Workforce Foresighting Hub

Designing, developing and implementing Quantum Sensing Technologies for enhanced positioning and monitoring of modes of transport.

Workforce Foresighting Hub findings report in collaboration with Digital Catapult.

CATAPULT Digital

February 2025

UKRI Innovate UK

Right skills, right time, right place

Acknowledgements

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

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 –

Any errors, omissions and incorrect data are the responsibility of the Workforce Foresighting Hub team, and all queries should be addressed to info@iuk.wf-hub.org

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 October 2024 – January 2025 using the data set and tools available at that time.

Contents

Executive Summary

Executive Summary

This report outlines findings from the Workforce Foresighting cycle focussing on *Designing, Developing and Implementing Quantum Sensing Technologies for Enhanced Positioning and Monitoring of Modes of Transport.* The study is supported by the Department for Transport and conducted by Digital Catapult in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative.

Workforce Foresighting is a systemic approach to planning ahead and 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 ensure a workforce is developed that is prepared to effectively implement these new technologies in the sector.

Quantum Sensing in the UK

Quantum sensing is a transformative technology, offering unprecedented precision in the measurement of quantities such as magnetic fields, gravity and passage of time. The UK's ambition for developing the technology, ensuring an important role globally, is set out in the Department of Science, Innovation and Technology's 2023 National Quantum Strategy.

There are numerous opportunities for adoption in the transport sector in terms of position, navigation and timing (PNT) and monitoring of critical infrastructure. This is underscored by a recent report published by the Department of Transport, which estimated that quantum technologies in the UK will have a net value creation impact of £4-8 billion by 2030-2035.

In terms of PNT, there are vulnerabilities in systems reliant on Global Navigation Satellite Systems (GNSS), as they are prone to spoofing, jamming, and natural disruptions. By further developing quantum-enabled technologies, such as quantum inertial sensors and quantum clocks, enhanced resilience could be achieved, as outlined by the National Strategy and Missions, and delivering on the PNT Policy Framework. It is estimated that disruption to the global navigation satellite system would have an economic impact of approximately £1 billion to the UK per day, affecting, for example, railways, telecommunications and emergency services. In addition, with regards to infrastructure, quantum sensing offers considerable potential for asset management and planning. For instance, the cost of maintenance of railway infrastructure in the UK currently runs to £7.5bn per year; quantum sensors could improve fault detection and condition monitoring and thus reduce costs.

In regard to the quantum sensing market, estimates vary considerably, potentially due in part to wide range of technologies and levels of maturity. However, looking at the total addressable market for quantum inertial sensors, for aviation alone, is estimated to be in the region $3.35bn - $5bn, will illustrates the magnitude of the opportunity for quantum sensing.

Workforce Foresighting in Quantum Sensing

Rather than selecting a single quantum sensing technology for this cycle, the lead contributors opted for a technology-agnostic approach. The reasoning for this is that the identified future organisational capabilities will be applicable to all quantum sensors being developed for PNT and infrastructure monitoring systems. Thus, this covers a range technologies, including magnetometry, gravimetry, quantum clocks and inertial systems.

This cycle is another contribution to Digital Catapult's previous Workforce Foresighting Cycles on '*Utilising real-time rendering engines to drive the acceleration of Advanced Media Production*' and '*AI tools for image asset creation and augmenting existing assets in advanced media production'*. Exploration of these cycles aimed at increasing productivity in the screen sector and enhancing the UK's position as a leader in CreaTech - a fusion of skills associated with the Creative Industries and emerging technologies, with Quantum Technologies being an emerging technology.

Cycle Participants and Stakeholders

Industry Participants	Skills Participants	Technology Participants
Department for Transport	Imperial College London/Quantum-enabled PNT Hub	Digital Catapult
Transport for London	Glasgow University / Quantum Sensing, Imaging and Timing Hub	Delta g
	Anchored In	ReThinkPNT
	Institute for Apprenticeships and Technical Education (IfATE)	BAE Systems
	King's College London	

Findings and Insights

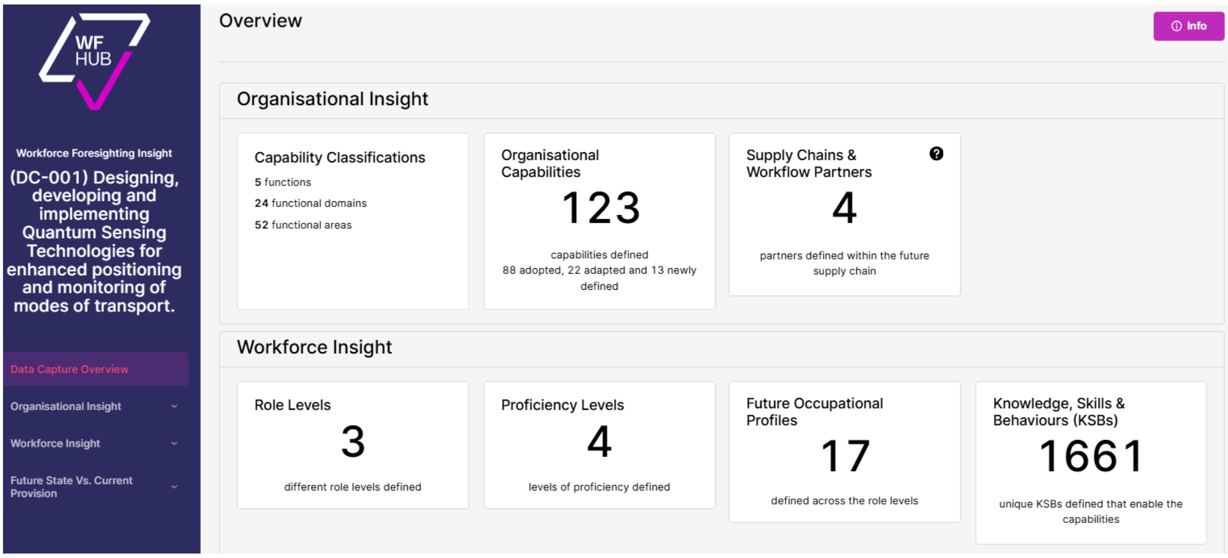
Exploration of the topic through this cycle has revealed that both the future development and adoption of quantum sensing technologies for transport will require core quantum skills (e.g. quantum mechanics) and a multitude of adjacent and supporting capabilities (e.g. photonic design and system implementation), together with more general technical (e.g. maintenance) and business skills (e.g. analytics).

Across the supply chain partners, system integrators in particular have a large number of capabilities, which is to be expected as there is the pressing need for more field trials of quantum sensing systems, including benchmarking and reduction of environmental noise. By virtue of the nascent nature of the quantum sensing technologies considered, and timescale addressed, there is a significant number of capabilities within design and prototyping.

The predominant role level - *Engineering* - is in line with current maturity of quantum sensors across the various technologies. PhD-level skills are central to the research and development of the core technologies, as captured by the *Research Fellow* level, whilst an array of engineering roles is required to refine, iterate and implement the sensors, including a multitude of hardware and software skills. The *Future Occupational Profiles* generated thus cluster around engineering to a large degree, including systems engineers, software integration engineers and component engineer, to name a few. Technician roles are also important, with examples including *Quality Assurance Tester* and *Maintenance Technician*.

What can be perceived as the overall poor matching of current educational provisions for future needs is a reflection of the emerging nature of quantum technologies, resulting in a lag of specific courses and training which have yet to be tailored. This would improve as the educational provisions are development and adapted, in light of the findings of this cycle. Moreover, the overall fit (88%) does indicate that the skills required can be often addressed with current educational resources, albeit in different configurations and complemented by tailored programmes to address gaps.

The visualisation tool is available at : Data Capture Overview | HVMC Foresighting



Next Steps for Workforce Foresighting in Quantum Sensing

A working group to '*Cause Action'* has been set-up post completion of this cycle. The group will meet on a regular basis for the first 12 months of the report being published. The agenda of the meetings will be to ensure adoption of the learnings from the report and to discuss dissemination of the report. Looking ahead, a trailblazer group could be established to help develop apprenticeships for future occupations, working with IfATE.

It is critical to address the gaps and challenges outlined here, in order to ensure the UK is able to successfully develop and adopt quantum sensing technologies to enhance functionalities, reduce costs and ensure great resilience for the transport sector.

1.0 Introduction

Section	Title
1.1	Background to Workforce Foresighting
1.2	Workforce Foresighting - process overview
1.3	Foresighting vs Forecasting
1.4	Visualisation tool

1.1 Background to Workforce Foresighting

The 2020 report '*Manufacturing the Future Workforce*' recommended the 'Skills Value Chain' as an approach to avoid shortfalls in workforce capabilities relating to future innovations (see Figure 1). This is the genesis of the workforce foresighting programme, which is sponsored by Innovate UK and delivered through the Innovate UK Catapult Network.

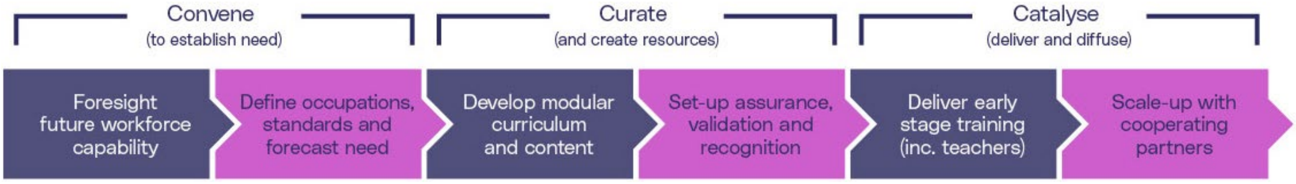


Figure 1: The Skills Value Chain

The first step of the skills value chain is to '*Foresight future workforce capability'*. This calls for technology, industry, education, and training partners to convene using government as a focal point, to "...*foresight and articulate future skills needs, standards and qualifications associated with emerging technologies*" .

1.2 Workforce Foresighting - Process Overview

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.

Organisational capabilities are captured using a bespoke classification that has been developed by the Workforce Foresighting Hub. The classification uses a structured common language to enable cross sector and cross centre collaboration and integration of data. Additionally, the classification enables data from a number of other national and international open-source workforce datasets to be integrated through the same common language. The data is held in a cloud based 'data-cube' that 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 Workforce Foresighting Hub team are constantly evolving and improving the detailed workshop process and workshop approach, but consistently 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 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

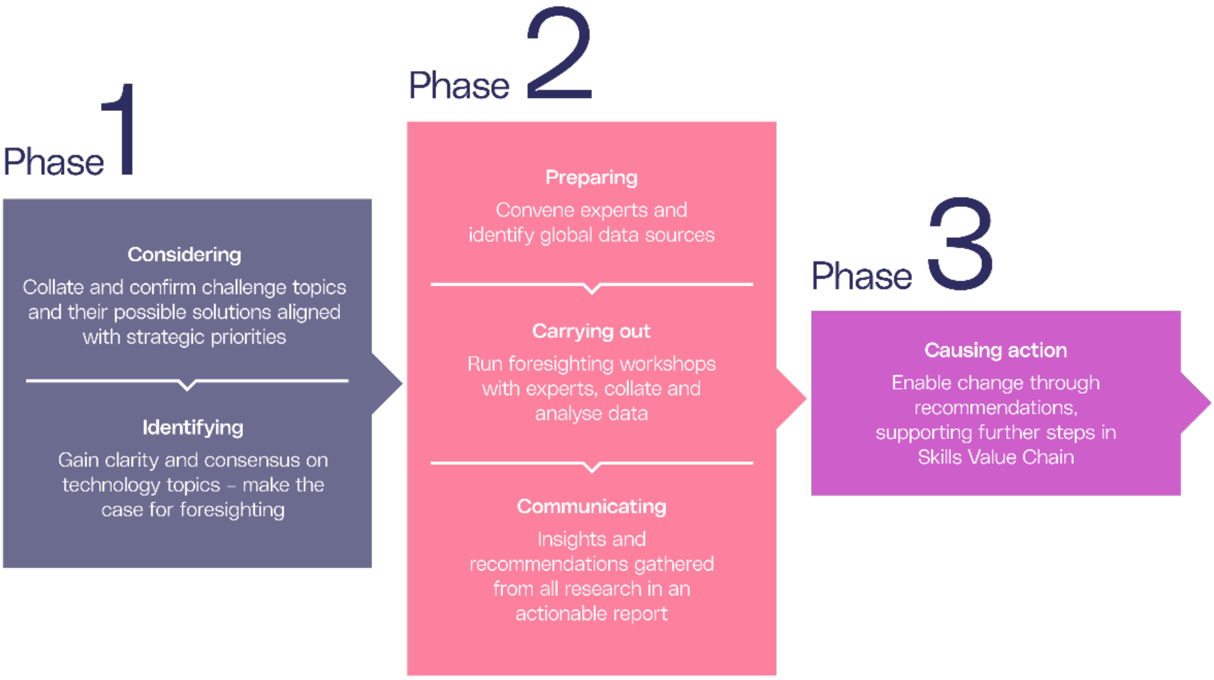


Figure 2 - The workforce foresighting process

1.3 Foresighting vs Forecasting

Although this study is focussed on workforce foresighting (capabilities required) it is important to keep in mind parallel findings from forecasting (required capacities and numbers). Forecasting, alongside foresighting, provides vital input to the sector, feeding into recruitment and development targets for employers, and consideration of economic class sizes and recruitment targets for educators. However, it is beyond the scope of the foresighting study to carry out independent forecasting, and as such readers should refer to referenced studies for detail on forecasting.

