorithms for supply chain optimization.	✓	✓	✓		
DESIGN	Implement quantum machine learning models to improve demand forecasting in telecommunications networks, ensuring resilient and efficient services.	✓	✓	✓		✓
DESIGN	Integrate quantum-enabled tools with client systems to enhance network resilience and efficiency.	✓	✓	✓		✓
DESIGN	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	✓	✓	✓		✓
DESIGN	Interpret hardware roadmaps to align organisational technology strategies with market developments.	✓	✓	✓	✓	✓
DESIGN	Design user interfaces for quantum computing platforms to facilitate intuitive quantum experiment programming.		✓	✓		✓
DESIGN	Develop specific quantum applications to solve industry relevant problems.	✓	✓	✓		✓

DESIGN	Integrate quantum and classical architectures to enhance computational performance in terms of accuracy, efficiency, and speed.	✓	✓	✓		✓
DESIGN	Identify promising quantum use cases to enhance computational efficiency.	✓	✓	✓		✓
DESIGN	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.	✓	✓	✓		✓
DESIGN	Verify results from quantum computations	✓	✓	✓	✓	✓
DESIGN	Develop understanding of international best practice in regulation to ensure these are included in UK regulation.				✓	
DESIGN	Develop an understanding of the risks of inappropriate Quantum Innovation, so that these can be mitigated in regulation, for example export controls.				✓	
DESIGN	Design energy-efficient equipment to optimise resource usage.	✓				
DESIGN	Develop specific skill sets for applying quantum technologies to address precise industry challenges.	✓	✓	✓		✓
DESIGN	Develop specific value propositions to facilitate the adoption of quantum computing technologies.	✓	✓	✓		✓
DESIGN	Develop specific methodologies within the organisation to accelerate the adoption of new technologies and processes.	✓	✓	✓	✓	✓
IMPLEMENT	Identify specific areas of processes that could benefit from quantum-enhanced solutions to provide organisational benefit.	✓	✓	✓	✓	✓
IMPLEMENT	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.	✓	✓	✓	✓	✓
IMPLEMENT	Advise on configuring hybrid quantum-classical workflows to optimise experimentation processes and recommend trusted platforms.	✓	✓	✓		✓
IMPLEMENT	Coordinate projects to improve collaboration and therefore adoption of quantum technologies.		✓	✓	✓	✓
IMPLEMENT	Train team members to manage specific quantum computing applications and systems.	✓	✓	✓		✓
IMPLEMENT	Using advanced computational modelling techniques to optimize energy generation processes.	✓	✓	✓		✓
IMPLEMENT	Analyse energy requirements and distribution systems to maximise the use of renewable energy sources like wind or nuclear.		✓		✓	
IMPLEMENT	Integrate quantum solutions into electrical systems with renewable energy systems for efficiency improvement.	✓	✓	✓		✓
IMPLEMENT	Implement quantum algorithms to optimise energy distribution networks, reducing losses and supporting decarbonisation efforts.	✓	✓	✓		✓
IMPLEMENT	Implement quantum computing solutions to optimise energy grid management, reducing carbon emissions and increasing resilience.	✓	✓	✓		✓
IMPLEMENT	Build cloud environments for quantum access to support decarbonisation efforts in energy, telecoms, and transport.	✓	✓	✓		✓
IMPLEMENT	Plan quantum-enhanced energy grid management strategies to optimise renewable energy integration and ensure grid stability.		✓	✓		✓
IMPLEMENT	Integrate quantum computing solutions to optimise energy distribution and reduce carbon emissions.	✓	✓	✓		✓
IMPLEMENT	Implement quantum algorithms to optimise energy grid management and improve efficiency.	✓	✓	✓		✓
IMPLEMENT	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.	✓	✓	✓		✓
IMPLEMENT	Implement quantum-classical interfaces to allow hybrid solution development.	✓	✓	✓		✓
LOGISTICS	Manage the scale up of new technologies for effective deployment in the sector.	✓	✓	✓	✓	✓

