Workforce Foresighting Hub

Developing Strategic PNT Workforce Capability

Building Robust Sovereign PNT Capabilities with Parallel Contingency Systems to Mitigate GNSS Vulnerabilities and Deliver Resilient UK Connectivity and Infrastructure Protection.

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Right skills, right time, right place

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 Nov 2025 - Feb 2026 using the data set and tools available at that time.

Executive Summary

This report outlines findings from the Workforce Foresighting cycle focussing on **Developing Strategic Position, Navigation, and Timing (PNT) Workforce Capability**. This industry challenge was sponsored by Telespazio, and the study was conducted by Satellite Applications Catapult in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative.

This report is supported by the **Visualisation Tool**, a dashboard providing access to the full dataset collected, curated and analysed by participants in this study. [1]

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 that education and training systems are prepared so that the workforce is ready to adopt new technologies and support future industrial growth.

This report sets out the findings of the workforce foresighting study for this technical area and recommends actions for various stakeholders to ensure a workforce is created that is prepared to effectively implement these new technologies in the sector.

Strategic context and purpose for Workforce Foresighting

The UK's growing dependence on precise Position, Navigation, and Timing (PNT) data makes national infrastructure increasingly vulnerable to disruption from foreign Global Navigation Satellite Systems (GNSS) jamming, spoofing, and geopolitical instability. To maintain continuity across transport, energy, finance, emergency response, and advanced connectivity, the UK must accelerate the development of sovereign PNT capabilities and parallel contingency systems. This workforce foresighting cycle provides the insight required to understand how emerging technologies such as multi-orbit PNT, quantum sensing, secure receivers, and terrestrial timing, will reshape national demand and expose critical workforce gaps.

The cycle **Building Robust Sovereign PNT Capabilities With Parallel Contingency Systems** responds directly to this challenge by examining the technologies and talent required to deliver resilient, sovereign PNT services. The study has identified 20 future occupational profiles which represent where the highest level of skills development is required for that future role type to be equipped. These skills are necessary to meet the future potential of the frontier technology. Within these, this report highlights the ten priority future occupations essential for full adoption of these systems:[2]

PNT Signal Integrity Engineer
Quantum Technologies Systems Engineer
PNT Strategy & Programme Lead
Geodesy & Reference Frame Specialist
PNT Simulation Specialist
PNT Systems Architect
PNT Test & Validation Engineer
Timing Network Integration Engineer
PNT Risk, Incident & Continuity Manager
RF Hardware Engineer (PNT)

Together, these core roles form the backbone of a future UK workforce capable of designing, integrating, and safeguarding multi-layered PNT solutions. This workforce foresighting cycle

[1] Visualisation tool https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?token=5d597bde255085e040d570bc7f94b33d

[2] Priority role profiles are discussed in detail in section 2.2. All future occupational profiles & capabilities can be found in the Appendix or explored in detail through the visualisation tool.

sets a clear, forward-looking agenda for building that capability - supporting national resilience, innovation in autonomous and connected systems, and long-term economic security.

Summary of Findings: the PNT workforce challenge at a glance

Both the process of undertaking this piece of work and its findings have revealed some crucial reflections on the workforce landscape for the future of resilient PNT systems.

1. There is a **consistent and coherent recognition across stakeholders in industry, academia, and government that there is a huge and growing skills issue within the PNT industry.** The skills issue will, with increased geopolitical stressors and the developments in technology required within this horizon will only increase in urgency and severity. On a positive note, this does mean that now is the right time to act together to take ambitious action to counteract this advancing problem.

2. Prior to the input of existing Higher Education provision to the study's map-and-gap analysis, the **gap in skills provision was wide, with most future occupational profiles only identified a 17% match to apprenticeship standards** (Skills England, 2026)**.** Those that were applicable were most commonly Level 7, which recently felt the impact of funding cuts from 1st January 2026.[3] Therefore, if apprenticeships are utilised as a route to address this issue, this analysis would suggest the requirement of a large-scale intervention, with likely a new apprenticeship developed to serve the needs of the PNT industry.

3. The study's analysis demonstrates that with the addition of Higher Education coverage, capabilities are much better served by existing provision. However, given that some of the University degree courses relied upon by this study are already being closed, or are under increasing pressure to close, **highlights the industry's acute reliance on a few key courses within UK universities to support this critical workforce.** It is recognised that not enough students, and for sovereign interests, especially not enough British nationals, are receiving this education provision. **This also suggests an underlying perception issue around career opportunities in PNT.**

4. Changes to Apprenticeships, University courses, and especially grass-roots perceptions about careers in PNT take time, and as such this report suggests that investment is made in CPD training in order to upskill the workforce that existing workforce, and those that will exit their education prior to any changes taking effect. **This study identified the potential for CPD training to specialise more generalist training**, especially in areas like PNT cyber resilience and PNT systems engineering, enabling skills from other applications and transform that experience into a workforce that can be applied to the challenges in PNT.

[3] DfE Update to further education, announcement 28th May 2025: https://www.gov.uk/government/publications/dfe-update-28-may-2025/dfe-update-further-education-28-may-2025

Next Steps

Communicating the outputs of this workforce foresighting study—and acting on them collectively—is essential to strengthening the UK's sovereign resilience in PNT. This report represents the starting point for coordinated action across government, industry, and academia. The findings will be presented to the PNT Committee (convened by TechUK and UK Space) and shared widely with stakeholders, but meaningful progress will depend on sustained collaboration, targeted investment, and a shared commitment to developing the specialised skills this national capability demands.

In the conclusion, this report suggests a 3-stage plan (**Suggested 3 - Stage Next Steps Plan for Delivering a Resilient UK PNT Workforce**) which details potential interventions and stakeholders to engage. To maintain momentum in the next 12 months, the following actions should be prioritised:

- **Disseminate findings** widely via channels like the PNT Committee to ensure alignment across industry, government, and educational partners.
- **Deepen collaboration** with National Positioning, Navigation and Timing Office (NPNTO), Defence Science and Technology Laboratory (DSTL), and other government bodies to align commercial, technical, and national-security interests.
- **Invest in targeted CPD programmes**—ideally through new or expanded funding—to rapidly specialise the existing workforce for high-priority roles.
- **Protect critical university provision** through targeted module development to the creation of a foundational PNT degree, depending on funding and need.
- **Advance apprenticeship pathways**, including the feasibility of tailored degree apprenticeships for PNT.
- **Elevate awareness of PNT careers** by embedding real-world case studies in school and university curricula and supporting broad outreach to reshape perceptions of PNT's importance.

This report provides a focused and collaborative route to securing the resilient, sovereign PNT workforce that the UK urgently requires. National co-ordination protected and modernised education pathways, and expanded hands-on industry experience will be critical to closing skills gaps and safeguarding future capability. With sustained cross-sector partnership, strategic investment, and proactive engagement from the PNT community, the UK can build the adaptable, expert workforce needed to secure and grow its national PNT infrastructure for decades ahead.

Participants and Stakeholders

Government Stakeholders	Industry Attendees	Institutes & Academia
DSIT National PNT Office	Airbus	Royal Institute of Navigation
Ordnance Survey	All.Space	NESST (Newcastle University, North East Space Skills Tech Centre)
National Timing Centre	Aquark	Herriot Watt University
Civil Aviation Authority	DDK Positioning	Imperial College London
DSTL	PA Consulting	University of Bath
NPL	Roke Manor Research	University of Cranfield
	Spirent	University of Northumbria
	Starion Group	University of Sussex
	TechUK	
	Telespazio	

Table 1: Participants and stakeholders

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
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 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

Table 2: Glossary

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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 emerging technologies. By identifying future occupational profiles 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 outlines findings from a Workforce Foresighting cycle focused on Building Robust Sovereign PNT Capabilities With Parallel Contingency Systems to Mitigate Global Navigation Satellite Systems (GNSS) Vulnerabilities and Deliver Resilient UK Connectivity and Infrastructure Protection. The study is sponsored by Telespazio and conducted by Satellite Applications Catapult, in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative. This report is designed to support strategic decision making and inform the next steps on the Skills Value Chain.

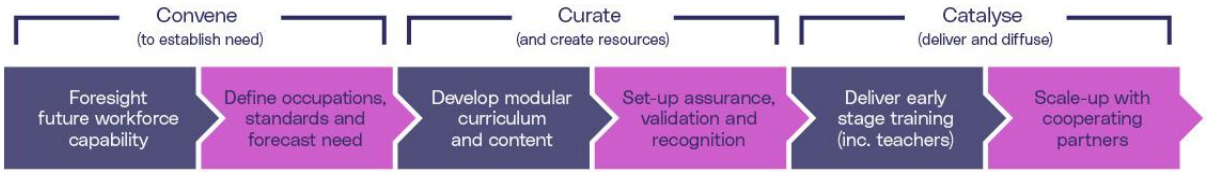

Figure 1 Skills Value Chain

1.2 Defining the Workforce Foresighting Topic

This foresighting cycle is centred on understanding the workforce implications of the UK's ambition to build sovereign, resilient Position, Navigation, and Timing (PNT) capabilities while developing the contingency systems needed to protect national infrastructure from Global Navigation Satellite System (GNSS) vulnerabilities. The challenge is not only technological but systemic: delivering secure PNT requires a coordinated pipeline of specialist skills spanning satellite engineering, signal assurance, geodesy, quantum technologies, and critical-infrastructure resilience—areas where the UK currently faces significant shortages. The cycle title reflects this dual imperative by focusing on both the advancement of robust, multi-layered PNT solutions and the talent needed to design, integrate, and safeguard them. By defining the topic through this workforce lens, the cycle enables us to anticipate emerging skill demands, map the specialist occupations essential for adoption, and inform a strategic approach to capability development that aligns with national resilience goals and future PNT innovation.

Published in March 2025, DSIT outlined guidance on PNT, why it matters, and the government framework for Greater PNT Resilience. In that guidance, the direction for skills was set as follows:

> *"PNT Skills: explore options for Centres for Doctoral Training in timing and PNT and review PNT skills, education, and training for long term sovereign PNT capability." [4]*

The Modern Industrial Strategy, published in June of the same year, also highlighted PNT within both the pages of the main report, and in the subsidiary sector plans. This paper also reflected and built upon the shift in recent policy and ministerial interest in skills provision, with a clear mandate from the outset to include workforce planning and development as a key lever in the ability to drive towards a better future UK economy:

> *"[To…] Enhance skills and increase access to talent by reforming the skills and employment support system to create a strong pipeline into the IS-8." [5]*

When considering this Workforce Foresighting challenge, the timely nature of an intervention was assessed as new funding became available to support skills initiatives. The team also looked at the economic, social, and geopolitical setting for this workforce need, and as explored below in more detail, where this work sits against other Skills activities undertaken within PNT and the scale of the technical challenge itself.

Defining the size of the UK PNT workforce is an ever-changing challenge, as provision is delivered not only by commercial businesses that may identify as part of the space sector or telecommunications industry, but also by government departments, public corporations, or government opened commercial entities. Just within industry (not including staff within the public bodies of the UK), and within those clearly aligned with the Space sector, the workforce applied to PNT as identified by the Catapult's Space Capabilities Catalogue suggests a number above 130,000 workers in the UK.[6] The workforce affected by the value-chain for services reliant on PNT as an integral system to their function, is by several orders of magnitude higher, and represents a huge economic block.