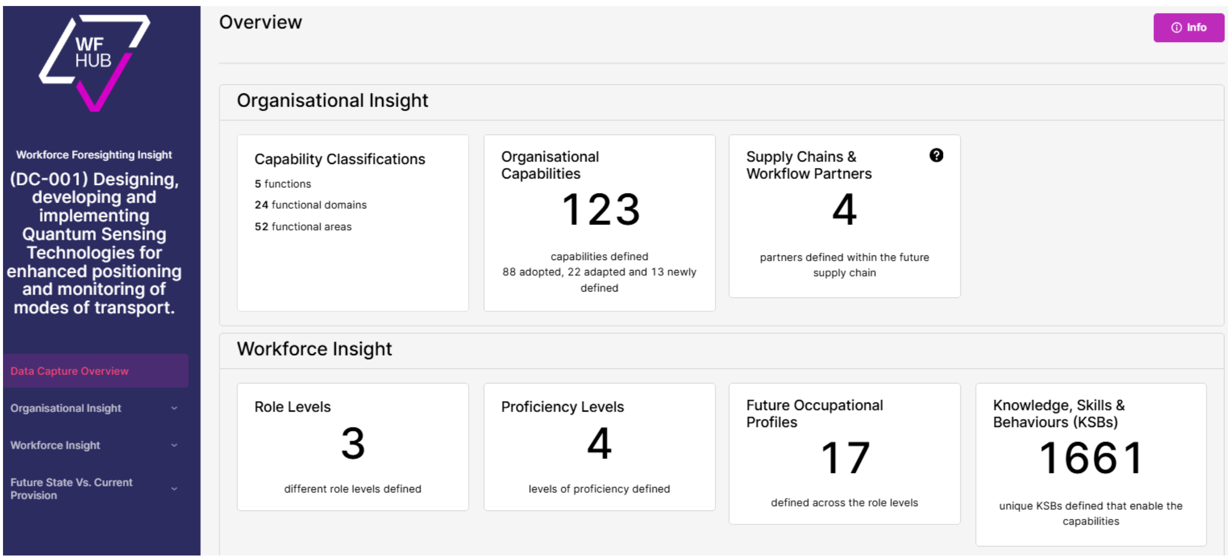
1.4 Introducing the Visualisation Tool

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 informs the development of future curriculums and course content as determined by the action plan. Using AI tools validated by human oversight, and by linking to external data sources, the tool identifies differences at the level of occupation/role as well as detailed changes required to help update/refresh knowledge, skills and behaviours thus delivering insights for learners, providers, creators and assurers of skills.

Detailed instructions on how to use the Visualisation Tool can be found in the appendix.

Data Capture Overview



2.0 Aligning the Challenge and Solutions with national priorities

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Section	Title
2.1	Positioning and context of challenges
2.2	Potential and prioritised Solutions to Challenge
2.3	Workforce foresighting for chosen prioritised technology solution
2.4	Current and predicted scale of technology deployment in UK
2.5	Key Stakeholders

2.1 Positioning and context of national challenge

The UK's National Quantum Strategy identifies quantum sensing as an important technology capable of transforming industries by providing, for example, unprecedented precision in measurements such as magnetic fields, gravity, and the passage of time. Two of the UK's quantum missions relate to PNT and infrastructure monitoring - by 2030, quantum navigation systems will be deployed on aircraft, enabling satellite-free navigation, and networking quantum sensors will unlock new capabilities, including for critical infrastructure in transport.

As previously noted, this aligns with the PNT Policy Framework, which builds upon the Blackett report (Government Office for Science, 2018), highlighting the critical nature of PNT technologies to the UK. Additional recent reports outline the raft of applications within the transport sector that could be addressed by quantum sensing technologies, as well as comparison with classical systems (QED-C – Quantum sensing). The UK has considerable strength within the quantum sector, as well as within enabling technologies such as photonics, and thus is in an excellent position to develop and adopt quantum sensing technologies.

2.2 Potential and prioritised technology solutions to the challenge

The successful deployment of quantum sensing technologies requires a skilled workforce capable of bridging the gap between research and commercialisation. Current shortages highlight the need for both PhD-level expertise in research and a range of skills for system integration and operation. Workforce Foresighting efforts aim to create pathways for upskilling, reskilling, and new skilling across roles such as technicians, engineers, and data specialists.

With regards to specific technologies, there is a range of quantum sensing technologies at various levels of maturity that share workforce challenges and thus is it critical to consider them as a whole. This includes those outlined below:

Quantum technology	Example transport use cases	Maturity
Magnetometers - optically pumped and solid state	Map - matching navigation, non-destructive testing	Limited commercial availability of some examples
Inertial sensors	Inertial navigation (dead reckoning)	Early commercial prototypes available
Gravity/gravity gradient sensors	Map - matching navigation, underground mapping	Early commercial prototypes
Atomic clocks - optical	Long-term holdover in absence of satellite navigation/ communication	Advanced research

2.3 Workforce Foresighting for chosen Prioritised Technology Solutions

Quantum sensing technologies are poised for staged deployment over the next decade, with early prototypes already developed, and specific examples commercialised, and potentially scaled industrial applications by 2030. Initial focus areas include integrating quantum inertial, magnetic field and gravity sensors, together with new quantum clocks, into critical infrastructure and transport systems, supporting a broader rollout in commercial sectors. . The anticipated scale-up may require coordinated efforts across the UK innovation landscape, including research institutions, Catapult Centres, other UKRI institutions and industry to ensure robust supply chains and operational readiness.

2.4 Current and predicted scale of technology deployment in UK

As previously noted, the recent report published by the Department of Transport on socio-economic impacts of quantum technologies in transport, estimated that quantum technologies as a whole, will have a net value creation impact of £4-8 billion by 2030-2035. Also highlighted are the commercial barriers for quantum technologies in general, including a talent gap, need for well-defined education strategy, mismatch between formal training and industry needs, need to upskilling programs and lack of widespread quantum literacy.

Quantum sensing has been highlighted as key to developing resilient PNT and monitoring critical infrastructure, and thus it is timely to address the future workforce needed for its development and deployment. Representing a range of emerging technologies, it is pertinent to consider the design, prototyping, development and integration stages during the cycle, with volume manufacturing outside of the scope.

There were four types of emerging quantum technologies that were highlighted prior to the start of the cycle (see table above). These relate to navigation, communication, infrastructure monitoring, amongst other transport-related use cases.

2.5 Key Stakeholders in industry and government

In the context of the national challenge, the following are key stakeholders:

Government Bodies: The National Office for PNT (DSIT), Office for Quantum (DSIT), Department for Transport, Innovate UK, and the Department for Education (DfE) are central to policy development and funding initiatives.

Research Institutions: The Hubs for Quantum-enabled PNT and Quantum Sensing, Imaging and Timing and Digital Catapult lead efforts in research and workforce training.

Industry Partners: Companies in transport, infrastructure, and advanced manufacturing sectors, such as Tier-1 OEMs and SMEs, are critical for implementation and adoption.

Educational Bodies: Universities and vocational training providers support skill development tailored to the sector's needs.

This collective approach ensures alignment between technological development, workforce readiness, and national priorities, enabling the UK to secure its leadership in quantum technologies.

3.0 Findings and Results

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Section	Title
3.1	Methodology and Findings
3.2	Step One – How will the Supply Chain change? - Organisational Changes Insight
3.3	Step Two – How will the Workforce change? - Occupational Change Insight
3.4	Step Three – How the current Education provision meets the future need Highlighted Changes for Future provision?

3.1 Methodology and Findings

Summary information on the foresighting process is provided with a narrative based on the underlying data which is also provided using bespoke visualisations to enable greater insight and access to detail. The report is aligned to the needs of those responsible for workforce planning – employers, educators, and skills providers.

Step One – How will the Supply Chain change? - Organisational Changes
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.

Typically, organisational changes will also require the adoption of new capabilities and a change in the distribution of these capabilities across supply chain partners. The change in capabilities within an organisation as well as their supply chain partners will determine the changes knowledge and skill changes required by the role levels within the workforce of each supply chain partner.

Step Two – How will the Workforce change? - Occupational Changes
A set of 'Future Occupational Profiles' (FOPs) is produced by the foresight process that demonstrates how current occupations may need to change in the future. FOPs are generated using a combination of attributes from the underlying capability classification and from data collected in the workshops. The FOP generation algorithm works to group capabilities into logical sets reflecting role levels, function, proficiency and capability similarity. As part of the foresight process the generated FOPs are reviewed, revised and distilled by the Employer group. The agreed set of FOPs are then compared with selected current education provision; the default reference is the set of Institute for Apprenticeships and Technical Education (IfATE) apprenticeship standards; to assess which current training and education provision could be used in the future. Two bespoke metrics - match and surplus - are used to evaluate the alignment of current provision with the set of FOPs proposed. Summaries are presented of the key findings related to each supply chain partner.

The key audience for the findings, are Employers, and Education and Training Providers, with the intention of identifying matches and gaps in future training needs compared with current provision to guide further detailed investigation.

Step Three – How does the current Education provision meet the future need? - Highlighted Changes to Future Provision
The report identifies suggested changes to education and training provision – principally apprenticeship standards that will deliver the knowledge, skills and behaviours required by future occupations. In some cases, this will include the development of short courses and continued professional development (CPD) to upskill the current workforce to meet future needs. Additionally, foresighting outputs can be used to develop programmes, qualifications, and apprenticeship standards for new entrants to the workforce joining via apprenticeship, taught qualification, or other training programme.

The insight and data in this part of the report are primarily aimed at educators training providers, apprenticeship standards bodies and awarding organisations. Combined with insight arising from the supply chain capability changes, the provision insight offers an effective way for employers to identify training opportunities that align to their future needs.

3.2 Insight into Step One – How will the Supply Chain change? Organisational Changes

Organisation functions

The Workforce Foresighting process uses an information architecture built on five functional areas which are common to any business:

Design	The function of an organisation that focuses on activities relating to product, service or solution design.
Implement	The function of an organisation that focuses on activities relating to producing / making / providing its products or services.
Logistics	The function of an organisation that focuses on activities relating to procurement, delivery, materials, or services necessary for operations – service / manufacturing, etc.
Support	The function of an organisation that focuses on activities relating to users, in-service support, repair / maintenance, recycling, end of life disposal.
Enterprise	Core functions of an organisation - e.g., strategic planning, leadership and management, human resources, digital backbone and data systems, integration of relevant statutory / regulatory requirements and compliance.

The functional structure is developed to levels of detail that enable the foresight process to reference external data sets including ONET (US) Occupational Information Network [[1]], ESCO – European Skills, Competences, Qualifications and Occupations[[2]], IfATE (UK) Institute for Apprenticeships and Technical Education[[3]] .

The five root functions comprise around 40 domains which are broken down to around 140 functional areas. The architecture is used to position ~ 25,000 capability statements which are the building blocks used in the workforce foresight process. Each capability statement has several attributes - some are static and reflect the position of the capability statement in the architecture, whilst others are dynamic and are assigned values through a cycle and set of workshops.

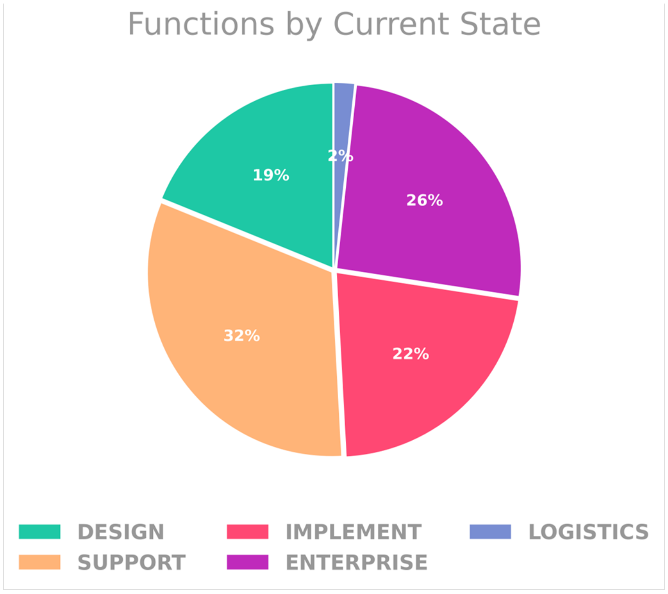
The data architecture is implemented in a bespoke 'data-cube' which underpins the foresight process, workshops, and enables extensive use of LLM and AI tools. Additionally, a key feature of the data-cube is that the data from each foresight topic cycle is added into the data set and can then be used, where relevant, in future cycles. This ensures that the capabilities of the system are dynamic and up to date.