LOGISTICS	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.	✓	✓	✓		✓
LOGISTICS	Utilise data provided by quantum sensors to monitor and assess transport infrastructure maintenance and resilience.	✓	✓	✓		✓
LOGISTICS	Deliver evidence-based recommendations using digital twins to enhance operational performance of transport services and networks.		✓	✓		✓
LOGISTICS	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	✓	✓	✓		✓
SUPPORT	Provide training materials to end users to clarify optimal integration of quantum computing technologies in their workflows.	✓	✓	✓		✓
SUPPORT	Update APIs and integration protocols to enhance system resilience and support decarbonisation efforts.	✓	✓	✓	✓	✓
SUPPORT	Develop quantum adoption standards to ensure consistent integration across energy, telecoms, and transport sectors.	✓	✓	✓	✓	✓
SUPPORT	Draft ethical guidelines for quantum deployment to address societal implications and promote responsible innovation.			✓	✓	✓
SUPPORT	Plan certification processes for quantum systems to establish trust and reliability in energy, telecoms, and transport applications.		✓	✓	✓	✓
SUPPORT	Develop ethical guidelines and security protocols to ensure responsible deployment of quantum technologies across critical infrastructure.			✓	✓	✓
SUPPORT	Draft ethical guidelines for quantum deployment to address societal impacts and promote responsible innovation.			✓	✓	
SUPPORT	Plan certification processes for quantum systems to establish standards and ensure compliance across industries.			✓	✓	
SUPPORT	Establish ethical frameworks for integrating quantum technologies into transport systems to ensure safety and public trust.			✓	✓	
SUPPORT	Implement quantum-secured communication protocols to protect critical infrastructure from cyber threats.	✓	✓	✓	✓	✓
ENTERPRISE	Design cloud service architectures to optimise energy efficiency and support decarbonisation initiatives.	✓	✓			✓
ENTERPRISE	Configure APIs for secure data exchange to facilitate interoperability between diverse energy systems.	✓	✓	✓	✓	✓
ENTERPRISE	Implement quantum-enhanced encryption methods to protect data transmission across transport infrastructures.	✓	✓	✓	✓	✓
ENTERPRISE	Develop ethical guidelines for quantum technology deployment to ensure responsible innovation and societal trust.				✓	✓
ENTERPRISE	Plan certification processes for quantum systems to validate performance and compliance with industry regulations.		✓		✓	✓

Table 13: B1 List of Cycle Capabilities Currently Not Served by Skills England Provision

Appendix C List of full FOPs by Role Level including Capabilities

FOP Title Information Technology Technical Directors
Role Level Enterprise Leadership
Required for supply chain partners RTO/COI - Research & Innovation Organisations. Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322845	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	Awareness
322372	Plan quantum technology integration strategies to enhance energy, telecoms, and transport sector decarbonisation efforts.	Expert
322834	Interpret hardware roadmaps to align organisational technology strategies with market developments.	Expert
322841	Develop specific methodologies within the organisation to accelerate the adoption of new technologies and processes.	Expert
322843	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.	Expert
210894	Manage the scale up of new technologies for effective deployment in the sector.	Expert

Table 14: B1 Information Technology Technical Directors FOP

FOP Title Research and Development (R&D) Directors
Role Level Enterprise Leadership
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
214017	Deliver evidence-based recommendations using digital twins to enhance operational performance of transport services and networks.	Awareness
322845	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	Awareness
189982	Research and develop quantum computing algorithms to optimize the analysis of superconducting materials.	Practitioner
322827	Research and implement quantum computing algorithms for supply chain optimization.	Practitioner
322833	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	Practitioner
322395	Collaborate with international partners to advance quantum technologies and enable commercial use cases.	Expert
322834	Interpret hardware roadmaps to align organisational technology strategies with market developments.	Expert
322841	Develop specific methodologies within the organisation to accelerate the adoption of new technologies and processes.	Expert
322843	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.	Expert
323148	Coordinate projects to improve collaboration and therefore adoption of quantum technologies.	Expert
322355	Draft ethical guidelines for quantum deployment to address societal implications and promote responsible innovation.	Expert
322830	Develop ethical guidelines for quantum technology deployment to ensure responsible innovation and societal trust.	Expert

Table 15: B2 Research and Development (R&D) Directors FOP

FOP Title Cyber Security Management and Governance Specialists
ROLE LEVEL Strategic & Operational Management
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322846	Utilise data provided by quantum sensors to monitor and assess transport infrastructure maintenance and resilience.	Awareness
322845	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	Awareness
322828	Develop sustainable transport strategies for supply chain operations	Practitioner
322412	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.	Expert
214017	Deliver evidence-based recommendations using digital twins to enhance operational performance of transport services and networks.	Expert