To justify engagement in this workforce study at this time, the challenge to technology and the implications of disruptions to PNT services, be they GNSS or terrestrial solutions, were assessed.

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[4] DSIT Guidance, *Positioning, Navigation and Timing: Overview,* released 26th March 2025. Available: https://www.gov.uk/guidance/positioning-navigation-and-timing-overview

[5] DBT Policy Paper, *Industrial Strategy*, released 23rd June 2025. Available: https://www.gov.uk/government/publications/industrial-strategy. Specific quote found in the mandate laid out in the executive summary.

[6] Satellite Applications Catapult, Space Capabilities Catalogue. Available: https://sa.catapult.org.uk/space-capabilities-catalogue/

1.3 Technology challenge and scale of the potential disruption to the UK economy

1.3.1 PNT workforce technical challenge

This cycle considers the workforce required to build capability in sovereign and resilient PNT in the UK, with a timeline horizon of three years. This is captured in the cycle title:

> Building Robust Sovereign PNT Capabilities With Parallel Contingency Systems to Mitigate GNSS Vulnerabilities and Deliver Resilient UK Connectivity and Infrastructure Protection.

This activity is designed to identify the skills required by the future workforce to meet the aims of and challenges related to PNT faced by the UK. This is critically important for the UK due to the increasing recognition of the vulnerabilities of GNSS and the dependence on PNT services across the UK economy, backed up by several independent reports.

A loss of position, navigation and timing services is listed on the national risk register with a likelihood of 0.2%-1% and a significant impact, though with the potential for a catastrophic impact and likelihood of up to 5% (HM Government, 2025). Studies by the Government Office for Science (2018) and London Economics (2023) concluded that six out of thirteen critical national infrastructure (CNI) sectors are dependent on GNSS, and it is separately expected that most of the others are also reliant to some extent (Government Office for Science, 2018) (London Economics, 2023). The London Economics report also determined that the economic benefits of GNSS to the UK are valued at £13.6 billion annually, and that a seven day disruption would cost the economy £7.6 billion, with the largest critical national infrastructure CNI sector benefiting being emergency services, illustrated in Figure 2 **(Figure 2 Expected loss to the UK economy of a 7-day GNSS outage (London Economics, 2023)** (London Economics, 2023). Further to this, GNSS was estimated to support 14% of UK GDP in the 2024 Size and Health of the UK Space Industry report (UK Space Agency, 2025).

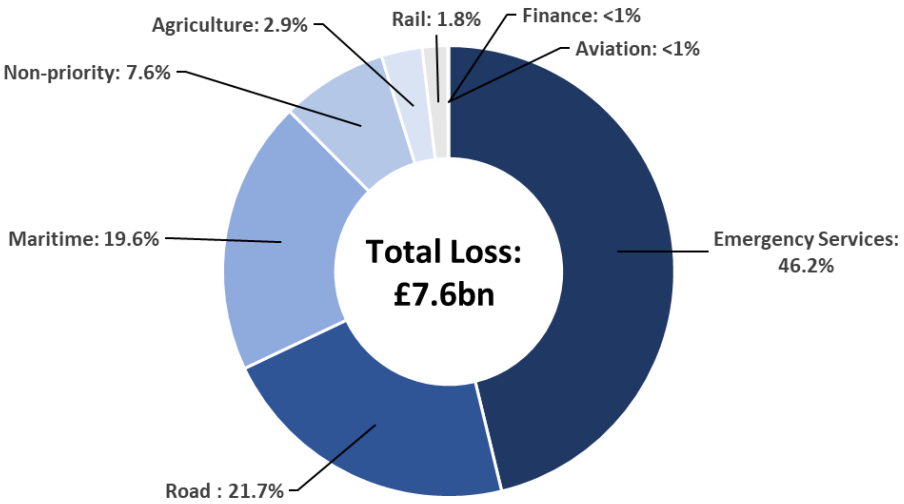


Figure 2 Expected loss to the UK economy of a 7-day GNSS outage (London Economics, 2023)

A change to the existing workforce in the UK will be required to meet the challenges indicated by these data, which permeate almost every CNI sector including those mentioned above, as well as defence and core government activities. It must be recognised that a

reliance on PNT, usually GNSS, affects daily life in the UK across personal, commercial, government, and security aspects.

1.3.2 Potential and prioritised technology solutions to the challenge

This cycle considered several different potential technological challenges which must be addressed by the future workforce, related to PNT sovereignty and resilience in the UK.

These are summarised below.

Technology Challenge	Opportunity	Blockers
Mapping vulnerabilities	This would enable businesses, government, and CNI operators to understand their dependencies on GNSS and the associated costs of disruption, leading to more effective planning.	This is a complex system-of-systems task, requiring a transdisciplinary view of the dependent systems.
High-performance time transfer	Timing is a critical service provided by GNSS, and alternative sources of timing either wireless or over fibre-optic cables have the potential to protect industries such as power distribution and finance from GNSS disruption.	This is a specialised field requiring a high-degree of training and is often undertaken by physics-focused organisations.
Multi-source receivers	These would enable a near-seamless transition between GNSS and alternative sources of PNT such as eLORAN or signals of opportunity and producing them in the UK would boost industries involved throughout the supply chain.	A sovereign supply chain for these devices would require greater provision of components such as chipsets in the UK, and the associated workforce must be expanded.
Alternative PNT provision	Alternative sources of PNT have the potential to increase the resilience of dependent industries in the UK, and the UK government has committed to the implementation of eLORAN as one such alternative source.	These sources will require ongoing support and maintenance, requiring an expansion of technician and logistics staff.
PNT testing provision	With new capabilities coming online, testing will be required across several domains such as antennas, RF simulators, and chipsets.	PNT testing in the UK is fragmented and often held by academic institutions or large primes.
Quantum PNT implementation	Quantum PNT has the potential to provide much greater accuracy of dead-reckoning based systems for several high-performance applications.	Like time transfer, this is a highly specialised field, with regular implementation likely being many years away.
Geodesy	Geodesy provides the precise understanding of the Earth's geometry, orientation in space and gravitational field with applications in mapping and surveying, construction farming, environmental monitoring, and the operation of systems like GPS and Galileo.	This field requires very strong mathematical and science skills and a lack of awareness of its role and importance along with a lack of educational pathways has resulted in a critical global shortage of geodesists.

Table 3 PNT technical challenges

These technologies each highlight an area of the cycle challenge that must be addressed for the growth and health of the UK PNT workforce.

1.3.3 Workforce Foresighting for prioritised technology solutions

To address the identified technology challenges, a variety of roles will be required within the workforce. These roles are expected to cover a breadth and depth of expertise, such as systems engineers or architects who will need a broad range of education and experience pertinent to PNT, and quantum PNT scientists, who will likely be educated to PhD level. Geodesy specialists are a unique case in that there is a lack of specialists available for roles, but also a lack of provision to train more. It is crucial that these problems are solved for the workforce to be built up.

The previously identified dependencies on GNSS and the PNT services highlight the need for a developed PNT workforce in the UK, as well as the expected increase in GNSS dependence for everyday operations as autonomous systems (cars, freight, aircraft) become more commonplace. The workforce will need to be nationwide, particularly in areas involving infrastructure deployment. If this challenge is not met, there are risks to UK businesses for loss of opportunity in a rapidly developing sector, as well as to government and society as threats to GNSS increase.

1.3.4 Current and predicted scale of technology deployment in the UK

As described already, PNT technology is deployed across UK industry and society, through many of the systems considered here more nascent, be they resilient receivers or alternative sources of PNT information. Plans have been set out by government for the deployment of new technology, with the changing global security environment providing impetus for activities.

For example, the UK has recently committed £155 million for a variety of PNT-related programmes including the deployment of a **national eLORAN system**, continued development of the **National Timing Centre**, a **GNSS interference monitoring system**, and the development of **space-based time transfer** (Department for Science, Innovation and Technology; Ordnance Survey; National Physical Laboratory; Lord Vallance, 2025). There is also the ongoing TOUCAN project under ESA NAVISP, which aims to provide time and frequency transfer via satellite for the UK's single eLORAN transmitter (European Space Agency, n.d.).

The newly allocated money is intended to be spent by 2029, and timelines have been attached to several of these programmes. Other PNT-related timelines also exist across government, such as the goal to have deployed **quantum navigation systems** onboard aircraft by 2030 (Innovate UK; Department for Science, Innovation and Technology, 2025).

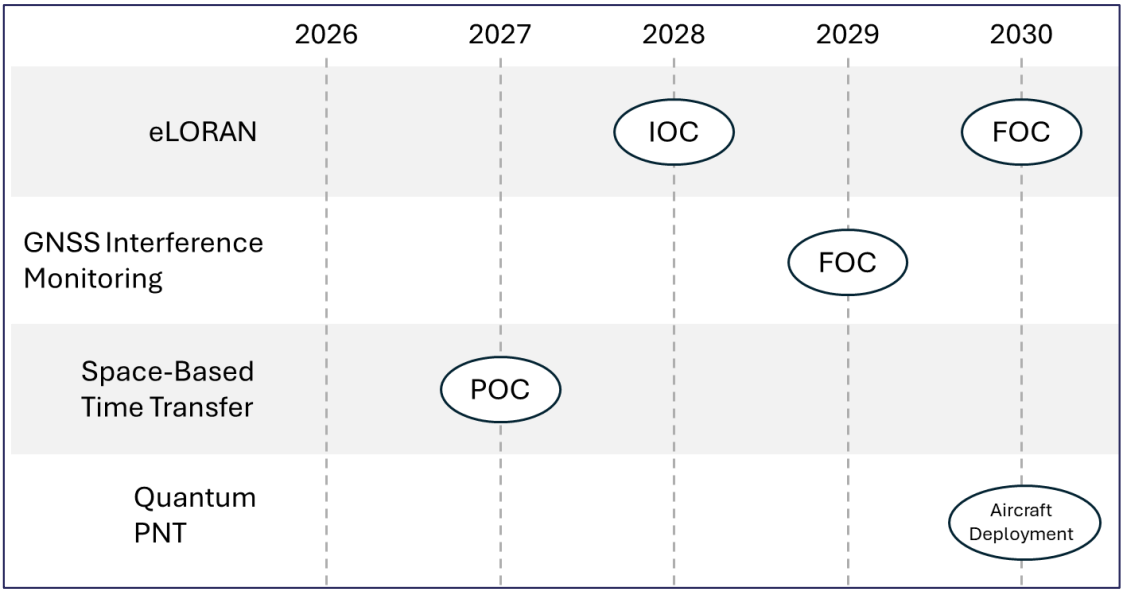


Figure 3 PNT technology government-defined timelines. Sources: (Department for Science, Innovation and Technology; Ordnance Survey; National Physical Laboratory; Lord Vallance, 2025; Innovate UK; Department for Science, Innovation and Technology, 2025

PNT technology government-defined timelines. Sources: (Department for Science, Innovation and Technology; Ordnance Survey; National Physical Laboratory; Lord Vallance, 2025; Innovate UK; Department for Science, Innovation and Technology, 2025; Department for Science, Innovation & Technology, 2025; Department for Science, Innovation and Technology; Lord Vallance, 2025)

A skilled workforce will be required to meet these goals by the times scheduled, highlighting the importance of this report Research and development will be required for each technology area, as well as ongoing operation, maintenance, and upgrade, in turn requiring the roles and skills identified throughout this foresighting activity. The last point of upgrade is important to emphasise, as new capabilities will be demanded and new threats and vulnerabilities will be discovered over time. In order to meet future demand, a strong training and research pipeline must be in place to ensure that the industry and systems on which the UK relies stay resilient and competitive.