[1] ONET - Occupational Information Network - https://www.onetcenter.org/
[2] ESCO - European Skills, Competences, Qualifications and Occupations - https://esco.ec.europa.eu/en
[3] IfATE – Institute for Apprenticeships and Technical Education - https://www.instituteforapprenticeships.org/

Identifying the Future Supply Chain Capabilities

The following charts and graphs summarise the changes in the set of capabilities that will be required by the supply chain in the future. The pie-charts reflect the distribution of capabilities across the five functions of the capability classification. The future state data is captured in three technology focused workshops. The current state data is derived from information collected on apprenticeship standards used across current supply chain partners. sector. This latter information is not as detailed as that produced by the workshops but is indicative and used to provide a point of comparison.

These initial pie charts summarise the changes that will be required by the whole supply chain, across the five functions. Overall, there is a relative increase in Design and Logistics and correspondingly relative decrease across Support, Enterprise and Implement, for the timescale considered.



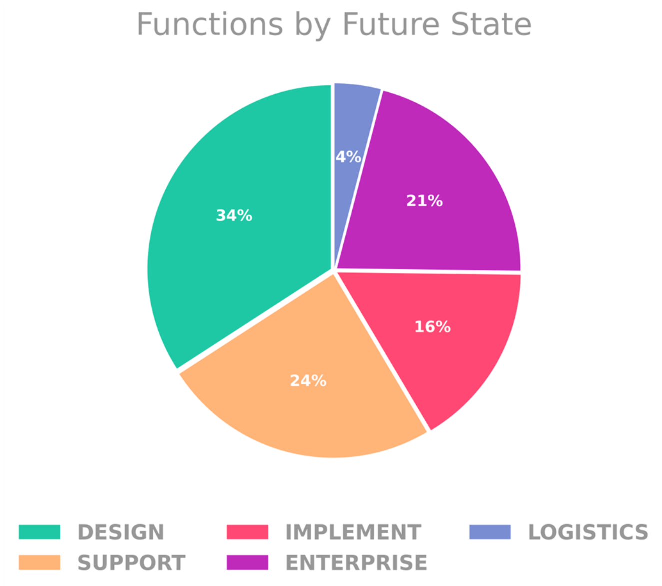


Figure 3: Current and Future – Whole Supply Chain - Capability Function Distribution %

Whilst the data on current and future supply chain capabilities is useful to indicate relative changes, factors such as volume of activity will also determine which functions may have greater future significance. In addition, *Design* becomes the largest portion, potentially due to the lower TRLs involved, as much work remains to be done in term of designing robust sensing systems that operate in industrial environments.

The graphs below show the distribution of capabilities assigned at domain level within the five main functions for this cycle. These graphs provide insight into the relative importance of each domain for the transport sector in the future.

Design Domains

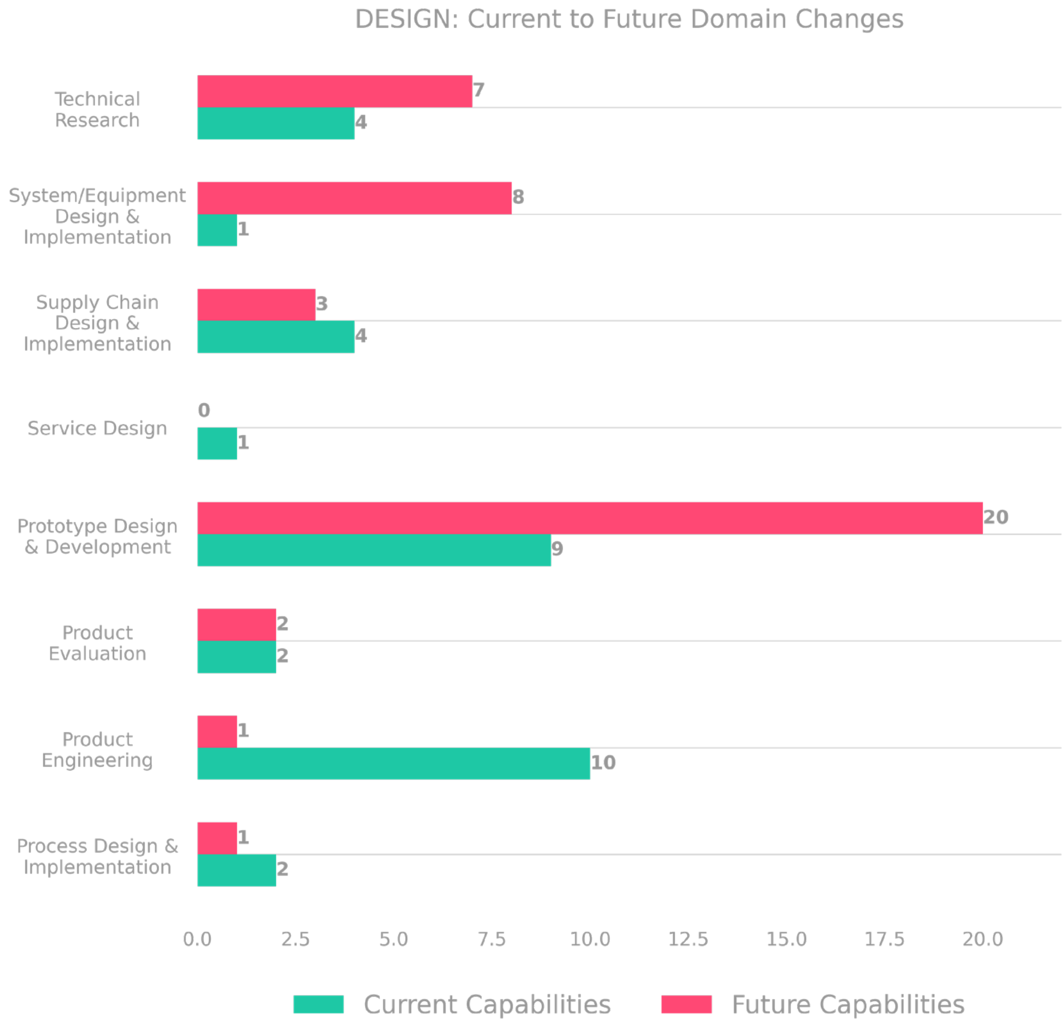


Figure 4: Design Future Domain Spread of Capabilities

The **Design** function has the highest number of organisational capabilities, with 42 out of a total of 123 capabilities for this cycle. At the domain level, the Prototype Design & Development domain has the most capabilities with more than doubling of requirements compared to current state. This reflects the early-stage nature of quantum sensing technologies, as there are still design challenges, such as with regard to miniaturisation, power consumption and ruggedisation. This led to the cycle's focus on defining the capabilities that will be required by the workforce to develop prototypes of quantum sensing systems, up to the stage of deployment and pilot testing of commercially viable systems in modes of transport.

The domain of Product Engineering indicates that less capabilities will be required in the future. However, this cycle focused on pre-production and premanufacturing stages and did not cover product engineering capabilities required for manufacturing products at scale, ongoing operation and maintenance, and end-of-life stages. Compared to current state for capabilities for mature technologies, this can, in part explain the higher current capability requirements in Product Engineering. Looking beyond the timescale considered, it would be reasonable to expect the Product Engineering domain to become more significant as the technologies mature.

Support Domains

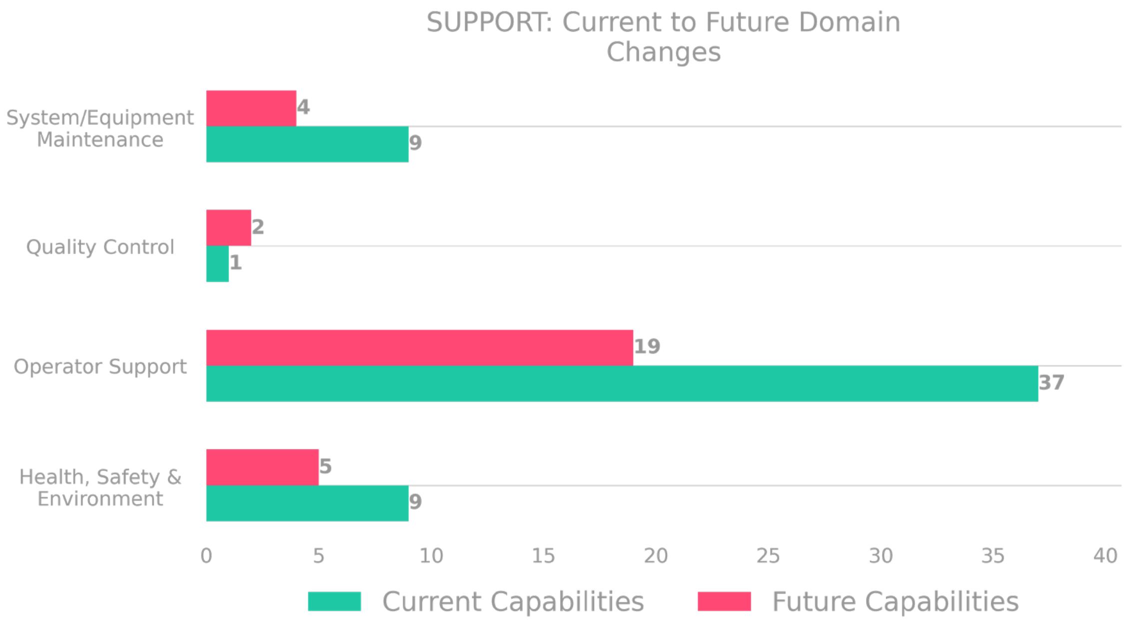


Figure 5: Support Future Domains - Future Spread of Capabilities

The **Support** function has the second highest capabilities assigned, with 30 out of the 123 total.

The highest number of capabilities under support, are within the operator support domain. Investigating further with the visualisation tool reveals that the capabilities for operator support are around designing and configuring support systems. This aligns very closely with the cycle focus. Compared to current state, the capabilities are reduced in number. This may be the case that quantum sensor sensing systems will require reduced operator support, however the cycle technologists only considered capabilities that will be required up to the point of supporting pilot testing of systems, not for ongoing operator support for commercial systems at scale.

Enterprise Domains:

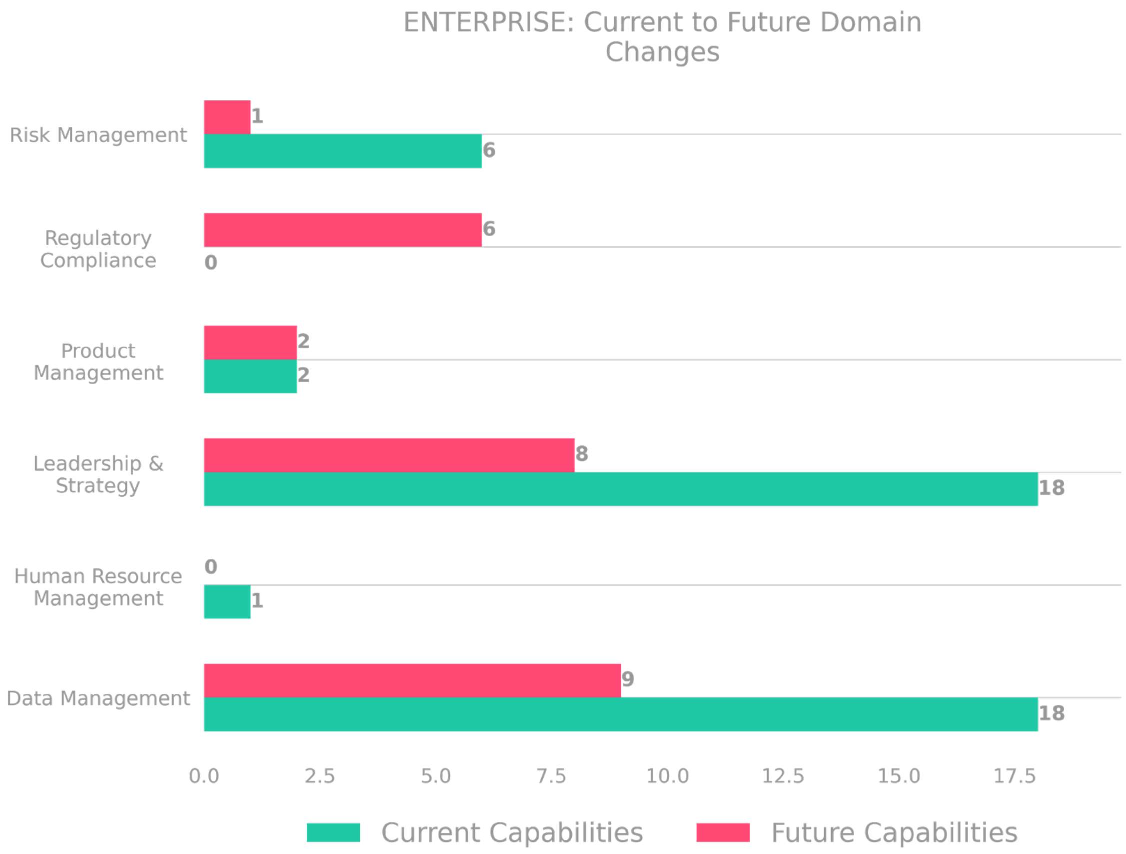


Figure 6: Enterprise Future Domain Spread of Capabilities

The **Enterprise** function ranks third with 26 out of 123 capabilities. The low future state capabilities requirement reflects this cycle's focus on designing, developing, and implementing a quantum sensing systems at the pilot testing stage.