Table 16: B3 Cyber Security Management and Governance Specialists FOP

FOP Title Managers & Directors in the management of energy
ROLE LEVEL Strategic & Operational Management
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
189856	Using advanced computational modelling techniques to optimize energy generation processes.	Awareness
322364	Implement quantum computing solutions to optimise energy grid management, reducing carbon emissions and increasing resilience.	Practitioner
322411	Integrate quantum computing solutions to optimise energy distribution and reduce carbon emissions.	Practitioner
322415	Integrate quantum computing solutions to optimise operational processes and decision-making in energy, telecoms, and transport industries.	Expert
322372	Plan quantum technology integration strategies to enhance energy, telecoms, and transport sector decarbonisation efforts.	Expert
300809	Analyse energy requirements and distribution systems to maximise the use of renewable energy sources like wind or nuclear.	Expert
322416	Integrate quantum solutions into electrical systems with renewable energy systems for efficiency improvement.	Expert
322397	Plan quantum-enhanced energy grid management strategies to optimise renewable energy integration and ensure grid stability.	Expert
210894	Manage the scale up of new technologies for effective deployment in the sector	Expert

Table 17: B4 Managers & Directors in the management of energy FOP

FOP Title Transport Planners
ROLE LEVEL Strategic & Operational Management
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322846	Utilise data provided by quantum sensors to monitor and assess transport infrastructure maintenance and resilience.	Awareness
322845	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	Awareness
322828	Develop sustainable transport strategies for supply chain operations	Practitioner
322412	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.	Expert
214017	Deliver evidence-based recommendations using digital twins to enhance operational performance of transport services and networks.	Expert

Table 18: B5 Transport Planners FOP

FOP Title Computer Analysts and Scientists
Role Level Professional and Delivery
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
190067	Develop expertise in quantum entanglement to explore potential applications in the field of superconductivity	Awareness
322827	Research and implement quantum computing algorithms for supply chain optimization.	Practitioner
322412	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.	Practitioner
322752	Implement quantum-secured communication protocols to protect critical infrastructure from cyber threats.	Practitioner
322829	Implement quantum machine learning models to improve demand forecasting in telecommunications networks, ensuring resilient and efficient services.	Practitioner
322410	Develop quantum-enhanced machine learning models to improve network anomaly detection and resilience.	Expert
322415	Integrate quantum computing solutions to optimise operational processes and decision-making in energy, telecoms, and transport industries.	Expert
322835	Develop specific quantum applications to solve industry relevant problems.	Expert
322836	Integrate quantum and classical architectures to enhance computational performance in terms of accuracy, efficiency, and speed.	Expert
322832	Identify promising quantum use cases to enhance computational efficiency.	Expert
322838	Verify results from quantum computations	Expert
322848	Implement quantum-classical interfaces to allow hybrid solution development.	Expert
322847	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.	Expert
322837	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.	Expert

Table 19: B6 Computer Analysts and Scientists FOP

FOP Title IT Solutions Architects and Designers
Role Level Professional and Delivery
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322838	Verify results from quantum computations	Awareness
323144	Provide training materials to end users to clarify optimal integration of quantum computing technologies in their workflows.	Awareness
322728	Support commissioning of early-stage quantum solutions to accelerate adoption in energy, telecoms, and transport sectors.	Practitioner
322367	Integrate quantum-enabled tools with client systems to enhance network resilience and efficiency.	Practitioner
322834	Interpret hardware roadmaps to align organisational technology strategies with market developments.	Practitioner
322833	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	Practitioner
322835	Develop specific quantum applications to solve industry relevant problems.	Practitioner
322836	Integrate quantum and classical architectures to enhance computational performance in terms of accuracy, efficiency, and speed.	Practitioner
322837	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.	Practitioner
322839	Develop specific skill sets for applying quantum technologies to address precise industry challenges	Practitioner
322841	Develop specific methodologies within the organisation to accelerate the adoption of new technologies and processes.	Practitioner
322840	Develop specific value propositions to facilitate the adoption of quantum computing technologies.	Practitioner
322843	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.	Practitioner
322844	Train team members to manage specific quantum computing applications and systems.	Practitioner
322361	Design cloud service architectures to optimise energy efficiency and support decarbonisation initiatives.	Practitioner
322831	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.	Expert
322374	Advise on configuring hybrid quantum-classical workflows to optimise experimentation processes and recommend trusted platforms.	Expert
322368	Build cloud environments for quantum access to support decarbonisation efforts in energy, telecoms, and transport.	Expert
322734	Design hybrid quantum–classical architectures to optimise network efficiency and resilience.	Expert