1.4 Positioning & context: Skills activities around PNT resilience

This activity builds on a plethora of work and skills activities in this sphere, hoping to offer detail and evidenced backing for action with its granular focus on the capabilities in question and an analysis of where those skills are lacking in current training provision. Before embarking on this study, it is important to recognise the substantial body of evidence already shaping this landscape, both from voices within industry, researchers discussing best teaching practice, and international efforts as comparanda to the strategies that could be built upon in the UK.[7] Research papers undertaken in this country discussing the dire need for resilience in PNT and providing frameworks for discussing these issues are underscored by publications from authors in other countries discussing that similarly discuss the training provision requirements.[8]

As has been established, there is a clear need and call for intervention in this technical challenge, and this critical need is underpinned by a reliance on a workforce ready to hire at the appropriate time. The potential risk to PNT services represented by a workforce that is either unprepared to the skills demand, too small to meet the demand, or critically vulnerable to sovereign interests cannot be underestimated. Elsewhere in the space sector, workforce shortages for similar skillsets mean that PNT skills challenges exist for an already constrained talent pool, as the PNT workforce must compete not only with other sectors, but other parts of the space sector that are more well-known.

As well as exploring the call to action, important work in the UK has already been undertaken by the National PNT Office, the National Physics Laboratory, Ordnance Survey, and the Royal Institute for Navigation, to name but a few.[9] This report seeks to augment and support those activities, and provide granular detail for the skills most in deficit, and data-driven justification for the investment in skills activities to support a workforce in PNT services. There is a clear need to build upon the work to date, utilise the demand signal that this report sends, and act with both timely interventions for the short term, and ambitious investment of effort to address the long-term challenge.

[7] Butinar, Z. et al. (2024), NLA International / ESA NAVISP (2025) SPARK Reports, SpaceSUITE (Erasmus+ 2024–2027), Vidal Bustamante, C.M. (2025)

[8] Proctor, A. (2022)'s approach outlines the challenge in a way that has shaped subsequent discussion in the UK. An interesting foil is He, X et. al (2021), where teaching methods to most effective train undergraduates in applicable fields were under discussion in China. The UK most accelerate their activities, not just in information gathering, but in developing the skills of our workforce.

[9] For example, but not as a comprehensive list: Claverley, J. (2020) NPL Metrology Foresighting; Ordinance Survey's Digimap for Schools project, and CPD training offered by the Royal Institute of Navigation.

1.5 Contributing Participants

Thanks to all those organisations for 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 sector.

Technology Participants	Industry Participants	Skills Participants
DSIT National PNT Office	Airbus	Royal Institute of Navigation
Ordnance Survey	All.Space	NESST (Newcastle University, North East Space Skills Tech Centre)
National Timing Centre	Aquark	Herriot Watt University
Civil Aviation Authority	DDK Positioning	Imperial College London
DSTL	PA Consulting	University of Bath
NPL	Roke Manor Research	University of Cranfield
	Spirent	University of Northumbria
	Starion Group	University of Sussex
	TechUK	
	Telespazio	

Figure 4: Contributing Participants

1.6 Methodology, Tools & Known Bias

This project sought the input and consultancy of stakeholders from the above organisations, from across industry, academia, and government. It is recognised that no study can be wholly without bias; the data captured below is therefore a representation of a snapshot of views across the sector, and was therefore influenced by the knowledge and opinions of those who contributed their time to the workshops that supported this activity, as well, of course, as the authors of this report. However, arguing an opinion and engaging in debate is an important expression of expertise in any subject area, and over the course of this study an effort has been taken to preserve a balanced view of the information and views supplied by the stakeholders.

The processes behind the generation of the data sets, appendix A, (**A Online Data visualisation tool**) also used AI tools and agents to make suggestions from which to start debates with subject-matter experts, and to standardise the language of the capabilities such that it would create a cohesive dataset. Every AI output has been reviewed, discussed, and where necessary edited to reflect an honest and human representation of the skills activities undertaken.

This study also utilised source data from national and international workforce datasets, primary amongst which the results were compared against the bank of exiting apprenticeship standards maintained by Skills England. This has also been augmented by a sample of Higher Education Course provision, as is discussed in section 2.3 (**2.3 Education and Training provision insights**)

Finally, the results of every Workforce Foresighting study are predicated on a matching threshold; the value to which the convening team considered the capabilities identified through capability mapping activities to be sufficiently matched to existing standards to warrant analysis. This match threshold was set at 48%; meaning that while there may be training provision with some overlap with the identified requirements, only those above the

threshold are considered fruitful avenues for development of training. Discussion of these matches is returned to in the following sections.

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, it explores how organisational capabilities must evolve to enable the adoption/deployment of new and emerging technology, 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 Future Occupational Profiles (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 (**Appendices**) and visualisation tool. [10]

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 emerging roles. Links throughout this report make it easy to identify existing Apprenticeship standards which meet the needs of these emerging roles and pinpoint where new standards may be necessary to develop a skilled workforce equipped to adopt new technologies.

The data is generated by the foresighting cycle, 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. (**Suggested 3 - Stage Next Steps Plan for Delivering a Resilient UK PNT Workforce**)

Using AI tools validated by human oversight, and by linking to external data sources, the visualisation tool identifies differences at the level of occupation or role, as well as detailed changes required to help update or refresh knowledge, skills and behaviours, thus delivering insights for learners, providers, creators, and assurers of skills.

Links: Link to **Visualisation Tool**

[10] Visualisation tool https://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?token=5d597bde255085e040d570bc7f94b33d

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 this foresighting cycle.

Insight:

This cycle identified 145 capabilities that represent a requirement in skills development from current activities undertaken within PNT technologies in the present day, and those which the foresighting activities identify as a requirement in order to enable the potential technology growth in this area. Overall, 83.4% of the capabilities identified showed at least a partial match with those mapped within existing provision, but this varies significantly depending on the area of the future supply chain: Design capabilities had the least applicable training provision, while Logistics demonstrated acceptable coverage.

Provision mapping included both **apprenticeships standards from Skills England**, and custom entered data from **university courses.** Provision supplied only from apprenticeships represents some considerable gaps in education and training for the skills needed for the future PNT workforce and represents therefore a need for this education route into the workforce to be developed much further. However, the capability coverage rose considerably once the sample of Higher Education courses were entered, suggesting that those courses, where they are still running, provide a good basis for a career in PNT (**2.5 Summary of Key Recommendations**) for a discussion of the issues around key courses at risk.

It is also worth noting that course capabilities list all those available on optional modules, and so it is unlikely that one single educational pathway could equip an individual with all the skills described in this review. This again reinforces the need for extra intervention to support the workforce behind this key area of national infrastructure.

2.1.1 Facilities and Infrastructure

In the exploration of this challenge, the question of the UK provision for testing facilities has been raised, for which there is a parallel workforce issue. PNT testing facilities in the UK are not common, and what provision there is rarely represents multiple PNT testing capabilities at one site. Work underway at the Satellite Applications Catapult to map the test facilities and infrastructure available for space or space-adjacent technology development suggests that it is likely that there is more testing provision available than is generally known about; this is then partly a challenge in raising understanding of what capabilities are housed within industry and academic testing facilities, and signpost these sufficiently to their customers to ensure appropriate utilisation of these expensive pieces of equipment to justify investment.[11] It also supports the development of new custom test facilities that would support this sector – incidentally, this was identified as a capability required in this cycle.

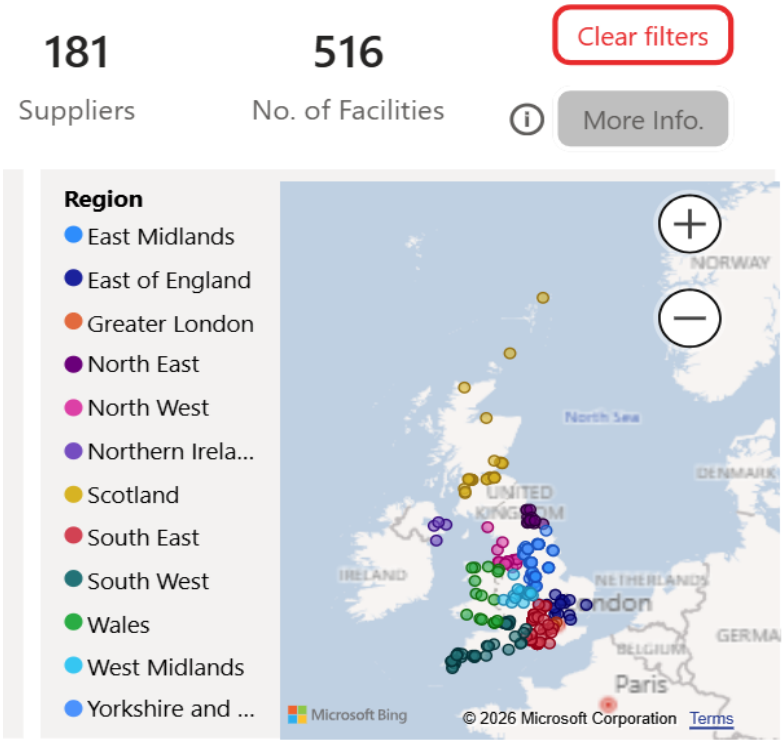


Figure 5 Space Capabilities Catalogue; Infrastructure tab facilities Map.

However, for each test site, a technician or engineer must be available to support those utilising the facilities, at which point creating a chicken-and-egg workforce challenge:

1. There is typically insufficient staffing of specialist technicians at the facility available at the times required by industry partners, leading to the utilisation levels of these equipment centres being lower than expected.
2. Utilisation rates mean that facilities are not motivated to invest in the training provision required to bring on board specialist technicians to run these facilities at full capacity.
3. A lack of demand means that there are not enough trained specialist technicians to support the utilisation of the equipment.
4. Under-utilised facilities are not well-known to the sector, forcing PNT technology companies in the UK to be reliant on testing facilities outside of this country.

[11] Space Capabilities Catalogue (Infrastructure tab): https://sa.catapult.org.uk/space-capabilities-catalogue/

2.1.2 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 is developed and compared to how they function today. This comparison helps highlight the areas where change is needed to meet new demands and opportunities.

It is recognised that there are multiple approaches when categorising a future workforce for PNT & alternative PNT technologies. One could approach the studies from a value chain, through which the consumers of this technology – be that on a large scale with a national infrastructure system, or simply on a personal level, where PNT reliant systems can be found in every day-life and increasingly, in the devices carried throughout the day. This can be a useful approach especially when considering the market pull that is likely to predicate much of the workforce growth in this sector; the value chain of this system of systems is there intrinsically connected to the scale of end-users of PNT services.