The technologists did not define the capabilities that will be needed for organisations in the supply chain for large-scale manufacturing and operation, which include strategic planning, leadership, human resources and digital systems to support these backbone enterprise domains. This contrasts with the current state, where workforce capabilities reflect mature supply chains.

Regulatory compliance capabilities for the future state are required in this new technology area in order to address the new, and enhanced, functionalities afforded by the range of technologies

Implementation Domains

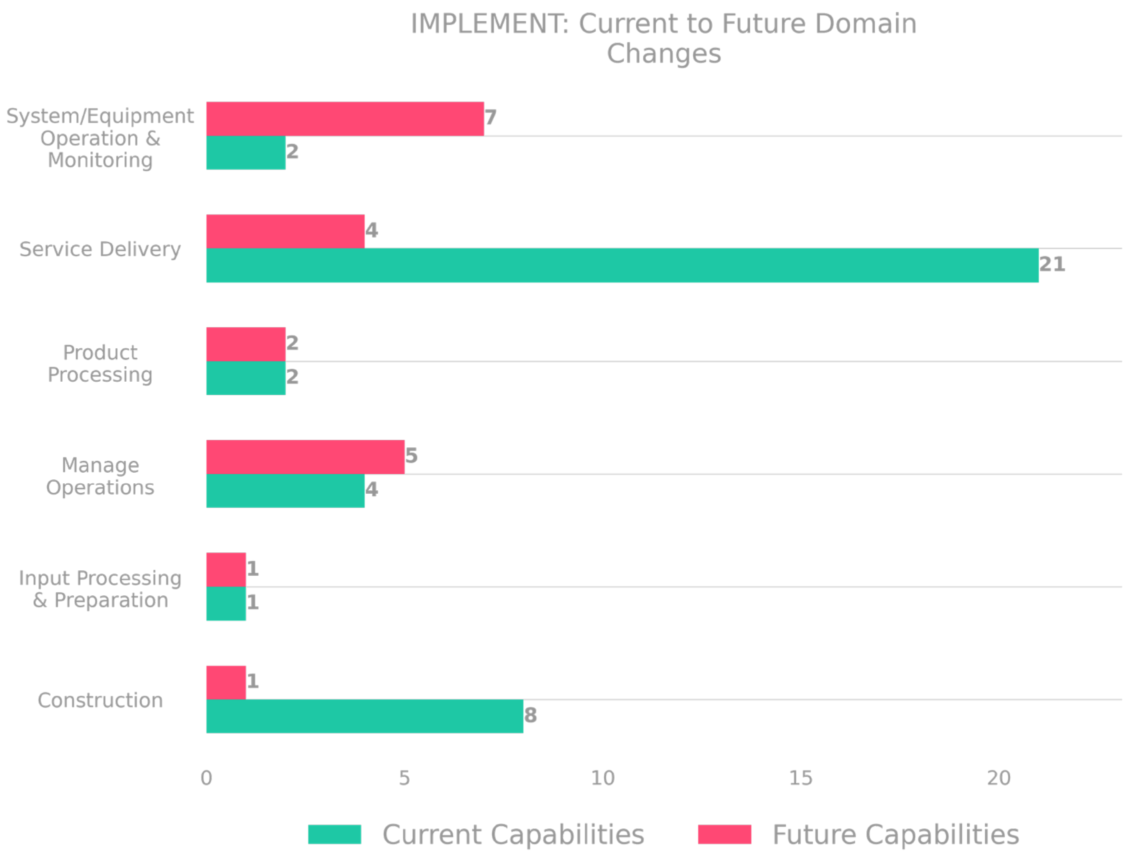


Figure 7: Implementation Future Domains Spread of Capabilities

Of the 123 capabilities for the cycle, 20 sit in the **Implement** function with most identified in the System/Equipment Operation and Monitoring domain, followed by Manage operations and Service delivery. The capabilities involve gathering, analysing and monitoring quantum sensing systems data and the collaboration required to implement the technology and allow effective and efficient operation of the systems.

Again, against current state for mature technologies, capabilities are reduced, partly due to cycle focus and relative immaturity of the technology at this stage.

Logistics Domains

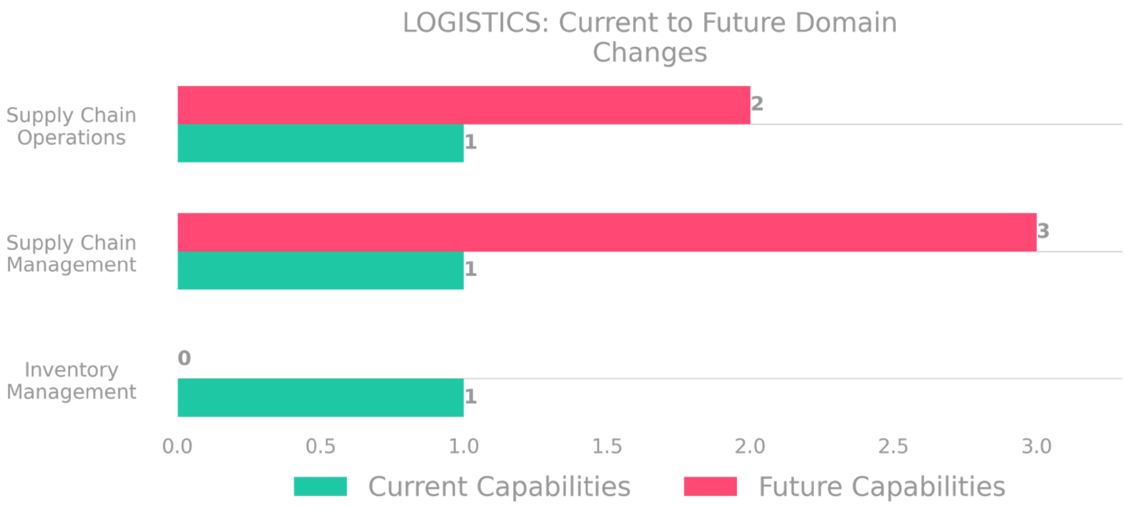


Figure 8: Logistics Future Domains- Future Spread of Capabilities

Of the 123 organisational capabilities, 5 sit in the **Logistics** function.

They include capabilities that are unique to the adoption of quantum sensing technologies, such as sourcing quantum raw materials for development of quantum sensing components and transportation of quantum sensor systems.

Visualisation Instructions

Visualisation Data Link	What is it and what can it be used for?
Organisational Capabilities	*The page provides details of the capabilities required by each supply chain partner and the supply chain as whole. The information is presented using the Capability Classification Framework, Design / Implement / Logistics / Support / Enterprise and can be interrogated and then exported to suit specific user requirements and interest.* *The information provided also identifies capabilities supported by existing provision, and also where there may be gaps that require new development to support to equip the future workforce.*

3.3 Insights into Step Two – How will the Workforce change? Occupational Change

Insight into occupational change uses the understanding of how capabilities will change across business functions (section 3.2) to inform proposals for how occupations and their associated skills sets for each supply chain partner may need be revised to reflect change for each role level within that partner.

Supply Chain partner organisation types

The workforce foresighting process recognises that different partners in a Supply Chain will require appropriate capabilities, and these are determined and agreed in the initial workshops.

In this cycle, the following Supply Chain partners were identified and then used during participant workshops and data analysis to determine the organisational needs:

1. Component and Software Suppliers
2. System Integrators
3. Transport Industry (Client & End User)
4. Universities and RTOs (including Quantum Hubs)

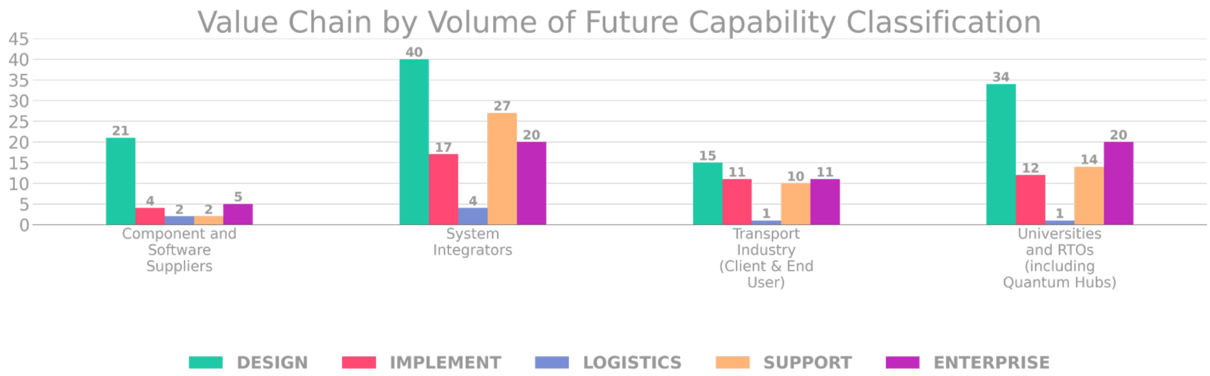


Figure 9: Distribution of Functions across each Supply Chain Partner

The graph illustrates the distribution of organisational capabilities by function across the Supply Chain Partners. These capability sets are used to form the set of Future Occupational Profiles within each role level. The highest number of capabilities align with System Integrators with 108 capabilities, 40 of which sit in the Design function. The second highest number of capabilities align with Universities and RTOs (including Quantum Hubs) with 80 and, again a high number of 34 capabilities sit in the design function.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Supply Chain Capabilities	This page provides an overview of the identified capabilities at a Supply Chain Partner level. By selecting/deselecting each Supply Chain Partner you can review the capabilities identified as required in that area of the Supply Chain. This can be used to generate organisational capability profiles for each area of the 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.

Role Levels

The foresighting process uses the concept of Role Levels to represent future occupations. Utilising this approach acknowledges that the workforce is not homogeneous - there will be varying levels of proficiency required across a workforce and qualifications and training may be aligned/require different types of vocational or academic qualifications. Additionally, the role level approach seeks to avoid presuming that the future workforce will be operating at a different level to the current state.

Role Levels determined through workshops:

1. Research Fellow
2. Technician
3. Engineer

Proficiencies

Each of these role levels will require proficiency that reflects their role and the needs of each Supply Chain Partner. The foresight process uses a three-point scale to capture and differentiate the proficiencies required. This information is used both in the generation of the Future Occupational Profiles, and to assist the definition of training needs identified. Within the workforce foresight process proficiency is defined as:

Awareness (A) - Has a foundational knowledge of tools, technology, techniques relevant to sector, industry, or organisation. Sufficient comprehension to know where to seek further information/details as necessary for a particular issue.

Practitioner (P) - Has the ability to apply and use independently a tool, system, or process. Understands the implications, consequences, and impact for their role/function. A Practitioner knows what key actions are required and in what context.

Expert (E) - Has detailed knowledge of process, system, tool, or technology. Can support others and identify improvements required for a process, system, or tool. An Expert can implement improvements personally or direct and guide others.

During the workshops participants applied their insight to assign proficiency for each role group to each capability. Individual responses were aggregated by the system to arrive at a consensus.

A summary of the distribution of required proficiency for the role levels in this cycle are:

	Engineer	Research Fellow	Technician
Awareness	1	0	2
Practitioner	59	5	20
Expert	121	17	4

It is notable that Practitioner and Expect levels dominate – high proficiency levels are required across the supply chain.