Table 20: B7 Computer Analysts and Scientists FOP

FOP Title Network Optimisation Specialist
Role Level Professional and Delivery
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers

ID	Capability Statement	Proficiency
322846	Utilise data provided by quantum sensors to monitor and assess transport infrastructure maintenance and resilience.	Awareness
189982	Research and develop quantum computing algorithms to optimize the analysis of superconducting materials.	Expert
322827	Research and implement quantum computing algorithms for supply chain optimization.	Expert
322833	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	Expert
322835	Develop specific quantum applications to solve industry relevant problems.	Expert
322832	Identify promising quantum use cases to enhance computational efficiency.	Expert
322358	Implement quantum algorithms to optimise energy distribution networks, reducing losses and supporting decarbonisation efforts.	Expert
322744	Implement quantum algorithms to optimise energy grid management and improve efficiency.	Expert
322412	Implement quantum algorithms to enhance transport network efficiency and reduce congestion.	Expert
322845	Analyse transport network data utilizing Artificial Intelligence and Quantum computing to simulate and improve operational strategies.	Expert

Table 21: B8 Network Optimisation Specialist FOP

FOP Title Molecular Chemists Computational Modelling
Role Level Professional and Delivery
Required for supply chain partners Quantum Service Providers

ID	Capability Statement	Proficiency
305565	Design energy-efficient equipment to optimise resource usage.	Awareness
322847	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.	Awareness
322395	Collaborate with international partners to advance quantum technologies and enable commercial use cases.	Practitioner
322833	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	Practitioner
322832	Identify promising quantum use cases to enhance computational efficiency.	Expert
322368	Build cloud environments for quantum access to support decarbonisation efforts in energy, telecoms, and transport.	Expert

Table 22: B9 Molecular Chemists Computational Modelling FOP

FOP Title Engineering Lead/Quality Assurance Professional
Role Level Professional and Delivery
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322416	Integrate quantum solutions into electrical systems with renewable energy systems for efficiency improvement.	Awareness
322364	Implement quantum computing solutions to optimise energy grid management, reducing carbon emissions and increasing resilience.	Awareness
322411	Integrate quantum computing solutions to optimise energy distribution and reduce carbon emissions.	Awareness
323146	Develop an understanding of the risks of inappropriate Quantum Innovation, so that these can be mitigated in regulation, for example export controls.	Practitioner
323145	Develop understanding of international best practice in regulation to ensure these are included in UK regulation.	Practitioner
305565	Design energy-efficient equipment to optimise resource usage.	Practitioner
322379	Draft ethical guidelines for quantum deployment to address societal impacts and promote responsible innovation.	Practitioner
322373	Develop ethical guidelines and security protocols to ensure responsible deployment of quantum technologies across critical infrastructure.	Practitioner
322742	Establish ethical frameworks for integrating quantum technologies into transport systems to ensure safety and public trust.	Practitioner
322355	Draft ethical guidelines for quantum deployment to address societal implications and promote responsible innovation.	Practitioner
322830	Develop ethical guidelines for quantum technology deployment to ensure responsible innovation and societal trust.	Practitioner
322378	Plan certification processes for quantum systems to validate performance and compliance with industry regulations.	Practitioner
322838	Verify results from quantum computations	Expert
322837	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.	Expert
322356	Plan certification processes for quantum systems to establish trust and reliability in energy, telecoms, and transport applications.	Expert
322354	Develop quantum adoption standards to ensure consistent integration across energy, telecoms, and transport sectors.	Expert
322729	Plan certification processes for quantum systems to establish standards and ensure compliance across industries.	Expert

Table 23: B10 Engineering Lead/Quality Assurance Professional FOP

FOP Title Software Developers
Role Level Professional and Delivery
Required for supply chain partners RTO/COI - Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), inc. Primes & Tier-1s, Quantum Application and Consulting, Quantum Service Providers, Regulatory Organisations