However, the rationale for organising the workforce by **supply chain** is derived from this assessment being predominantly an analysis of the **skills requirement**, and therefore **qualitative assessment** of the skills gap, as opposed to a quantitative assessment of the number of individuals within each predicted future role. The premise of the cycle, as outlined in the **Introduction** of this report, established that the importance of the skills gap within this area, both in **criticality** and in **scale, was sufficient to merit this investigation.**

Throughout the process, close engagement with participants to identify which supply chain partners will be affected by the technology in question. This ensures that the analysis is grounded in real-world contexts and considers the full ecosystem of organisations involved.

This does not mean that these categories are exclusive to the entire supply chain affected by systems which establish PNT services: but they are the areas within which capability mapping was organised to ensure that skills development requirements were considered across the various stakeholder groups involved in realising the growth potential of PNT systems. The supply chain partners related to the analysis are as follows:

Supply Chain Partners

RTO/COI – Research & Innovation
Organisations Advances alternative and resilient PNT technologies through research, prototyping, and testing, enabling innovation that strengthens national navigation and timing capability.

Original Equipment Manufacturers (OEMs), Primes, Tier-1s
Designs and integrates advanced PNT technologies, validating performance and embedding security-by-design to deliver robust, deployable timing and navigation solutions.

Small to Medium Enterprises (SMEs)
Delivers specialist, agile PNT solutions by developing components and services that enhance resilience, strengthen security, and support supply chain continuity.

Regulators
Sets and enforces PNT standards by updating policies, auditing compliance, and guiding operators to maintain safe, secure, and resilient infrastructure.

Infrastructure Operators & Government
Supports national PNT resilience by operating critical systems, coordinating cross-sector policies, and implementing contingency measures that maintain service continuity during GNSS disruption.

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 are assessed as they shift.

Design → **Implement** → **Logistics** → **Support** → **Enterprise**

Insight: Capabilities identified in this cycle were distributed across functional domains in a fairly consistent spread, with the exception of Logistics function, which sees fewer capabilities that represent a skills development requirement for the future horizon. The largest number of capabilities fall within the Design function. This reflected the nature of this technology area; PNT resilience represents the next stage in an evolution of well-established technologies, both where this applies to improvements to existing GNSS systems and developments or interoperability with terrestrial systems that could represent contingencies and alternate PNT solutions.

This means that while many of these functional areas, especially in designing these adaptations and integrations (see capabilities identified by this cycle) there is fewer new skill requirements to the logistics of administering this technology, as pre-existing roles within connectivity services will likely continue without considerable change.

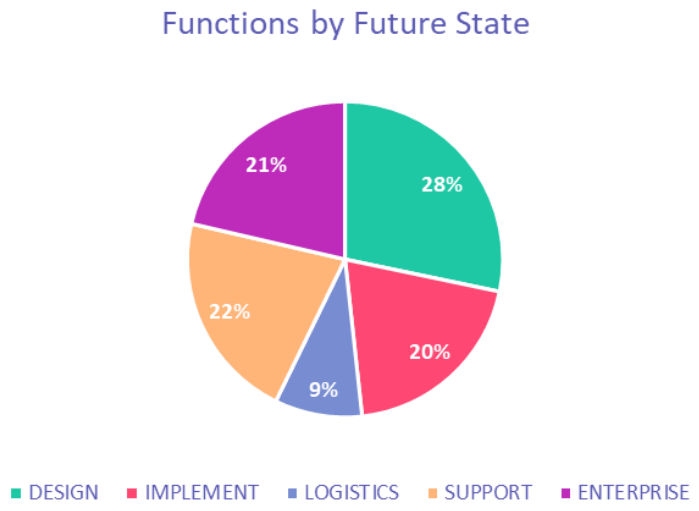


Figure 6: Future Supply Chain Capability Function Distribution %.

Insight: The graphics below from the visualisation tool show the distribution of capabilities predicted by the cycle across the functional domains, and the supply chain partners we identified for this technology focus. The distribution for OEMs and SMEs is similar, with weight on both implementation & design, but in this case more so than perhaps some technology areas, Infrastructure Operators and Government shoulder a considerable share of Implementation & Enterprise, taking leadership decisions about the solutions resilient PNT may offer.

This is a reflection of both the national scale of the technical challenge, affecting both critical use-cases within commerce, with a considerable economic consequence to any interruption in service, but also the defence considerations which warrant national oversight.

See below the breakdown and insight from each supply chain partner. The full list of capabilities for each partner can be found in the visualisation tool.

Links: Link to visualisation tool for **145 capabilities** and visualisation tool for **5 supply chain partners**.[12]

By mapping these partners against the five functional domains, it is possible to pinpoint where capability changes are required and who will need to adapt—whether through new skills, new roles, or new ways of working.

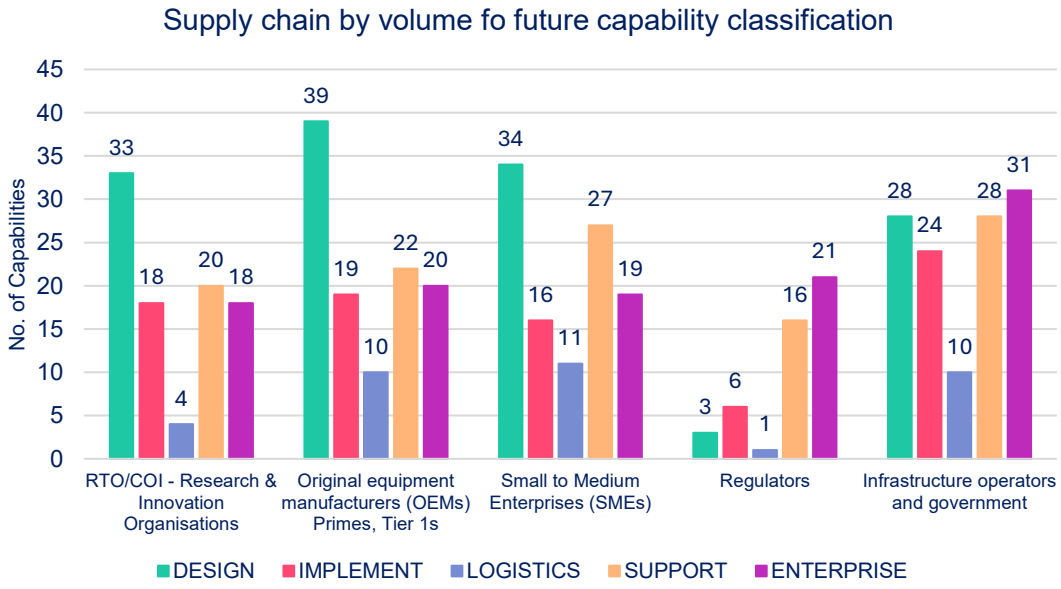


Figure 7 Distribution of Functions across each Supply Chain partner.

The graph illustrates the distribution of 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.

[12] Supply chain partners https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=5d597bde255085e040d570bc7f94b33d

Capabilities for Original Equipment Manufacturers (OEMs), Primes, Tier-1s

Within the OEMs, nearly a third – 39 – of the capabilities fall under the design function, and within that, the majority are themed around Technical Research and System/Equipment Design & Implementation. The Support function features next highly with 22 capabilities, mostly split between Operator Support and maintenance of safety standards.

Figure 8 Capability map for OEMs, Primes & Tier-1s: Interactive graphic found on Supply Chain Capabilities tab of the Visualisation tool.

12.7% of the capabilities identified by this cycle are not covered by existing training provision, and only 7 of the 110 capabilities have over a 70% match, suggesting that while the general knowledge base is theoretically covered, much of the specialist skills specific to PNT are not addressed.

Capabilities for Small to Medium Enterprises (SMEs)

As one would expect, many of the capabilities undertaken by Primes are also managed by SMEs. Design and Support feature similarly heavily to the above graphic with 34 and 27 capabilities to each function, respectively.

Figure 9 Capability map for SMEs: Interactive graphic found on Supply Chain Capabilities tab of the Visualisation tool.

Here, 17.8% of the capabilities identified do not meet the match threshold of 48%, with only 8 capabilities matching over 70%.

Capabilities for Infrastructure Operators & Government

The most evenly spread of the capability maps is across the Infrastructure Operators & Government stakeholders.

This distribution sees 31 capabilities for Enterprise, especially in Leadership & Strategy, 28 in Design where the largest segment is Technical Research, 28 also in Support where the capabilities are split between maintaining safety standards and Operator Support, and 24 in Implementation where the majority fall under Manage Operations. This reflects the nature of PNT as a system of systems. Achieving a future where PNT Systems in the UK are not only robust, resilient with contingency strategies, and ultimately nationally separable, this will require and engage all levels of government and systematic planning to commission national or international scale projects.

Figure 10 Capability map for Infrastructure Operators & Government: Interactive graphic found on Supply Chain Capabilities tab of the Visualisation tool.

Of these 121 capabilities 16.5% do not meet the match criteria of 48%, and again the majority are a low match, with only 9 scoring a match of over 70%. Again, this suggests that while there is some provision for this area, there are still some gaps in the specialist knowledge required for a career in PNT.

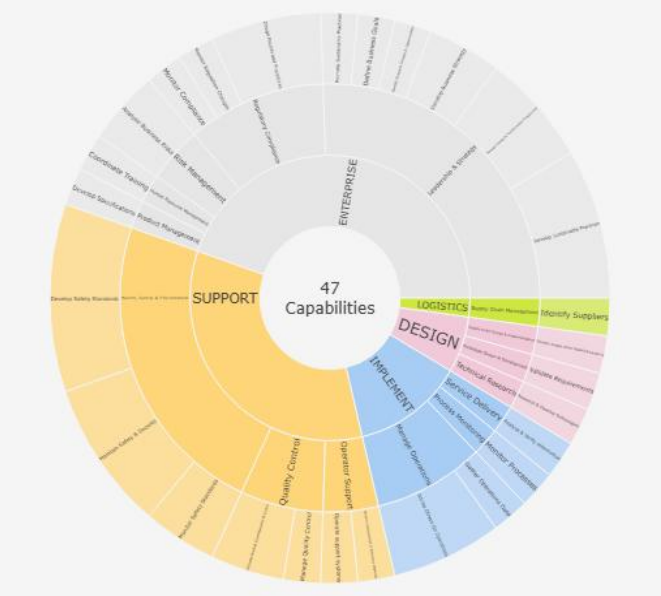
Capabilities for Regulators

The capability maps for the regulator supply chain group are the most specialist, with the majority of roles within Enterprise (21) and Support (16).

In the discussions around the future role of the regulator in PNT systems, there was a recognition that, achieving true resilience in this arena, will require within the cycle something of a systemic skills change for the regulator (in regulatory skills); that positions the regulator as an active participant and empowered to engage directly with those implementing solutions. This would enable safety standards and regulation to potentially adapt and evolve alongside such a fast-paced technology area.

It was recognised that this is not necessarily the case at present, but that the skills of the regulator to be utilised strategically across the PNT sector, in order to encourage interoperability of systems and fast adoption of standards that enable this technology.