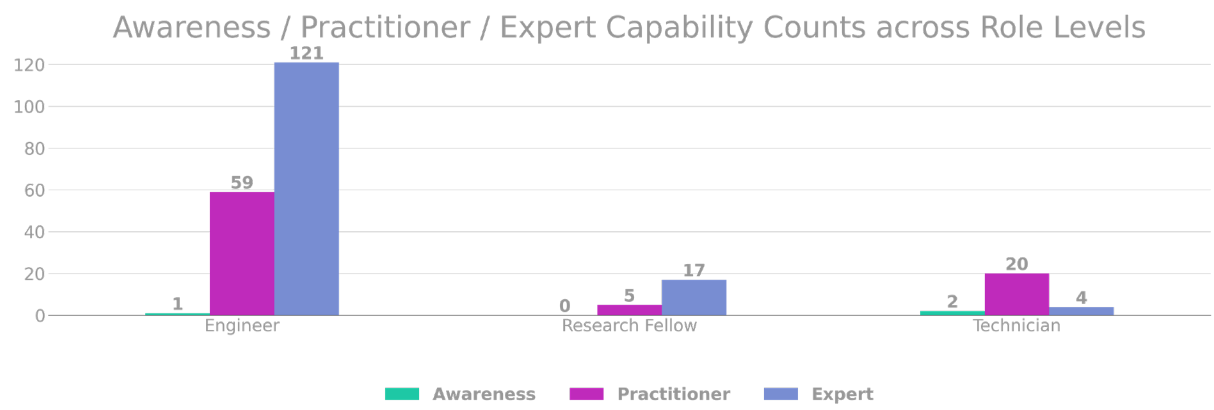


Figure 10: Proficiency details by Role Level

Future Occupational Profiles

FOPs are used to describe and suggest occupations, or roles, that may be required in the future and provide a framework to indicate capabilities and related duties. They can be used to review the impact on current roles and the adaptation that may be required in the future.

Educators can review current apprenticeship standards against the requirements of the FOPs and interpret which need to be changed to fill the gaps between the current and future state.

Employers can consider existing apprenticeship standards and make a judgement on adapting an existing apprenticeship standard to upskill their workforce to meet the requirements of a particular FOP.

FOPs and indicative skills need

Combining proficiency with the identified FOPs, the following graphs indicate the priority needs across the supply chain for each Role Group to deliver future capabilities.

Research Fellow Role Level FOPs:

For the purposes of this cycle, the role level of Research Fellow could only be defined within the parameters of current IfATE qualifications or apprenticeships and their academic levels. The highest academic level IfATE standards reach is level 7. All of which fall below the academic level required for a Research Fellow which is level 8 PhD.

For the purpose of the map and gap analysis a lower minimum academic level of 5 was set for the FOP within this Role Level to capture qualifications or apprenticeships to inform CPD development.

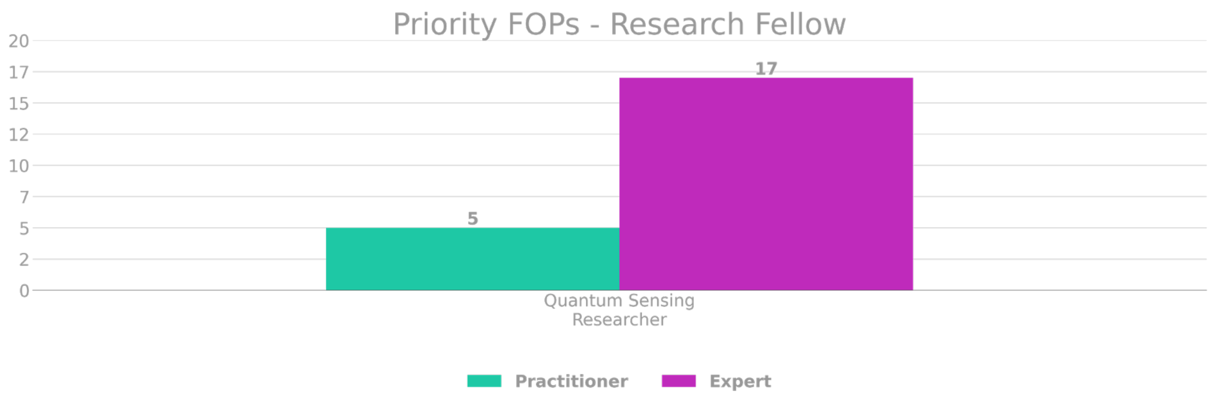


Figure 11: Priority FOPs - Research Fellow Role Level

Engineer Role Level FOPs:

In this cycle the Engineer role level was defined as occupations and roles requiring a minimum of level 4 up to level 7 qualifications or apprenticeships. It is foresighted that they will typically need to achieve levels 5 and 6 (foundation degree and degree standards or apprenticeship equivalent) to allow them to carry out capabilities as duties in this Engineer role level.

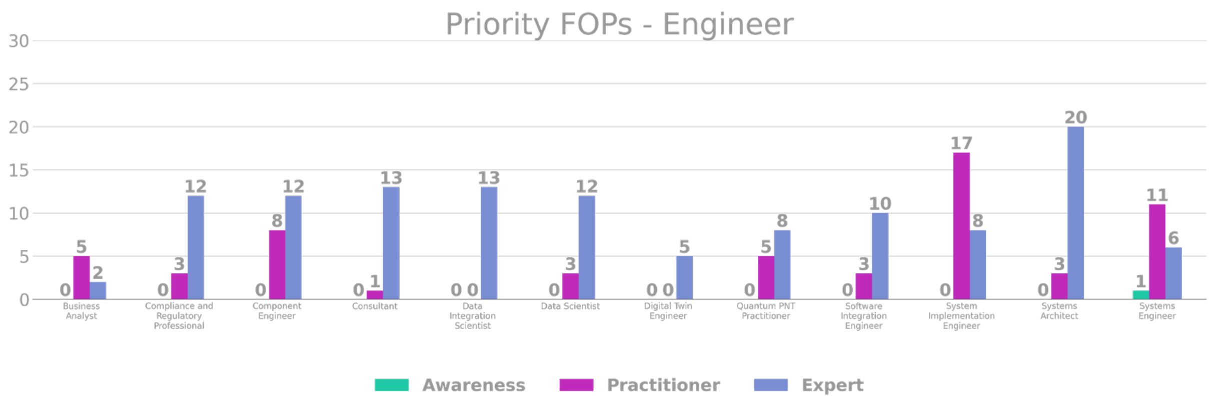


Figure 12: Priority FOPs - Engineer Role Level

Technician Role Level FOPs:

It is anticipated that technicians, particularly at the initial stages of quantum sensing systems development and adoption, will require level 5 qualifications or apprenticeships. For the purpose of the map and gap analysis a lower minimum academic level of 3 was set to ensure we looked at a fuller breadth of current qualifications or apprenticeships that could in part fulfil requirements for FOPs in this Role Level.

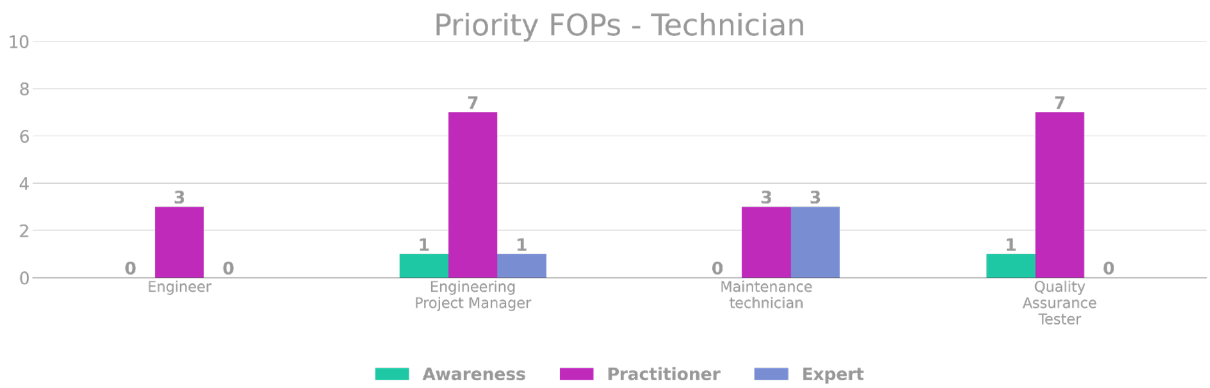


Figure 13: Priority FOPs - Technician Role Level

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
FOP Matrix	This page 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 level by selecting one (or more) of these from the drop down. This will then allow you to select the FOPs aligned to that role level. The populated table allows you review and compare different FOPs within or across role levels. You can view the capabilities in each FOP and the assigned proficiency levels.

3.4 Step Three – How the current Education provision meets the future need - Highlighted Changes for Future Provision

The Workforce Foresighting process has developed two metrics to quantify the alignment between a FOP and a current standard or qualification:

Fit – expressed as a %, it is a measure of the proportion of a FOP that is covered by an existing standard or qualification.

Surplus – expressed as a %, it is a measure of the not relevant material in an existing standard that is not required for a FOP.

An ideal existing qualification or standard would have a high fit and low surplus – this implies good coverage of the FOP but with little material that is not relevant to the FOP. Conversely a poor candidate would have a low fit and high surplus. Using these two metrics it is possible to quantitively evaluate, rank, and compare a range of existing provisions against a set of FOPs describing future needs.

Our interpretation is represented by a simple nine-box model to position the suitability of a given current occupational standard to a future occupational profile:

Factor scores

Fit Factor	Fit score	Surplus Factor	Surplus score
0 - 32%	1	81-100%	1
33-65%	2	51-80%	2
66-100%	3	0 - 50%	3

(Multiplying the Fit score by the Surplus score gives a Suitability Grid score of 1-9 as below)

Suitability Grid

Reducing Surplus	4	7	9
	2	5	8
	1	3	6
	Improving Fit		

Figure 14: Fit Factor scores and Suitability Grid

Using this score and indicated 'RAG status' the following interpretations can be made:

High Suitability – 7,8,9 – for standards that have good coverage of FOPs.
Represents good candidates from current apprenticeship standards used as the basis of development to meet FOP requirements and inform elements of short course and CPD provision.

Some Suitability– 4,5,6 – for standards that have only partial coverage of FOPs.
These are likely to require extended work to meet FOP requirements, further review of the data may be necessary. They are likely to contain some useful information to inform elements of short course and CPD provision.

Low Suitability – 1,2,3 – for standards that have poor coverage of FOPs.
These are unlikely to be adaptable to meet future needs but may contain some useful information to inform elements of short course and CPD provision, which can be assessed using the data visualisation tools.

FOP findings compared with current standards

Using the approach described above and applying the 'RAG' scores to each FOP indicating the suitability of current apprenticeship standards selected from the IfATE set, the following table begins to identify areas of action and concern for the provision of future skills for each Supply Chain Partner to respond to the challenge.

This high-level suitability summary compares the best 10 matching current IfATE qualifications or apprenticeship standards and gives the current suitability summary in the table below. Only 1 FOP has a **good** suitability match based on fit and surplus score to 1 current apprenticeship standard. Please see the 'Detailed Breakdown' below each Supply Chain Partner table to identify if any of the best 10 offer **some** suitability and go into the visualisation tool to see the detail in those IfATE standards.