ID	Capability Statement	Proficiency
322838	Verify results from quantum computations	Awareness
323144	Provide training materials to end users to clarify optimal integration of quantum computing technologies in their workflows.	Awareness
322366	Develop quantum software development kits to facilitate application creation for energy, telecoms, and transport sectors.	Practitioner
322410	Develop quantum-enhanced machine learning models to improve network anomaly detection and resilience.	Practitioner
322391	Integrate quantum technologies into telecommunications infrastructure to improve network resilience and efficiency.	Practitioner
322726	Apply quantum computing techniques to optimise telecommunication network operations, increasing efficiency and reliability.	Practitioner
322734	Design hybrid quantum–classical architectures to optimise network efficiency and resilience.	Practitioner
322831	Design secure cloud connectors to facilitate compliant data exchange between telecommunications networks.	Practitioner
322827	Research and implement quantum computing algorithms for supply chain optimization.	Practitioner
322367	Integrate quantum-enabled tools with client systems to enhance network resilience and efficiency.	Practitioner
322835	Develop specific quantum applications to solve industry relevant problems.	Practitioner
322832	Identify promising quantum use cases to enhance computational efficiency.	Practitioner
322837	Evaluate and benchmark quantum computing systems' performance against classical computing systems to identify efficiency improvements.	Practitioner
322843	Develop deployment strategies for quantum solutions that align with specific technology roadmaps and requirements.	Practitioner
322847	Deploy quantum error correction protocols to enhance the reliability of quantum computations in energy grid simulations.	Practitioner
322848	Implement quantum-classical interfaces to allow hybrid solution development.	Practitioner
322371	Update APIs and integration protocols to enhance system resilience and support decarbonisation efforts.	Practitioner
322833	Analyse advancements in quantum algorithms to apply the latest findings in research & development projects.	Expert
322739	Design user interfaces for quantum computing platforms to facilitate intuitive quantum experiment programming.	Expert
322370	Configure APIs for secure data exchange to facilitate interoperability between diverse energy systems.	Expert

Table 24: B11 Software Developers FOP

Appendix D Background to Workforce Foresighting Hub

Addressing future workforce challenges

The global marketplace is changing at a rapid pace, and the continued development of innovative technologies is creating opportunities for growth in all sectors.

Whilst the UK is well placed to take advantage, the Government and industry have identified the need for a workforce which is able to adapt to new capabilities requiring different and often higher skill sets. The 'Manufacturing the Future Workforce' report, published in 2020, states: "Failure to address the workforce development challenge will mean missing out on opportunities to build the UK's manufacturing base and to take market leading positions."

Developing this workforce and preventing a skills shortfall will provide future-thinking organisations with the capabilities to successfully adopt innovation and enable the UK to build a prosperous economy.

The Skills Value Chain

A Skills Value Chain (SVC) approach promotes connectivity between upstream UK innovation and downstream skills systems, as well as enabling better co-operation within education and training provider eco-systems. It aligns and integrates innovation and skills strategies with a common purpose.

The SVC approach was proposed in the 'Manufacturing the Future Workforce' report, which examined global best practice and convened UK pioneers to explore how the UK can develop skills to exploit innovative technologies.
And it starts with workforce foresighting.

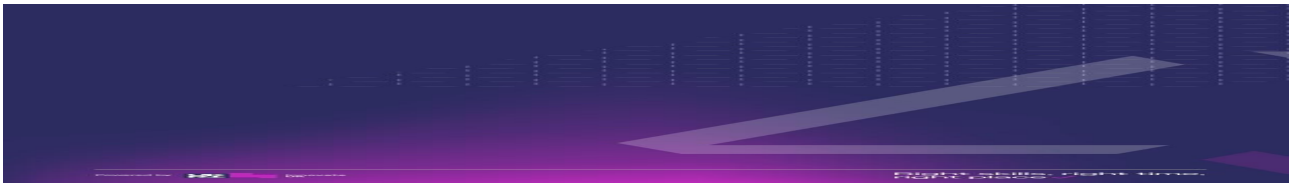

Figure 5: Skills Value Chian (SVC)

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Workforce foresighting

Using the Skills Value Chain approach, the UK will start building the skilled workforce required by tomorrow's industries and employers and understanding what these future needs will be.

Workforce Foresighting is a systemic approach to identifying the organisational capabilities and workforce skills necessary to enable industry to adopt and exploit innovative technologies which respond to global, national and sector challenges.