As such, within Enterprise, the cycle saw the majority of capabilities fall under Leadership & Strategy, specifically the development of new standards and strategy, and then in Support, the maintenance of those new standards.



11 Capability mapping for Regulators: Interactive graphic found on Supply Chain Capabilities tab of the Visualisation tool.

As such, the outcomes of the cycle recommend a refocus and integrated approach to regulation in this sensitive technology area. Thankfully, this adaptation in reflected in the capability mapping, as while the data still identifies **17% of the capabilities as not served by existing provision, those that are matched are on average a better match than the other parts of the supply chain, reflecting the transferable skills required by this part of the sector.**

Capabilities for RTOs, COIs & Research Institutions

This category covers both research institutions and university research departments as well as industry-based centres for innovation and technology. Of all the supply chain categories, this one sees the largest proportion of design skills (33 of the 93 capabilities), as this is where new technologies are developed (18 capabilities), as well as some of the prototyping for how those technologies might be implemented and deployed (5 capabilities themed under prototyping, 5 under system or equipment design & implementation.

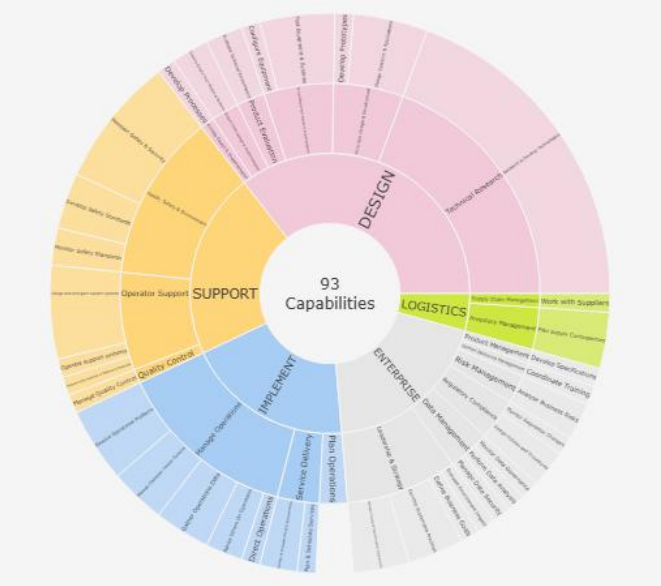


Figure 12 Capability mapping for RTOs, COIs & Research Institutions: Interactive graphic found on Supply Chain Capabilities tab of the Visualisation tool.

18.3% of the capabilities described in this part of the workforce do not meet the 48% threshold for a match, especially around those areas that represent cutting edge research (quantum timing applications, for example) or the development of sufficient testing facilities in order to advance the technology readiness level of many of these research projects from concept to reality.

2.1.3 Functional Cycle Capabilities Currently Not Served

Please see the Capabilities Matched to Current Provision tab on the Visualisation tool to see the data behind this discussion.

Insight:

Out of the 145 future capabilities identified for this cycle to adopt this technology across the supply chain, **87 are not currently well matched with any duty statements found in existing apprenticeship standards.** Where we do see the best matches from apprenticeship standards, these are typically from courses from level 7. This then represents another issue with training provision, as from the 1st of January 2026, the UK government funding to support the Level 7 apprenticeship was cut, meaning that industry would be required to fund the considerable costs of any learners above the age of 22 into their businesses.

However, if one also looks at Higher Education provision, **the number of under-served capabilities reduces to 24 capabilities** once Higher education provision has been included in the data set, underscoring this sectors' reliance on higher education provision to deliver the training required.

However, as was discussed in 1.5, the University courses from which the sample of capabilities were drawn are under threat. With pressures across the higher education system, many courses are being dissolved in favour of more generalised courses that would maintain higher class-sizes. However, this means a removal of many of the specialist skills that this part of the UK industry requires. Some of the courses reviewed in this report are already being retired, and others are on their final cohorts of study. Intervention is therefore critical to protect or reinvigorate the courses available to support the PNT industry and drive more awareness of careers in PNT to encourage more students to undertake study in this field.

The requirement for these specialist skillsets can be measured both in numbers & in the critical need for these individuals. The burgeoning need for resilient PNT solutions requires increasing numbers of skilled individuals to hire, in a landscape where it is already a known struggle to hire an appropriately experienced worker. Some of the urgency behind this requirement is not for scale; for both geodesy & quantum, a relatively small workforce is required. However, it is an imperative for the sovereign security of the UK PNT network that that is an indigenous workforce of skilled individuals who can succeed the existing holders of this critical knowledge – in this case, it is not a question of scale, but of national security.

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. See Appendix B for the full list of 24 unmatched capabilities See Appendix B. (**B Functional Cycle Capabilities Currently Not Served**).

2.1.4 Prioritised Capability Themes

Within the cycle workshops a number of few activities were underwent to establish which themes were most key, or most urgent to the success of the deployment of PNT systems in the future. This included surveying the cohort to rank the criticality of each capability, and then a full workshop were the contributing experts discussed the capabilities that occupied that tension point of least served by provision, and most critical to the future.

Within the cycle priority roles came out of the activities to develop Future Occupational Profiles which are explored in detail in the next section, and these too can be mapped within these the six core themes that underpin this report.

Please see visualisation tool for the full details of all 145 capabilities identified by the cycle. [13]

Top 6 Priority Themes (Ranked by participants)

1. **PNT System Resilience & Alternative Positioning Solutions**
   which might include: PNT Simulation Specialist, RF Hardware Engineer, PNT ML/Data Engineer, Manufacturing & Qualification Engineer (PNT).

2. **PNT Infrastructure Development & Integration**
   which might include Geodesy & Reference Frame Specialist, PNT Systems Architect, Timing Network Integration Engineer, PNT Strategy and Programme lead, PNT Procurement Manager.

3. **Regulatory Frameworks, Standards & Certification**
   which might include PNT Standards & Regulatory Affairs Officer, AI Ops Manager, PNT Regulatory Compliance Specialist, PNT Policy Lead.

4. **Cybersecurity, Threat Mitigation & National Security Assurance**
   which might include: PNT Risk, Incident & Continuity Manager, PNT Cyber Security Engineer.

5. **PNT Technology Innovation & Research**
   which might include Quantum Technologies Systems Engineer.

6. **Service Assurance (Spectrum Management, Signal Assurance and Equipment & Services Testing)**
   which might include PNT Signal Integrity & Testing Engineer, RF Spectrum Specialist, PNT Test & Validation Engineer, PNT Field Operations Engineer.

These themes, broken down below, are also represented by the 10 priority Future Occupational Profiles, which can be found at Appendix C **(C List of full FOPs by Role Level including capabilities and proficiency)**. Later in this report, in section 2.3.4, these themes will be returned to with recommendations about how educational or training reform could be implemented to anticipate the requirements of these key occupational roles within the horizon.

[13] Organisational capabilities https://hvmcatapultforesighting.retool.com/embedded/public/f56f84e9-8ab8-414f-aa1a-0b42ab5c71df?token=97f32699b61bd02b863f006b3dbc6e28

Insight:

Analysis was done to assess the capabilities that were considered most crucial within the future workforce, and those which have a poor coverage from existing training provision. Those capabilities were then themed to establish six priority capability themes, as follows:

1. **PNT System Resilience & Alternative Positioning Solutions**
   These capabilities represent those various technical activities which evaluate & implement both augmentation or improvements in design to GNSS systems to improve their resiliency, and those which represent integration with alternate systems, which may be terrestrial in source. These are the crucial breakthrough technologies that underpin the core of this cycle, which require workforce to design their component parts – either hardware or software in nature.

2. **PNT Infrastructure Development & Integration**
   These capabilities underpin the first theme, as they enable the integration of augmentation systems to the existing technology, or the interoperability, be that constant or in emergency situations, of alternative systems to support a resilient PNT provision.

3. **Regulatory Frameworks, Standards & Certification**
   Capabilities within this theme highlight the importance of an agile regulator in this field. These focus around the establishment of evolving standards that encourage indigenous development of resilient PNT components and the facilitation through both regulation, safety standards, and policy to ensure a nationally separable system which provides security against disruption which would have social, economic, fiscal, and ultimately defence implications.

4. **Cybersecurity, Threat Mitigation & National Security Assurance**
   These capabilities focus around the mitigation of disruption which could lead to issues of national security. It is worth noting here that while it is possible that these interruptions to service may be malicious in nature, it is more likely that environmental hazards, be those physical hazards to satellites, or interference due to space weather or other environmental events are those eventualities which must require mitigation strategies for the preservation of critical national infrastructure.

5. **PNT Technology Innovation & Research**
   This category covers the development and investigation into solutions, such as those available via quantum technologies, which are still in varying stages of research, and whose application is still to be determined.

6. **Assurance (Spectrum Management, Signal Assurance and Equipment & Services Testing)**
   This capability theme encompasses testing, both in the field and via simulation, to both ensure signal integrity, and to manage and maintain the interoperability of the plethora of systems that represent a robust PNT network.

2.2 Workforce Insight

2.2.1 Future Occupational Profiles (FOPs)

Future Occupational Profiles (FOPs) indicate how roles in the industry will need to evolve as the sector 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 the industry's transformation.

The FOPs defined for this cycle do not capture the full extent of a current or future job role. Workforce Foresighting identifies new capabilities and changes required in an occupation that will be required in the future to allow technology adoption.

Links: Link to **FOP Matrix**[14]

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 responsibilities are well defined and expectations aligned. Each level builds on the last in terms of complexity, autonomy and impact enabling effective collaboration and accountability.

Workforce Foresighting the same role levels are used across Supply Chain Partners for a given technology and defined within this context. This shared framework supports consistency, clarity of FOPs and capability development within and between sectors. Each Workforce Foresighting challenge defines role levels that reflect the requirements of the challenge and sector.

Role Levels for this cycle are:

1. **Professional/Tactical Specialist: Tactical Delivery**
   Diagnose, adapt, and collaborate within known systems.
2. **Operational Leadership**
   Lead teams, assess performance and improve systems.
3. **Strategic Management**
   Design systems, manage resources and drive innovation.
4. **Enterprise/Strategic Leader**
   Drives enterprise foresight, policy, and transformational strategy.

While these role levels can be mapped broadly to education levels if one were to expect a trained individual to be immediately suitable for hire into these roles, it is worth recognising that while level of study should be a worthwhile preparation for the workplace, much of the knowledge base required for these roles can and should be picked up through experience, where time, mentorship and professional development prepare an individual for the next Role Level.

As such, this report encourages multiple avenues of training to support the roles identified by the cycle, especially those on-the-job training opportunities that can uplift a student either from a less specialist University degree course or from an apprenticeship pathway and upskill them into the PNT specialists this emergent technology requires.

[14] https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=5d597bde255085e040d570bc7f94b33d

2.2.3 Future Occupational Profiles results

20 Future occupational profiles were developed as part of this cycle to address the development of technologies to support robust PNT services, including both GNSS and alternate PNT systems.

Table Key supply chain partners

1 RTO/COI – Research & Innovation.
2 Original Equipment Manufacturers (OEMs), Primes, Tier-1s.
3 Small to Medium Enterprises (SMEs).
4 Regulators.
5 Infrastructure Operators & Government.