Supply Chain Partner - Universities and RTOs (including Quantum Hubs)

Role Level	Selected Future Occupational Profiles	Current Suitability Summary
Engineer	Business Analyst	Low
Engineer	Compliance and Regulatory Professional	Low
Engineer	Component Engineer	Low
Engineer	Consultant	Low
Engineer	Data Scientist	Low
Engineer	Digital Twin Engineer	Low
Engineer	Software Integration Engineer	Low
Engineer	Systems Architect	Low
Engineer	Systems Engineer	Low
Research Fellow	Quantum Sensing Researcher	Low
Technician	Engineering Project Manager	Low
Technician	Maintenance technician	Low

Detailed breakdown:

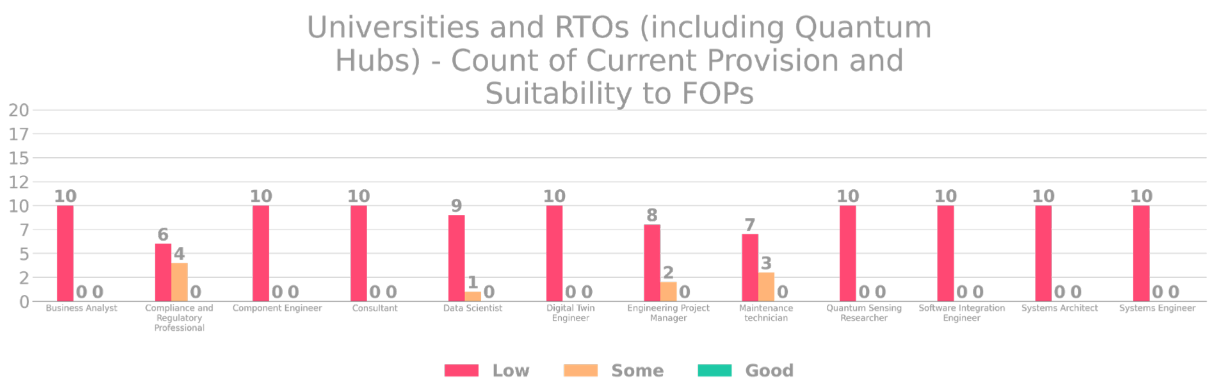


Figure 15: Suitability Summary - Universities and RTOs (including Quantum Hubs)

Supply Chain Partner - Transport Industry (Client & End User)

Role Level	Selected Future Occupational Profiles	Current Suitability Summary
Engineer	Business Analyst	Low
Engineer	Compliance and Regulatory Professional	Low
Engineer	Data Integration Scientist	Low
Engineer	Data Scientist	Low
Engineer	Digital Twin Engineer	Low
Engineer	Quantum PNT Practitioner	Good
Engineer	Software Integration Engineer	Low
Engineer	Systems Engineer	Low
Technician	Engineer	Low
Technician	Engineering Project Manager	Low
Technician	Maintenance technician	Low

Detailed breakdown:

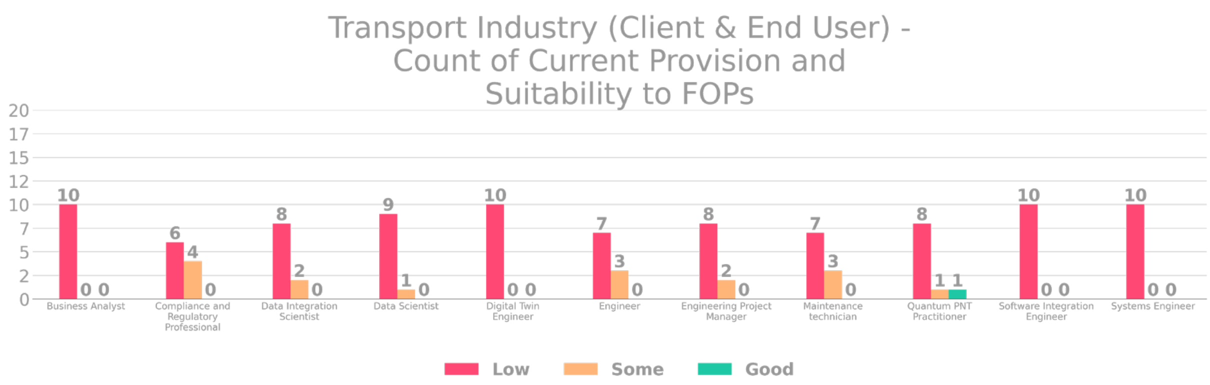


Figure 16: Suitability Summary - Transport Industry (Client & End User)

Supply Chain Partner - System Integrators

Role Level	Selected Future Occupational Profiles	Current Suitability Summary
Engineer	Business Analyst	Low
Engineer	Compliance and Regulatory Professional	Low
Engineer	Component Engineer	Low
Engineer	Data Integration Scientist	Low
Engineer	Data Scientist	Low
Engineer	Digital Twin Engineer	Low
Engineer	Quantum PNT Practitioner	Good
Engineer	Software Integration Engineer	Low
Engineer	System Implementation Engineer	Low
Engineer	Systems Architect	Low
Engineer	Systems Engineer	Low
Research Fellow	Quantum Sensing Researcher	Low
Technician	Engineering Project Manager	Low
Technician	Maintenance technician	Low
Technician	Quality Assurance Tester	Low

Detailed breakdown:

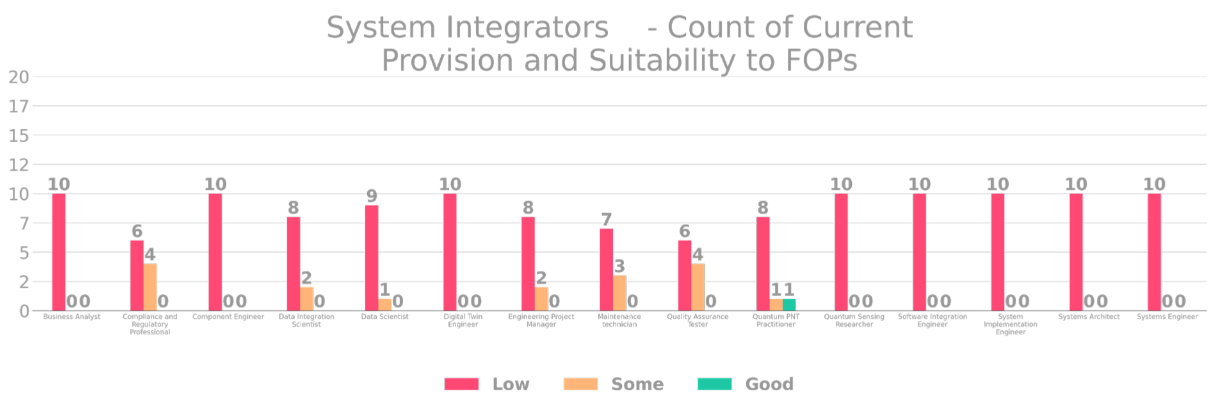


Figure 17: Suitability Summary - System Integrators

Supply Chain Partner - Component and Software Suppliers

Role Level	Selected Future Occupational Profiles	Current Suitability Summary
Engineer	Compliance and Regulatory Professional	Low
Engineer	Component Engineer	Low
Engineer	Software Integration Engineer	Low
Engineer	Systems Engineer	Low
Technician	Engineering Project Manager	Low
Technician	Quality Assurance Tester	Low

Detailed breakdown:

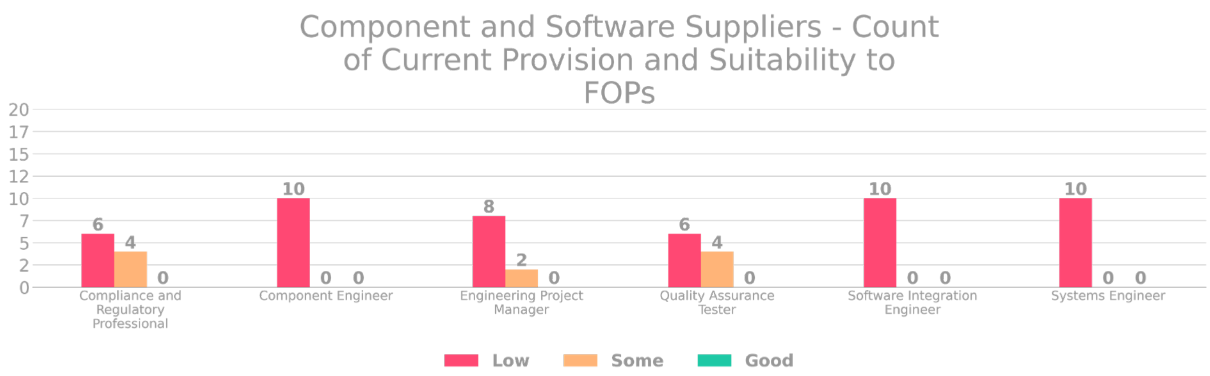


Figure 18: Suitability Summary - Component and Software Suppliers

[Link to full data set - Visualisation Instructions]

Visualisation Data Link	What is it and what can it be used for?
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 Level 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.
Future KSBs Summary	This page 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 level/occupational profile grouping.
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 (IfATE) provision. • By capabilities that **are not** served by the reference mapping framework, e.g., IfATE 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 Apprenticeship 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.
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 (IfATE). 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.
Fit & Surplus Matrix	This page is a visual representation of the ‘Fit and Surplus Factor’ insight. You can visually review ‘Fit’ and ‘Surplus’ of Prototype Future Occupation Profiles (FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). This can help you identify which provision may align 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.
FOP Capability Matches	This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (IfATE) 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 Prototype Future Occupational Profiles (FOPs) or review all FOPs under a Role Level, to give a more holistic view of Capabilities and Matches Where a future capability has been matched to existing provision (currently, by default, IfATE apprenticeship 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 Levels and FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level

4.0 Conclusion and Next Steps

Section	Title
4.1	Summary of key insights
4.2	What this means for Industry and the Workforce
4.3	What this means for Education
4.4	Recommended next steps

4.1 Summary of Key Insights

Work conducted as part of this workforce foresighting cycle has revealed that the future development and adoption of quantum sensing technologies for transport will require core quantum skills (e.g. quantum mechanics) and a multitude of adjacent and supporting capabilities (e.g. photonic design and system implementation), together with more general technical (e.g. maintenance) and business skills (e.g. analytics).

Across the supply chain partners, system integrators in particular have a large number of capabilities, which is to be expected as there is the pressing need for more field trials of quantum sensing systems, including benchmarking and reduction of environmental noise. By virtue of the nascent nature of the technologies considered, and timescale addressed, there are a large number of capabilities within design and prototyping.

The predominant role level – engineering - is in line with current maturity of quantum sensors, across the various technologies. PhD-level skills are central to the research and development of the core technologies, as captured by the Research Fellow level, whilst an array of engineering roles are required to refine, iterate and implement the sensors, including a multitude of hardware and software skills. The Future Occupational Profiles generated thus cluster around engineering to a large degree, including systems engineers, software integration engineers and component engineer, to name a few. Technician roles are also important, with examples including quality assurance tester and maintenance technician.

The overall poor matching of current educational provisions for future needs is a reflection of the emerging nature of quantum technologies, resulting in lag in terms of specific courses and training, which have yet to be tailored. However, the overall fit (88%) does indicate that the skills required can be often addressed with current educational resources, albeit in different configurations and complemented by tailored programmes to address gaps.

The below table **counts** the top 10 best fit IfATE standards by suitability score for each FOP. For this report, we’ve utilised the suitability grid to highlight the top IfATE standards that support each FOP. The table identifies if they have low, some or high suitability and colour-coded their overall suitability.

Role Level	Primary Supply Chain / Supply Chain Partner	Future Occupation Profile	Low Suitability	Some Suitability	High Suitability	Overall Suitability RAG
Engineer	Component and Software Suppliers, System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Compliance and Regulatory Professional	6/10	4/10	0/10	Low
Engineer	Component and Software Suppliers, System Integrators, Transport Industry (Client End User),	Software Integration Engineer	10/10	0/10	0/10	Low

	Universities and RTOs (including Quantum Hubs)					
Engineer	Component and Software Suppliers, System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Systems Engineer	10/10	0/10	0/10	Low
Engineer	Component and Software Suppliers, System Integrators, Universities and RTOs (including Quantum Hubs)	Component Engineer	10/10	0/10	0/10	Low
Engineer	System Integrators	System Implementation Engineer	10/10	0/10	0/10	Low
Engineer	System Integrators, Transport Industry (Client End User)	Data Integration Scientist	8/10	2/10	0/10	Low
Engineer	System Integrators, Transport Industry (Client End User)	Quantum PNT Practitioner	8/10	1/10	1/10	Good
Engineer	System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Business Analyst	10/10	0/10	0/10	Low
Engineer	System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Data Scientist	9/10	1/10	0/10	Low
Engineer	System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Digital Twin Engineer	10/10	0/10	0/10	Low
Engineer	System Integrators, Universities and RTOs (including Quantum Hubs)	Systems Architect	10/10	0/10	0/10	Low
Engineer	Universities and RTOs (including Quantum Hubs)	Consultant	10/10	0/10	0/10	Low
Research Fellow	System Integrators, Universities and RTOs (including Quantum Hubs)	Quantum Sensing Researcher	10/10	0/10	0/10	Low
Technician	Component and Software Suppliers, System Integrators	Quality Assurance Tester	6/10	4/10	0/10	Low
Technician	Component and Software Suppliers, System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Engineering Project Manager	8/10	2/10	0/10	Low

Technician	System Integrators, Transport Industry (Client End User), Universities and RTOs (including Quantum Hubs)	Maintenance technician	7/10	3/10	0/10	Low
Technician	Transport Industry (Client End User)	Engineer	7/10	3/10	0/10	Low

Top Fits

By reviewing the FOPs against the suitability grid, we can determine which of the groups of current apprenticeship standards are more applicable than others.

The Top Fit FOP identified is:

1. Quantum PNT Practitioner

Suitable standards are listed in the table below:

Role Level	Future Occupation Profile	IfATE Apprenticeship Standard	Suitability
Engineer	Quantum PNT Practitioner	Geospatial mapping and science specialist (degree)	Good

The use of the data visualisation tool is recommended to access the next layer of detail and review the specific standards that have been identified as having Good Suitability, Some Suitability or Low Suitability.

As a comparison we can also list the standards that score lowest against the required FOPs, suggesting that there are very little suitable in the IfATE standards to support these Future Role Profiles.