The Workforce Foresighting Hub, initiated and funded by Innovate UK, and built in collaboration with the Catapult Network, provides the processes and data that inform insight and support the recommendations required for industry, policymakers and educators to respond to continuing change.

Our Vision: To foster the organisational capabilities and workforce skills required to adapt to continuing change and enable adoption of innovative technologies to enable a prosperous UK industry.

Our Mission: To provide the process, insight and recommendations required to identify and address future skills demands to enable the UK to adopt innovation and succeed in the dynamic global marketplace.

Our Goals:

Define future capabilities required across a sector in response to a challenge, or technology innovation and consequently define the skill sets of the workforce of the future.
Understand and explain gaps between technology adoption, organisational capability and workforce profiles that could hamper innovation.
Identify and communicate insights, future requirements and the action required by industry and educators.
Enable and deliver a consistent approach to workforce Foresighting.

Outcomes:
The process integrates insight from experts in three categories – domain specialists/technologists, employers, and educators. Using a structured and facilitated series of collaborative information-gathering workshops, combined with data from open-source global data sets, the workforce Foresighting process can produce a wealth of detailed quantitative data to inform action.

At the heart of the Foresighting process are working groups consisting of the industry sponsor and centre of innovation, with support from the Workforce Foresighting Hub team, who undertake detailed analysis to report and summarise key data insights and recommendations for action. This report details future supply chain capabilities, prototype future occupational profiles and identifies changes required to current training provision for the sponsor to take forward and address skills challenges relating to the specific topic.

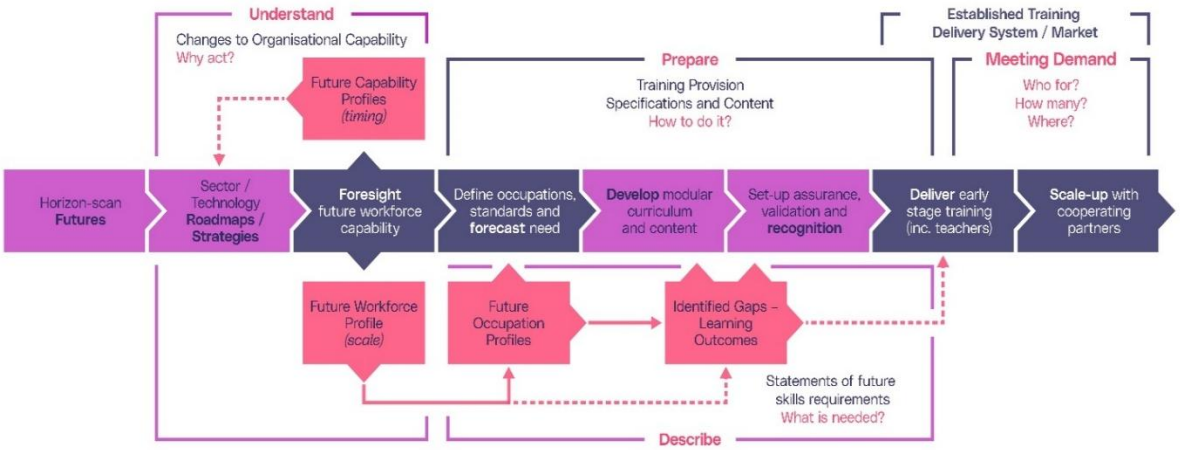

Figure 6: Workforce Foresighting & Skills Value Chain

Approach used: principles and implementation

The core of workforce Foresighting is convening three groups of relevant specialists to conduct structured, Delphi-style, facilitated workshops to capture and discuss the set of organisational capabilities that will be required to respond to and exploit technology innovation. Lists of workshop participants are provided in **Table 2: Contributing Participants**

Organisational capabilities are captured using a bespoke classification developed by the Workforce Foresighting Hub. The classification applied a structured common language to enable cross sector and cross-centre collaboration and integration of data. Additionally, the classification allows data from a number of other national and international open-source workforce datasets to be integrated through the same common language. The resulting data were held in a cloud based "data-cube" which is dynamically growing as each workforce foresighting cycle adds to the shared data relating to future workforce capabilities.

Using cutting edge AI and Large Language Model data tools, the data-cube is used to undertake detailed analysis to 'map' future workforce capability requirements against the current education and training provision to identify where existing provision can be used and where new provision, CPD or qualifications are required.