RL	FOP	1	2	3	4	5
1	Manufacturing & Qualification Engineer (PNT)	✓	✓	✓	✓	
	PNT Cyber Security Engineer	✓	✓	✓	✓	✓
	PNT Field Operations Engineer	✓	✓	✓	✓	
	PNT ML/Data Engineer	✓	✓	✓	✓	
	PNT Regulatory Compliance Specialist	✓	✓	✓	✓	✓
	PNT Signal Integrity Engineer	✓	✓	✓	✓	✓
	PNT Simulation Specialist	✓	✓	✓	✓	
	PNT Test & Validation Engineer	✓	✓	✓	✓	✓
	Quantum Technologies Systems Engineer	✓	✓	✓	✓	
	RF Hardware Engineer (PNT)	✓	✓	✓	✓	
	RF Spectrum Specialist (PNT)	✓	✓	✓		✓
	Timing Network Integration Engineer	✓	✓	✓	✓	
2	AI Ops Manager	✓	✓	✓		✓
	Geodesy & Reference Frame Specialist	✓	✓	✓	✓	✓
	PNT Risk, Incident & Continuity Manager	✓	✓	✓	✓	✓
	PNT Standards & Regulatory Affairs Officer	✓	✓	✓	✓	✓
3	PNT Procurement Manager		✓	✓	✓	
	PNT Systems Architect	✓	✓	✓	✓	✓
	PNT Strategy & Programme Lead	✓	✓	✓	✓	✓
4	PNT Policy Lead	✓	✓	✓	✓	✓

Table 4 FOP by Role Level mapped across supply chain partners.

2.2.4 Priority FOPs

The FOPs were reviewed by the expert cycle participants against the context of importance to the sector, demand, and mapping against current provision. The following FOPs have been prioritised for initial action and further analysis. The FOPs outlined below have been identified as key roles within the future workforce, essential for delivering the capabilities required to drive industry transformation, enabling the adoption of robust sovereign PNT technologies and parallel contingency systems.

As part of the strategic workforce planning, Future Occupational Profiles (FOPs) were identified and prioritised based on a set of key criteria. A Priority FOP is a role that is critical to future success and must be developed ahead of others to meet evolving business needs.

These roles were 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.

Insight:

1. PNT Signal Integrity Engineer

The role will advance from monitoring GNSS signals to designing intelligent, multi-source architectures for continuous positioning. It will integrate AI, multi-source fusion (GNSS, 5G/6G, signals of opportunity), backed by resilience test protocols and robust user equipment to detect disruptions, enable rapid failover, and ensure operational integrity for critical infrastructure. By delivering secure, high-integrity signal environments and enabling assured performance across diverse sensor inputs, this role is pivotal to supporting disruption-tolerant PNT capabilities for the UK's critical infrastructure.

2. Quantum Technologies Systems Engineer

This role will transition from supporting precision timing systems to designing and integrating quantum-enabled PNT solutions, advancing GNSS-independent timing and navigation through optical and quantum-based technologies. It will drive miniaturisation, scalable manufacturing, and precision calibration to deliver resilient, high-accuracy solutions for critical infrastructure. By embedding quantum-secure timing and navigation capabilities into future PNT architectures, this role is essential to delivering GNSS-independent assurance and strengthening the UK's ability to maintain precise operational continuity across critical sectors.

3. PNT Strategy & Programme Lead

This role will shift from coordinating existing programmes to delivering national PNT strategies through advanced technology integration and stakeholder alignment. It will manage complex initiatives that embed resilience and sovereign capabilities into governance frameworks for critical infrastructure security. By shaping cohesive, sovereign PNT roadmaps and driving cross-sector adoption of assured capabilities, this role is central to delivering a disruption-tolerant national PNT ecosystem and strengthening the UK's ability to safeguard critical services.

4. Geodesy & Reference Frame Specialist

This role will move beyond maintaining geodetic systems to designing and managing advanced platforms that monitor GNSS integrity, detect interference, and integrate augmentation data. It will develop and protect national reference frames, apply space-weather

insights, and ensure secure, accurate positioning for critical UK infrastructure. By delivering precise, secure, and interference-resilient positional foundations, this role becomes essential for protecting critical infrastructure and accelerating the uptake of trusted positioning across the UK.

5. PNT Simulation Specialist

The role will evolve from performance testing to developing advanced digital twins and simulation platforms for PNT infrastructure. It will model complex scenarios, integrate cybersecurity testing, and optimise designs to ensure reliability under diverse simulated operational and environmental conditions. By delivering high-fidelity modelling environments and validating system behaviour under stress, this role is critical to enabling required PNT capabilities and supporting the design of robust architectures for the UK's critical services.

6. PNT Systems Architect

This role will progress from designing conventional architectures to implementing multi-layered, fault-tolerant PNT systems with sovereign capabilities. It will lead innovation in satellite payloads, secure communications, and interoperability to ensure continuity and protect critical infrastructure from emerging threats. By defining PNT architectures and integrating secure, multi-path positioning and timing solutions, this role is pivotal to delivering disruption-tolerant national capabilities and ensuring dependable operation across the UK's critical infrastructure.

7. PNT Test & Validation Engineer

This role will move from routine functional testing to designing and executing advanced protocols that validate PNT resilience against jamming, spoofing, and GNSS denial. It will implement automated frameworks, failover drills, and integration testing to ensure secure, reliable performance across all platforms. By verifying performance under contested and degraded conditions and certifying system robustness against real-world threats, this role is essential to delivering PNT capabilities and ensuring dependable operation across the UK's critical services.

8. Timing Network Integration Engineer

This role will progress from maintaining existing timing systems to designing, integrating, and certifying advanced, resilient timing networks. This role will hybridise systems including but not limited to quantum, optical, and terrestrial network technologies, ensuring resilience to GNSS disruption. It will enable secure, scalable infrastructure and interoperability to protect critical services and support national resilience. By delivering assured, multi-layer timing architectures and certifying GNSS-independent synchronisation pathways, this role is fundamental to enabling disruption-tolerant PNT capabilities and ensuring dependable operation across the UK's critical services.

9. PNT Risk, Incident & Continuity Manager

The role will progress from managing recovery plans to leading integrated risk and continuity strategies for PNT systems. It will use automated workflows, scenario testing, and multi-layered contingencies to anticipate threats, ensure rapid recovery, and maintain uninterrupted operations during GNSS disruptions. By embedding high-assurance risk analysis and coordinated incident response across PNT architectures, this role becomes vital to safeguarding critical services and supporting the UK's shift toward trusted and disruption-tolerant positioning capabilities.

10. RF Hardware Engineer (PNT)

This role will evolve from developing and testing standard GNSS receivers to designing advanced RF hardware for resilient PNT systems, integrating multi-source receivers, software-defined radios, and interference mitigation. It will drive antenna innovation and secure

architectures to ensure reliable positioning and timing across critical infrastructure. By delivering robust RF front-ends and interference-tolerant architectures, this role is central to enabling sovereign, assured PNT performance and ensuring dependable operation across the UK's critical infrastructure systems.

Links: See Appendix C (**C List of full FOPs by Role Level including capabilities and proficiency**) and visualisation tool for **10 FOPs**.[15]

[15] Visualisation tool https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=5d597bde255085e040d570bc7f94b33d

2.3 Education and Training provision insights

A note on existing Training Provision; Apprenticeships, University Courses, and CPD Provision.

Workforce Foresighting is primarily designed to compare future skills requirement as defined within workshops against Apprenticeship standards. However, as a highly specialist sector, and utilising data from the Space Skills Census from recent years, it has been established that the majority of the existing space sector workforce holds university degrees, and usually at least a Masters in a relevant postgraduate degree.[16] As such, for the purposes of this cycle, custom input capabilities were included from a sample of degree courses (please note that this is not an exhaustive review, and more work could be done here) so that provision for these capabilities are more pragmatically mapped against the likely educational pathways into the sector.

This cycle does not map these capabilities against existing CPD courses, as there is not a consistent system of capabilities defined by those courses. However, to review CPD provision available for PNT, it is recommend utilising the Space Skills Alliance Space Training Catalogue, which collects a regularly updated overview of CPD courses and other training offerings across the UK.[17] This does not, however, present a particularly rosy view of provision for PNT; 43 training opportunities identified quickly turns to 23 when refined to currently available courses or short courses, the majority of which are accompanied by a considerable investment in funds. The leading CPD provision recommended by this report are those run by the Royal Institute for Navigation.

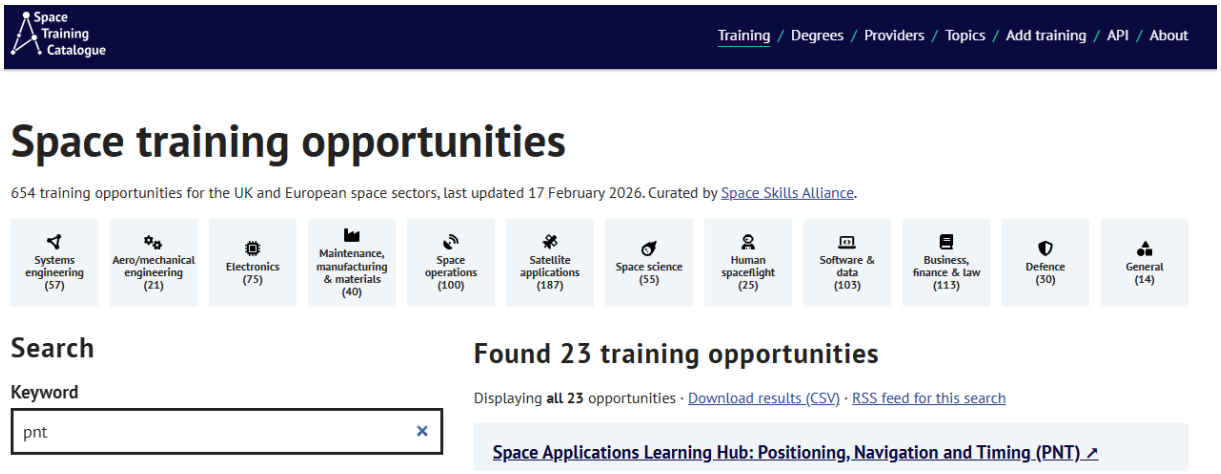


Figure 13 Space Skills Alliances' Space Training Catalogue, filtered to review current courses and short courses tagged with PNT training provision.

[16] *Space Skills Census* undertaken by the Space Skills Alliance. Available: https://spaceskills.org/#demographics
In the 2020 Census, in answer what their highest qualification was; 7% Apprenticeship, 22% Bachelor's degree, 38% Masters Postgraduate Award, 30% PhD.
[17] *Space Skills Training Catalogue*, Space Skills Alliance. Available: https://training.spaceskills.org/

2.3.1 Provision Analysis of FOPs and Capabilities

Below is a comparison of each priority FOP against highest scoring existing education provision. The tables highlight the highest-scoring standard for each and identify capabilities that are not currently addressed by the selected standard. These unmet capabilities could inform the development of future education and training provision, either by adapting existing programmes or through the creation of short continuing professional development (CPD) courses aimed at upskilling the current workforce.