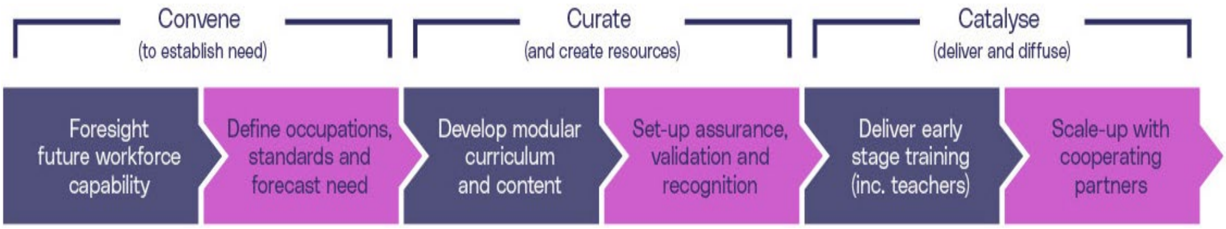
FOPs with the lowest scores are:

1. Compliance and Regulatory Professional
2. Software Integration Engineer
3. Systems Engineer
4. Component Engineer
5. System Implementation Engineer
6. Data Integration Scientist
7. Business Analyst
8. Data Scientist
9. Digital Twin Engineer
10. Systems Architect
11. Consultant
12. Quantum Sensing Researcher
13. Quality Assurance Tester
14. Engineering Project Manager
15. Maintenance technician
16. Engineer

4.2 What this means for Industry and the Workforce

Collective Action

Foresighting has been developed to provide insight and the detailed information required to enable action by relevant stakeholders but is the first step of the Skills Value Chain. Collective action will be required by all stakeholders to ensure that the changes identified by foresighting – to the supply chain, the workforce and education provision are implemented.



Representing both clients and end users of quantum sensing technologies in this cycle, the transport sector plays a critical role. Specifically, ongoing dialogue between the transport sector and both Universities / RTOs and systems integrators is essential for ensuring technology requirements are outlined and addressed, thus impacting the future workforce.

In general, there is a need for greater use-case exploration and subsequent development for transport applications, including hybrid classical-quantum systems, their integration and analysis of economic benefits compared to classical technologies. Moreover, it is important for employers to ensure there is a sufficiently skilled workforce, and hence actively engaging with the findings of the cycle, including the ongoing revision, will be crucial; in particular, working with universities and skills programme providers.

4.3 What this means for Education

Evidently, core quantum skills, covered by physics undergraduate degrees and quantum-focused masters and PhD programmes, are critical to the development of quantum sensing technologies. In addition, industry-focused, tailored courses, addressing the gaps highlighted by this cycle, would greatly benefit the supply chain, particularly within the System Integrator role.

In general, raising quantum literacy will benefit the supply chain as a whole. Ultimately, core quantum skills will not be required by end users of quantum sensors as they mature, where an understanding of the underlying physics will not be required for their operation.

In the area of quantum computing, there are several examples of programmes (both in term of skills and technology access), including by the National Physical Laboratory, National Quantum Computing Centre and Digital Catapult. Moreover, the Quantum Hubs will help to develop commercial skills for the quantum industry. Since the publication of the National Quantum Strategy, the UK increased the number of Centres for Doctoral Training centres, funded PhDs and career development fellowships. Nonetheless, the area of quantum sensing has not been addressed to the same extent as computing, where the breadth of technologies is perhaps a hurdle.

Looking ahead, a trailblazer group, collecting together employers, could be established to help develop apprenticeships for future occupations. Working it IfATE, the group would also monitor the impact of apprenticeships and revising when necessary. As quantum sensing technologies develop and mature, it is important to continuously assess the capabilities and occupations required.

Skills bootcamps are another potential route to addressing gaps, where individuals would be given the opportunity to develop skills over the course of numbers of weeks. An example of bootcamp programme has been run in the integrated photonics space, upskilling in photonic chip development.

Whilst outside the scope of the cycle, the wider technology context is also important: quantum technologies – sensing, computing and communication – often share a range of underpinning components, to a degree. For example, in terms of photonics, thus includes single photon sources, detectors, modulators and lasers. As a result, there will be overlap with capabilities for adjacent technologies, which provides opportunities for coordination to the benefit of the wider quantum sector.

4.4 Recommended next steps

A working group to "Cause Action" has been set-up post completion of this cycle. The agenda of the meetings will be to ensure adoption of the learnings from the report and to discuss dissemination of the report. Specific potential actions include:

1. Validate, refine and update FOPs developed during the cycle
2. Upskilling and general increase of quantum sensing literacy, particularly for end users
3. Engagement and coordination with adjacent technology areas: the workforce will overlap with other technology areas, including the broader quantum space and enabling technologies, such as photonics (potential to look at transferable skills programmes)
4. Dissemination and ongoing review – the key finding of the report should be disseminated with stakeholders, including the quantum sector, with ongoing review and discussions on the next steps. This includes the Year of Quantum event at Digital Catapult

Although this cycle has been specifically focused, its findings will have wider applications beyond the transport sector. Future foresighting cycles should explore quantum technologies in various other fields. Future publications within the area will also be important to revising the recommendations. Thus, it is important to coordinate with the DSIT Quantum Skills Taskforce and UK Quantum Working Group on quantum skills in terms of the 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.

In summary, acting upon the recommendations will likely have the outcome of strengthening the UK workforce both in the development and adoption of quantum technologies, and thereby ensuring greater resilience for transport – critical to the functioning of many sectors and the UK economy.

5.0 Appendix

5.0 Appendices

Section	Title
5.1	Cycle timeline
5.2	Access to output data - link and authorisation
5.3	Glossary - common language
5.4	Visualisation links and illustrations

5.1 Cycle timeline

Workforce Foresighting cycle started the Carry Out phase in October 2024. The Carry Out phase concluded in January 2025. The Findings report was prepared following the data validation period and published in February 2025.

5.2 Access to output data - link and authorisation

Data Capture Overview

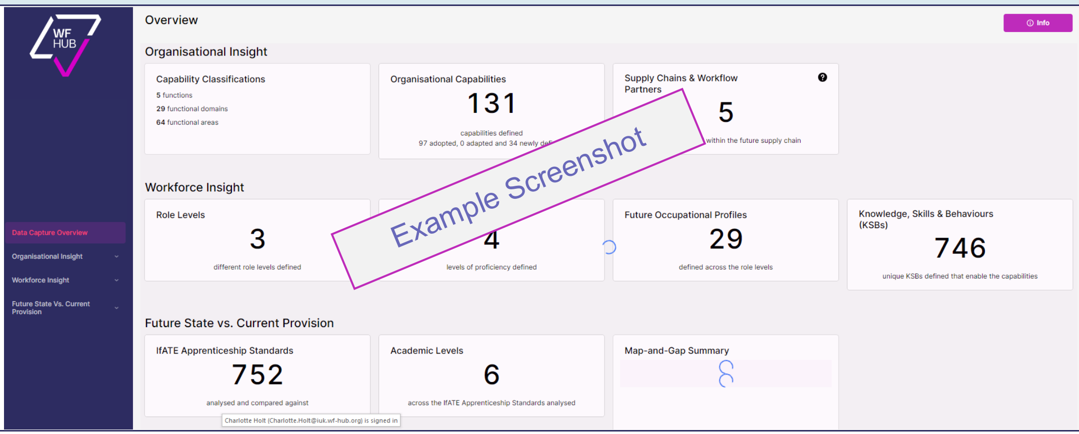
5.3 Glossary - common language

Term	Definition
Impact Domains	Innovate UK domains used as Strategic Categories to assist setting and monitoring priorities
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
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
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
Delphi Process	Foresighting takes a Delphi approach which has come to represent consulting expert opinion. (Harking back to the Delphic Oracle of ancient Greece)
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 KBS output from the Educator workshop for each Role Group

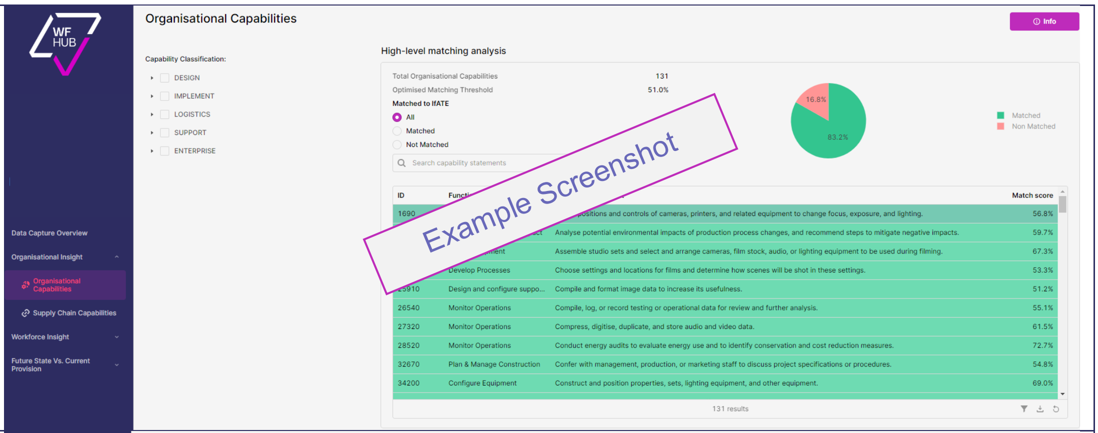
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
Organisation Type	Simple description of nature of organisation for which capability is required
Proficiencies	Proficiencies differentiate the degree of competencies required from differing Role levels to support capabilities
Project Sponsor	Typically, a stakeholder in the challenge being successfully met who requires information to under-write plans to act
Role Group	Role levels are a collective of roles that exist in a typical manufacturing business / industrial sector
Syntax	The way in which a statement is phrased to ensure reliable, repeatable and meaningful interpretation
Technologies	The technology 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
Roadmaps	Sector, Industry, Regional view of emerging opportunities and their market entry
Participants	Technologists, Educators, Employers

5.4 – Visualisation links and Illustrations

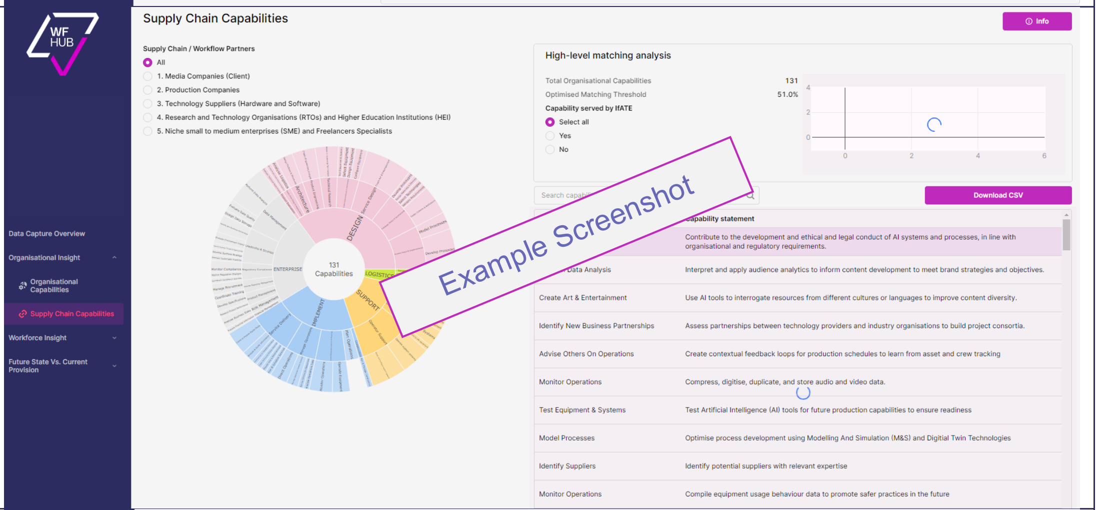
Images are not cycle specific and just for guidance purposes