As an agile development project, the WfH team are constantly evolving and improving the detailed workshop process and workshop approach, but essentially always consists of the following stages:

- **Considering** – Clarifying the Challenge to be met (the 'what' and the 'when') and collating solutions (the 'how') as Foresighting topic suggestions align with strategic priorities
- **Identifying** – Gain clarity and consensus about the solutions to be put forward – make the case for Foresighting
- **Preparing** – The convening of specialists and scheduling of workshops
- **Carrying out** – Run Foresighting workshops with experts, collate and analyse data
- **Communicating** – Insights, findings and recommendations gathered from all research in an actionable report
- **Causing action** – The driving of action based on the recommendations (promoting progress down the rest of the skills value chain) built on the findings and recommendations of Foresighting

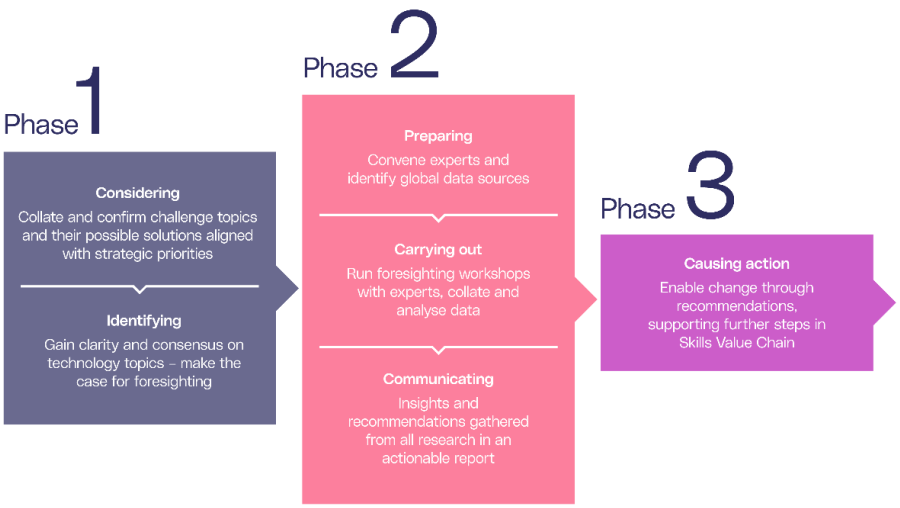

Figure 7: The workforce foresighting process

Forecasting and Foresighting

The result of workforce Foresighting is understanding why skills requirements will need to change to enable the adoption of innovative technologies, and to define what this change is likely to be in terms of future occupations and shorter-term skills gaps. Forecasting of demand can then take these future focused findings and work with industry and government stakeholders to estimate the quantity of workers necessary for an industry to fulfil emerging skill demands at a given time and place. The two approaches are linked in that workforce Foresighting identifies the requirements and forecasting can then determine the quantity needed; the people needing the skills and therefore prepare programmes to deliver them.

Outcomes - insights and recommendations

Workforce Foresighting is a data intensive approach that can provide sponsors, stakeholders and participants with detailed insight about future workforce requirements. A dynamic data set is provided for each cycle to allow all stakeholders and participants to freely access and interrogate the data. Additionally, the WFH team will support the production of a report that provides targeted recommendations that require action to address gaps in training and education provision relevant to the challenge and planned technology solution.

The dynamic data portal provides a range of standard data sets and visualisations. Additionally, users can download data to undertake their own more detailed interrogation of data to guide and inform subsequent actions.

The key aspect is to provide insight about gaps – which capabilities required in the future are NOT addressed by aspects of current provision – apprenticeship standards, qualifications or other provision. Gaps represent:

- **Short term CPD** – topics required across the workforce to upskill members of current workforce
- **Medium term** – topics to be included as current provision / standards are reviewed and updated
- **Longer term** – new qualifications and standards that may be needed to equip new entrants

The insight produced by a workforce Foresighting cycle (project) provides:

- **Technologists** and technical leads with insight of the organisational capability sets required across future supply chain partners in response to the identified challenge.
- **Employers** with insight about possible future roles and occupations that may be required across the whole workforce, operators to researchers, to ensure they are equipped and ready.
- **Educators** with details of the gaps to be addressed by short-course training to upskill the existing workforce and also insight about qualifications and provision that will be required to support new entrants in the future.