Please note: the following 10 roles have been highlighted and analysed using the Visualisation tool. There are 10 other roles identified in this cycle which can be analysed as below using the FOP vs Provision page on the Future State Vs Current Provision tab.[18]

PNT Signal Integrity Engineer
Role Level: Professional/Tactical Specialist

Key Tasks: Detect and mitigate spoofing and jamming; test PNT resilience; fuse GNSS with alternative signals; develop AI and classical algorithms; use 5G and signals-of-opportunity; prototype multi-source receivers; design integrity and failover architectures; monitor signal paths and space-weather effects; maintain timing and geodetic frameworks.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government.

In FOP vs Provision there was a 64.0% Fit with Technological University Dublin Geospatial Engineering and Data Management MSc (including all module options). The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Develop algorithms to detect and mitigate GNSS spoofing and jamming attacks.
DESIGN	Develop and implement a nationally separable terrestrial timing infrastructure to ensure national resilience against GNSS disruptions.
DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.
IMPLEMENT	Monitor ionospheric perturbations to improve the reception of signals from space.
IMPLEMENT	Monitor PNT signal paths to maintain service delivery.
IMPLEMENT	Maintain a national geodetic reference frame to ensure the accuracy of position and time signals for the UK.
SUPPORT	Study the effects of space weather on space-based PNT systems to inform development of more resilient solutions.
ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.
ENTERPRISE	Augment PNT systems with AI analytics to reduce and manage disruption impacts, ensuring consistent and reliable PNT services.

Table 5 PNT Signal Integrity Engineer capabilities not served by Technological University Dublin Geospatial Engineering and Data Management MS.

[18] FOP vs Provision https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=97f32699b61bd02b863f006b3dbc6e28

The above list of capabilities within the PNT Signal Integrity Engineer that are not met by existing education programmes. This means these are areas where new training provision should be developed to support the future workforce needs. This role is likely to require a significant rise in the size of the workforce undertaking activities within this role profile.

As this represents a good coverage from the Technological University **Dublin Geospatial Engineering and Data Management MSc degree course,** at 64%, one action could be to protect the continuation of this degree training and undertake module content review to integrate these capabilities into the existing course. Alternatively, a bolder strategy could be inclusion of these recommendations into the development of a PNT specific HE courses, as even with a reasonable match factor, there is a surplus of training of 93.8% (the amount of the course that would be extraneous to this specific job role). In the short term, before these strategies render outcomes for the future workforce, these capabilities could provide the foundation for a curriculum for new CPD courses to upskill individuals from less specific educational training into specialists in this field.

Quantum Technologies Systems Engineer
Role Level: Professional/Tactical Specialist

Key Tasks: Develop quantum-enabled PNT systems; build optical and quantum ranging/time-transfer methods; create high-accuracy distributed time transfer; design quantum components; develop miniaturised and manufacturable quantum PNT devices; calibrate atomic-clock and RF subsystems; integrate optical precision timekeeping systems.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Infrastructure Operators and Government.

In FOP vs Provision there was an 42.9% Fit with Astronautics and Space Engineering MSc, Cranfield University (combination of modules). The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Design quantum components to support production of quantum-enabled PNT devices.
DESIGN	Calibrate PNT systems, including atomic clocks and RF subsystems, to ensure high accuracy.
DESIGN	Develop techniques for miniaturisation and scalable manufacture of quantum-enabled PNT devices to ensure practical deployment.
IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.

Table 6 Quantum Technologies Systems Engineer capabilities not served by Astronautics and Space Engineering MSc, Cranfield University.

Quantum technology is one of the arenas where the demand for workforce provision is not in the scale of engineers that will be working within this field in the short-term future, as this is still a technology a little further down the pipeline than many other aspects of this cycle. However, in order to maintain the UK's position and competitiveness with other countries, it is important to encourage sufficient provision for the education of future workforce into this field.

This review identified two courses with some coverage of the capabilities defined by the cycle, the second of which was highlighted above for this role as it represents lower surplus training:

- **Glasgow Geospatial & Mapping Sciences MSc/PgDip/PgCert (including all module options) | Fit 57.1% | Surplus 98.7%**
- **Astronautics and Space Engineering MSc (combination of modules) | Fit 42.9% | Surplus 95.8%**

However, it is recognised that there are also specialist master's courses available at Oxford and Strathclyde (amongst others) which likely represent reasonable coverage of these capabilities without the large amount of surplus training on their course curricula.

In addition, CPD courses include.

- **NQCC-Bristol Quantum Courses (University of Bristol & National Quantum Computing Centre six-week intensive course, £3000)**
- **An Introduction to Quantum & Hybrid Computing (University of Oxford one-day intensive, £120)**

PNT Strategy & Programme Lead
Role Level: Strategic Management

Key Tasks: Develop and prototype multi-source PNT systems; build data pipelines and interoperability frameworks; design alternative-source architectures; integrate advanced timing systems; manage suppliers and manufacturing; create policies on sovereignty, spectrum, and resilience; run risk, impact, and recovery planning; support innovation; lead stakeholder engagement; mentor staff.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government.

In FOP vs Provision there was an 29.2% Fit with Skills England Infrastructure asset management professional The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Prototype multi-source receivers to integrate GNSS, 5G, and other signals for robust positioning.
IMPLEMENT	Establish national test facilities to support the safe and efficient introduction of new PNT technologies.
IMPLEMENT	Design architectures that switch to alternative PNT sources when GNSS signals fail to maintain continuous service delivery.
IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.
IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.
IMPLEMENT	Implement data pipelines to integrate diverse PNT data sources, enhancing system resilience and reliability.
IMPLEMENT	Integrate multi-constellation and multi-frequency GNSS receivers to enhance signal resilience.
LOGISTICS	Collaborate with OEMs and SMEs to set up manufacturing lines for PNT technologies, enhancing supply chain resilience.
SUPPORT	Develop interoperability frameworks to integrate Positioning, Navigation, and Timing (PNT) with sector-specific systems, enhancing resilience and efficiency.
SUPPORT	Develop secure firmware to safeguard PNT systems against cyber threats, malicious damage, and environmental risks.
SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.
ENTERPRISE	Analyse business impacts and risks to determine recovery time periods and resource requirements.
ENTERPRISE	Implement strategic communication plans to inform stakeholders about the national security and economic benefits of resilient PNT systems.
ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.
ENTERPRISE	Develop strategies to integrate new technologies that maintain business relevance, improve operational efficiency, and support threat analysis.
ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.
ENTERPRISE	Develop policy to address social, economic, and fiscal impacts of PNT disruption.

Table 7 PNT Strategy and Programme Lead capabilities not met by Skills England Infrastructure asset management professional.

This role is one of the least well covered from the training provision, with the best match being:

- **Infrastructure asset management professional | Fit 29.2% | Surplus 77.8%.**

This is perhaps because this role represents an intersection of both technical and transferable skillsets, requiring the individual to have either strong awareness or expert-level engagement with the technical requirements of the sector, as well as a strategic and tactical approach to the direction the sector should take to improve the resilience of PNT systems across the UK. It is likely therefore that roles such as this are held by individuals with a long heritage in the sector, having undertaken more technical jobs before moving into this role. As such, training for this role is far more likely to be experience driven and less likely to be identified from a singular training route; instead for this role, the use of robust mentorship practices is recommended within the industry to facilitate the translation of technical expertise into strategic planning.

Geodesy & Reference Frame Specialist
Role Level: Operational Leadership

Key Tasks: Create and maintain the national geodetic reference frame; operate geodesy infrastructure; provide augmentation and validate signal data; monitor ionospheric, space-weather and GNSS signal integrity; detect interference; design and install monitoring systems; develop PNT monitoring standards; advise on regulatory protocols; mentor staff.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government.

In FOP vs Provision there was an 42.9% Fit with Newcastle Geospatial Artificial Intelligence MSc (including all module options). The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
IMPLEMENT	Advise on regulations and protocols, including trade embargoes and supply chain monitoring, to ensure compliance and secure operations.
IMPLEMENT	Monitor ionospheric perturbations to improve the reception of signals from space.
IMPLEMENT	ingest augmentation data via web services to validate position and signal intelligence.
IMPLEMENT	Monitor PNT signal paths to maintain service delivery.
SUPPORT	Design, test, and install new systems to monitor system performance post-commissioning.
SUPPORT	Monitor GNSS signals to detect and respond to spoofing and jamming attempts, ensuring resilient UK connectivity and infrastructure protection.
ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.
ENTERPRISE	Develop standards for monitoring PNT signals to detect interference and protect critical use cases.

Table 8 Geodesy & Reference Frame Specialist cpabiliites not served by selected provision

This role is one of the most specific, but also most crucial of those outlined in this cycle and has very high demands upon the expertise of individuals active in these roles.

From a national security perspective, it is recognised by stakeholders in defence and public bodies involved in mapping this cycle that this skillset is one that is both critical to the goal of having a nationally separable supply chain for PNT services, and one that is alarmingly under-served by young British nationals to create a secure succession of workforce. While this role is not likely to address a particularly large-sized workforce, the importance of establishing some resilience in the professionals working on Geodesy in the UK should not be underestimated.

Not only this, but the specialism level and depth of knowledge required by the workforce in roles like a Geodesy & Reference Frame specialist makes this a particularly weighty topic to approach when it comes to training; it is not a small ask to upskill practitioners in adjacent areas to hold true expertise in geodetics. A specialist in geodesy needs to understand, establish and maintain reference systems, reference frames, co-ordinate systems, and temporal reference systems, in order to develop high-accuracy time transfer and ranging methods. This would consider stability over time and guard against either accidental or

malicious factors which may cause drift over time, with the goal to manage the system of systems which deliver the required level of resilience in this area.

In order to support resilient PNT services, a geodesy specialist would also need to hold an understanding of alternative systems like eLoran and be aware of the needs of the global supply chain of geodetic products, including the UK contribution, to support a resilient supply chain. This level of intense expertise is unlikely to come solely from anyone training provider as it is likely to require mentorship and hands-on experience to provide adequate succession from the current workforce, but this study recommends that this issue is addressed swiftly and efficiently to support this critical part of the PNT workforce.

The visualisation tool identifies a best fit as follows, but this course, or any alternative, will likely require intervention to both ensure that it continues running, and to promote more workforce to undertake the training to specialise in this field:

- **Newcastle Geospatial Artificial Intelligence MSc (including all module options) | Fit 42.9% | Surplus 91.8%.**

Some work is already proposed in this field with interventions and professional development opportunities being scoped by both DSTL and Ordinance Survey.

PNT Simulation Specialist
Role Level: Professional/Tactical Specialist

Key Tasks: Develop low-SWaP payloads; build PNT testbeds and automated testing frameworks; run field tests and simulations; model PNT performance and vulnerabilities; simulate environmental and threat conditions; test spacecraft systems; create digital twins; establish cybersecurity and GNSS-denial simulation platforms.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Infrastructure Operators and Government.

In FOP vs Provision there was a 27.3% Fit with Skills England High integrity software engineer. The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.
DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.
DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.
DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.
IMPLEMENT	Simulate diverse environmental conditions to assess PNT device performance under realistic adverse scenarios.
SUPPORT	Establish cybersecurity simulation platforms to test and improve the security measures of critical infrastructure systems.
SUPPORT	Develop digital twins of UK PNT infrastructure and GNSS to support scenario planning and resilience testing.
SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.