Link to Visualisation	View of data
Data Capture Overview	

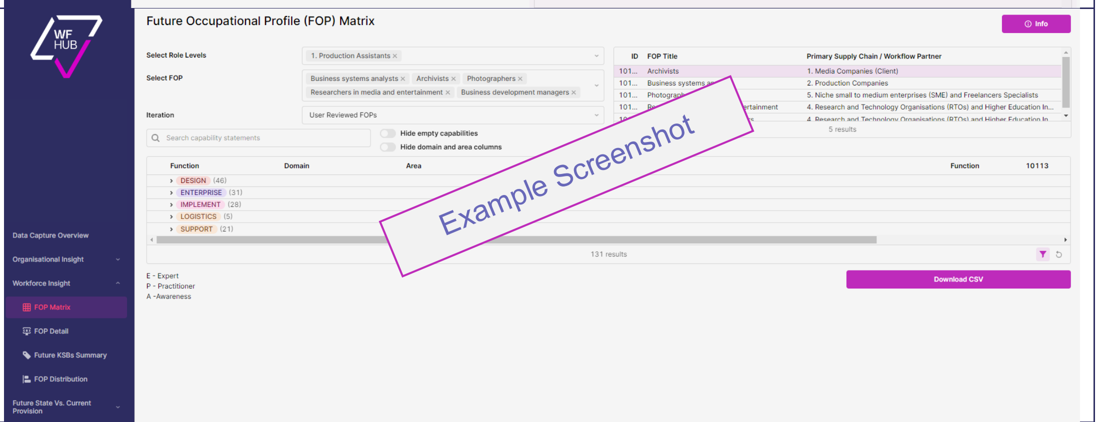
Organisational Capabilities

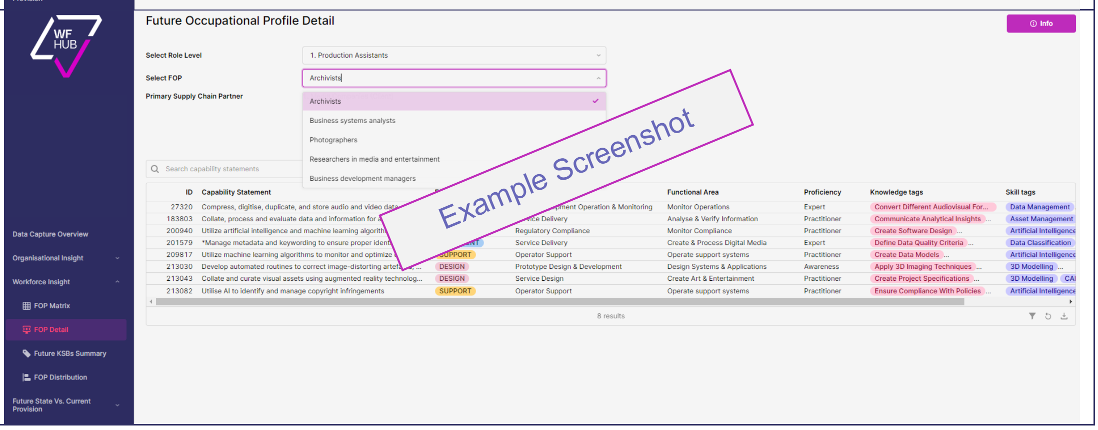


Supply Chain Capabilities

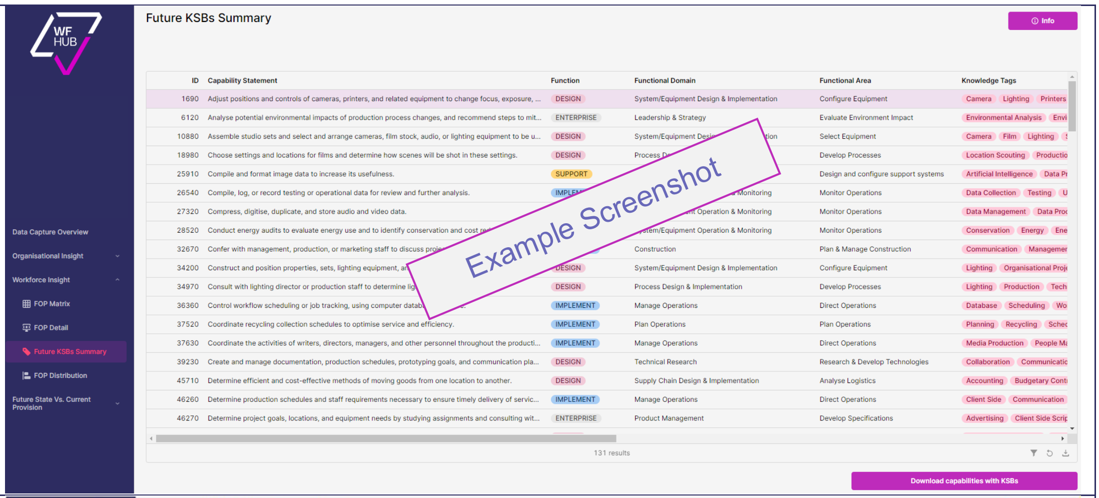


FOP Matrix

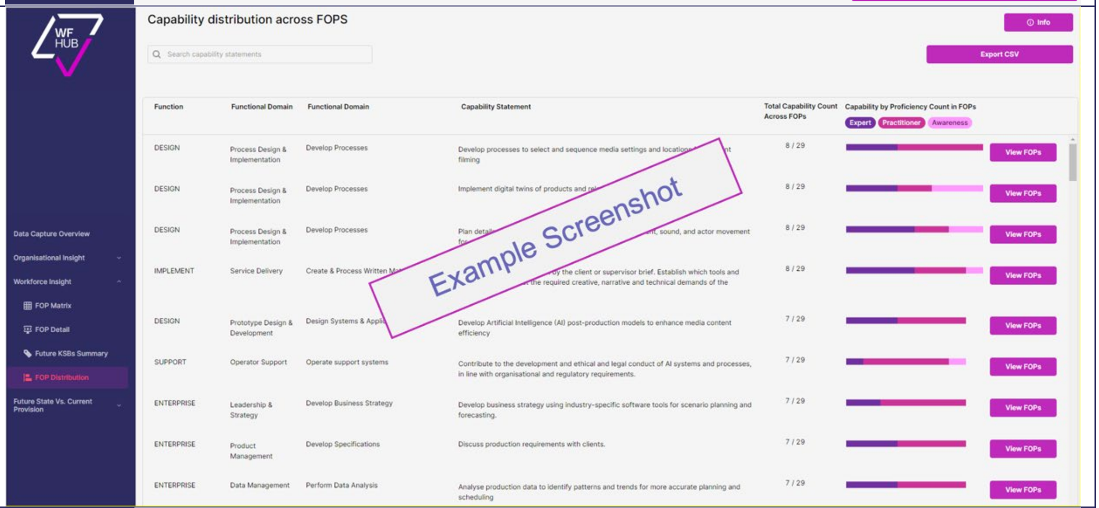




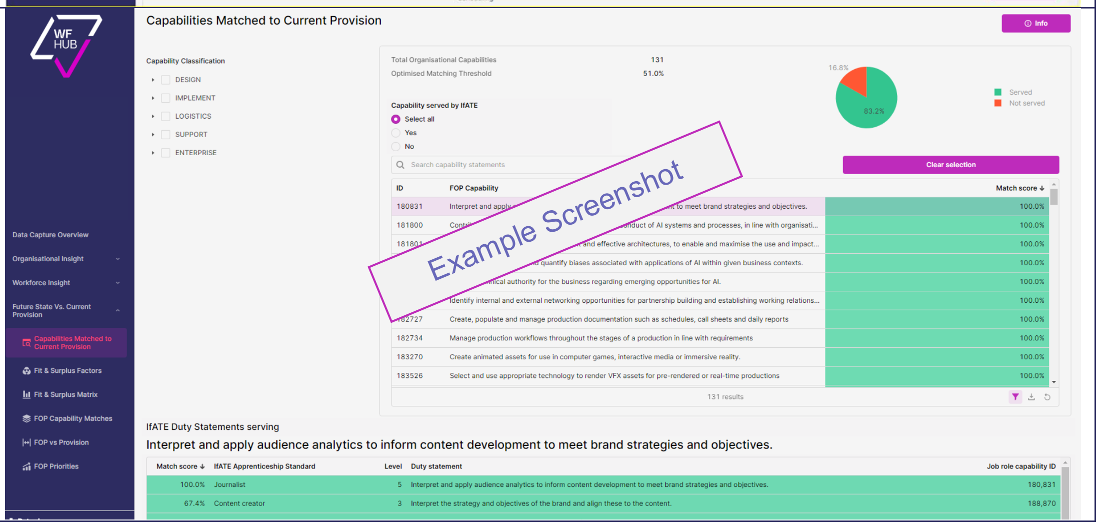
Future KSBs Summary



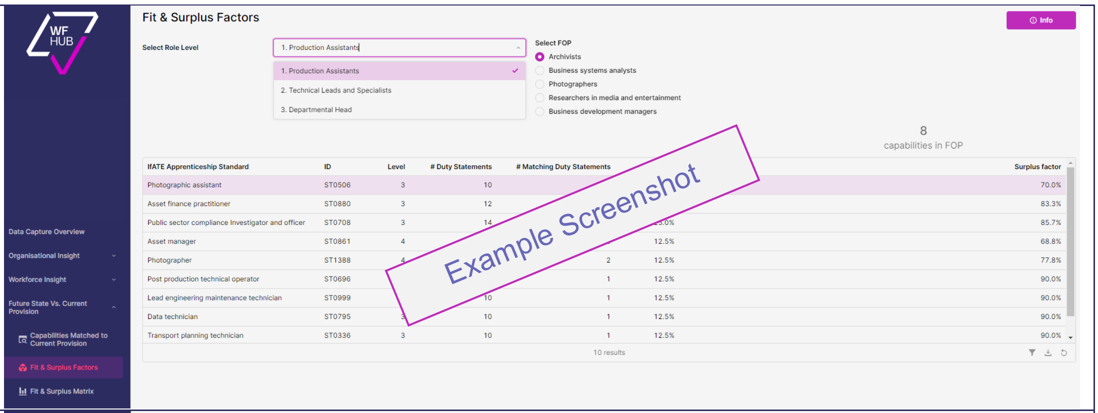
FOP Distribution



Capabilities Matched to Current Provision

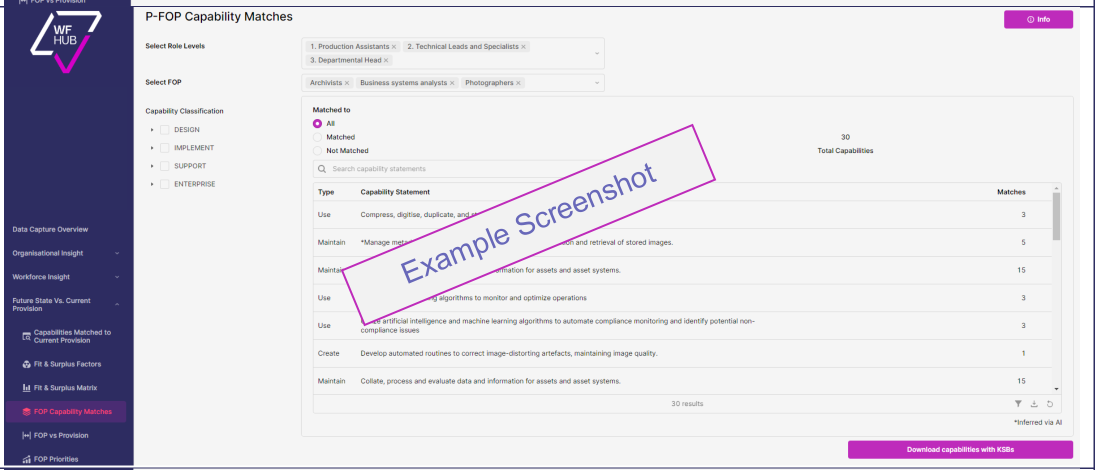


Fit_Surplus Factors

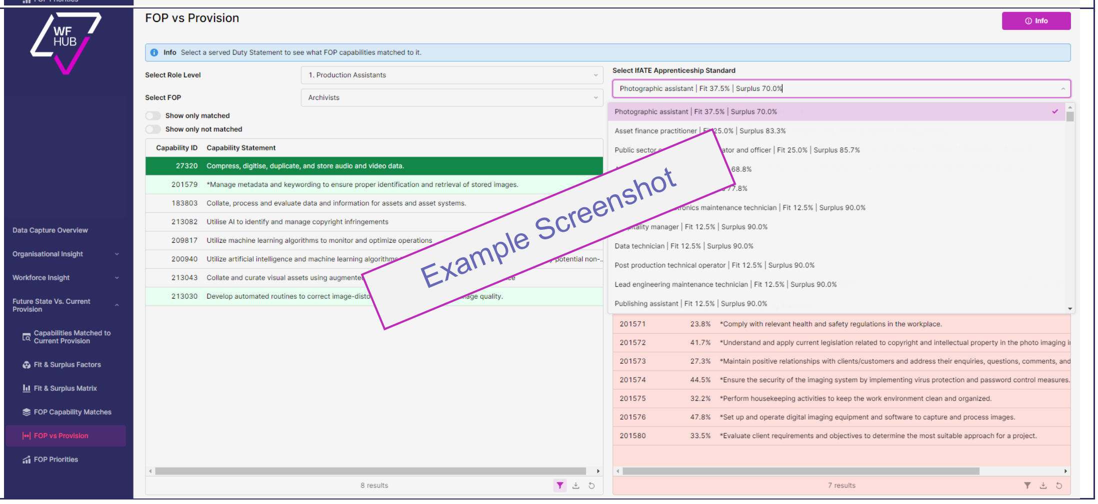


Fit_Surplus Matrix

FOP Capability Matches



FOP vs Provision



FOP Priorities