Table 9 PNT Simulation Specialist capabilities not met by Skills England High integrity software engineer.

In a similar theme to those observed previously, this role has capabilities not covered by the existing provision that are highly specialised to PNT systems. The two best matches for training provision are as follows:

- **High integrity software engineer | Fit 27.3% | Surplus 85.7%.**
- **Software tester | Fit 27.3% | Surplus 80.0%.**

This demonstrates that there is some considerable need for these skills – especially where it pertains to technologies like digital twins, which is likely to be a technology area applicable to multiple space-enabled applications.

PNT Systems Architect
Role Level: Strategic Management

Key Tasks: Develop multi-layer PNT architectures; design auto-switching failover mechanisms; build interoperability frameworks; integrate PNT resilience into governance and risk systems; develop national-security compliance frameworks; implement automated PNT testing pipelines; run integration and interoperability tests; develop sovereign/nationally separable PNT policies; establish regulatory and cybersecurity frameworks; deploy and assess LEO-based PNT solutions; design low-SWaP satellite payloads; develop spectrum-sharing policies; implement multi-layer PNT security protocols; assess and upgrade infrastructure for PNT resilience; support early-stage PNT innovation; mentor new recruits and build organisational capability.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government

In FOP vs Provision there was a 17.6% Fit with TU Dublin Geospatial Engineering and Data Management MSc (including all module options).[19] The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.
DESIGN	Conduct integration testing for distributed PNT systems to ensure interoperability and performance.
DESIGN	Deploy low Earth orbit satellite constellations to enhance PNT signal resilience and coverage.
DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.
IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.
IMPLEMENT	Develop fault-tolerant architectures to ensure continuous operation of critical infrastructure during PNT disruptions.
SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.
SUPPORT	Develop and enforce regulatory frameworks to strengthen the cyber defences and resilience of critical infrastructure sectors.
SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.
SUPPORT	Assess and enhance infrastructure to improve resilience against PNT disruptions.
ENTERPRISE	Integrate PNT resilience strategies into existing governance and risk management frameworks.
ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.
ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.
ENTERPRISE	Implement multi-layered security protocols to protect PNT data and communications from malicious and accidental threats.

Table 10 PNT Systems Architect capabilities not met by Tech Uni Dublin Geospatial Engineering and Data Management MSc

[19] TU Technological University Dublin

This role profile represents a core role which will enable the infrastructure development that is required to support interoperability between GNSS and alternate PNT systems and therefore is key for the future ability to deliver on the improvements required to make PNT services more robust.

This role has particularly poor coverage from existing training provision with the two best options being:

- **Astronautics and Space Engineering MSc, Cranfield University (combination of modules) | Fit 29.4% | Surplus 95.8%.**
- **Tech Uni Dublin Geospatial Engineering and Data Management MSc (including all module options) | Fit 17.6% | Surplus 96.6%.**

Here, we've highlighted the course at the Technological University Dublin, as this includes more of the specialist skills for PNT, but an alternative approach would be to support the Space Engineering MSc at Cranfield, and then support that individual's training pathway by developing a CPD programme that would specialise a more generalist skillset into the required skills for a PNT Systems Architect.

While logically, a Systems Engineering degree should be applicable to this role, these degree courses are similarly poorly supported, and with the high level of specialisation required, the visualisation tool only identifies a match at 5.9%, further underscoring the need for course development to support this future role.

PNT Test & Validation Engineer
Role Level: Professional/Tactical Specialist

Key Tasks: Design and install performance-monitoring systems; automate PNT device testing; develop jamming/spoofing resilience tests; build and run PNT testbeds; conduct field tests, simulations, and GNSS-denial exercises; test spacecraft systems and install mission subsystems; run resilience and environmental assessments; conduct failover drills and security acceptance tests; perform functional, integration, and supplier quality checks; use customer feedback for continuous improvement; maintain regulatory compliance and update standards; install and test remote sensing stations; design low-SWaP satellite payloads.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government.

In FOP vs Provision there was an 26.1% Fit with Skills England Space engineering technician. The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.
DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.
DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.
DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.
DESIGN	Implement resilience analysis tools to evaluate and enhance robustness of interconnected infrastructure networks.
DESIGN	Test security measures for final acceptance.
DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.
IMPLEMENT	Simulate diverse environmental conditions to assess PNT device performance under realistic adverse scenarios.
IMPLEMENT	Evaluate and review system function tests to ensure regulations and protocols remain effective and fit for purpose.
LOGISTICS	Conduct quality and compliance checks on all goods and supplier processes to ensure standards are met.
SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.
SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.
ENTERPRISE	Use customer feedback and failover testing to continuously improve product performance and ensure reliable service delivery.
ENTERPRISE	Respond to customer feedback on quality and implement amendments to maintain consistent delivery and meet service standards.
ENTERPRISE	Adapt to changing national regulatory and compliance requirements.
ENTERPRISE	Develop and maintain policies and procedures that comply with government requirements to ensure legal and regulatory adherence.
ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.

Table 11 PNT Test & Validation Engineer capabilities not served by selected provision.

For this profile, the highest matches come from two apprenticeship standards, suggesting a gap in the Higher Education course provision, and room for improvement in the apprenticeships available to train for this role, as again the matches represent non-specialist training with a large amount of the training delivered by the course being irrelevant to this role:

- **High integrity software engineer | Fit 30.4% | Surplus 71.4%**
- **Space engineering technician | Fit 26.1% | Surplus 40.0%**

It is would recommend that any adaptation would be made to the Space Engineering Technician course, as that represents less surplus, and would outfit the individual to multiple areas within the space sector that experience this pressure point in workforce demand; Satellite Applications Catapult identified a similar need in the Test & Validation Engineers for 5G/6G Telecommunications services, and electronics design in general has been identified by the Space Skills Alliance as one of the most challenging areas for space sector businesses to recruit from.[[20][

Again, alternative solutions would be to deliver CPD training courses to serve key roles in order ensure sovereign protection of the workforce required to enable this technology area.

[20] Space Skills Alliance, Space Sector Skills Survey 2023, 13th September 2023. [Online]. Available: https://spaceskills.org/reports/space-sector-skills-survey#recruitment-by-skills-theme. [Accessed 19 February 2026].

Timing Network Integration Engineer
Role Level: Professional/Tactical Specialist

Key Tasks: Develop quantum and eLORAN PNT; build UK-compliant certification pathways; operate national PNT services; integrate optical precision timing; develop PNT interoperability and nationally separable compliance; secure sovereign supply chains; build multi-constellation receivers and 5G localisation; deploy hybrid optical-wireless timing networks; run resilience analysis and manage spectrum access; develop free-space optical and quantum time transfer; maintain distributed and terrestrial timing networks; manage specialist timing-equipment logistics; maintain the national geodetic reference frame.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Infrastructure Operators and Government

In FOP vs Provision there was an 50.0% Fit with Glasgow Geospatial & Mapping Sciences MSc/PgDip/PgCert (including all module options). The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Develop and implement terrestrial eLORAN systems to provide resilient backup positioning and navigation services.
DESIGN	Implement resilience analysis tools to evaluate and enhance robustness of interconnected infrastructure networks.
IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.
LOGISTICS	Secure essential product and service supply chains including identifying sovereign requirements and nationally separable alternatives.
LOGISTICS	Develop specialist shipping solutions for precision timing equipment to ensure safe handling and timely delivery across global destinations.
SUPPORT	Develop certification pathways to ensure compliance with UK standards for resilient Positioning, Navigation, and Timing (PNT) systems.
SUPPORT	Operate and maintain PNT systems daily to provide accurate and resilient positioning, navigation, and timing services across the UK.
SUPPORT	Develop interoperability frameworks to integrate Positioning, Navigation, and Timing (PNT) with sector-specific systems, enhancing resilience and efficiency.
SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.

Table 12 Timing Network Integration Engineer capabilities not served by Glasgow Geospatial & Mapping Sciences MSc/PgDip/PgCert

The closest educational training provision for this role is:

- **Glasgow Geospatial & Mapping Sciences MSc/PgDip/PgCert (including all module options) | Fit 50.0% | Surplus 98.1%**

However, this course is focused far more on the geographic elements of this capability than those for timing, which is reflected in the high surplus of provision in this area.

The National Physics Laboratory (NPL) have developed three timing nodes with Universities across the UK, at Cranfield, Surrey, and Strathclyde, to support their NTC Programme.[21]

[21] NPL, Timing Innovation Nodes [Online] Available: https://www.npl.co.uk/ntc/innovation-nodes [Accessed 19 February 2026].

These support research underway at these universities, but existing courses at these Universities do not provide specialist education in Timing Network integration below postgraduate study (at time of writing):

- **Ubiquitous Cognitive Navigation with AI Based Systems PhD, Cranfield University.[22]**
- **Hybrid monolithic lasers for quantum-enabled position, navigation & timing PhD, Strathclyde University.[23]**

[22] Cranfield University, Ubiquitous Cognitive Navigation with AI based Systems PHD, [Online] Available: https://www.cranfield.ac.uk/research/phd/ubiquitous-cognitive-navigation-with-ai-based-systems-phd. [Accessed 19 February 2026].

[23] Strathclyde University, Hybrid monolithic lasers for quantum-enabled position, navigation & timing PhD, [Online] Available: https://www.strath.ac.uk/studywithus/postgraduateresearchphdopportunities/science/physics/hybridmonolithiclasersforquantum-enabledpositionnavigationtiming/ [Accessed 19 February 2026].

PNT Risk, Incident & Continuity Manager
Role Level: Operational Leadership

Key Tasks: Run GNSS-denial exercises and failover drills; map critical assets and dependencies; implement hardware/software/human contingencies and automated failover; design GNSS-mitigation and rapid-recovery protocols; assess risks and business impacts and embed in governance; identify alternates and manage supplier continuity; engage operators on resilience needs; execute business recovery; mentor recruits; develop/maintain early-warning systems; assess space-weather impacts on PNT.

Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Regulators, Infrastructure Operators and Government

In FOP vs Provision there was a 39.1% Fit with Skills England Resilience and emergencies professional, The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
LOGISTICS	Identify assets and facilities critical to national security to implement appropriate protection measures.
LOGISTICS	Develop automated continuity workflows to enable rapid failover to alternative PNT sources during GNSS outages.
LOGISTICS	Identify suitable alternatives for system components to maintain service continuity and operational resilience.
LOGISTICS	Select suitable replacements when items are unavailable to maintain service continuity.
LOGISTICS	Design and implement contingency protocols to mitigate GNSS vulnerabilities and ensure continuous operation of essential systems.
SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.
SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.
SUPPORT	Develop software security contingency plans to protect PNT systems from cyber threats, malicious damage, and environmental risks.
SUPPORT	Develop early warning defence systems to support national security objectives.
SUPPORT	Maintain early warning defence systems to support national security objectives.
SUPPORT	Study the effects of space weather on space-based PNT systems to inform development of more resilient solutions.
ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.
ENTERPRISE	Build contingencies for human-driven and machine-learning risk alert systems.
ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.

Table 13 PNT Risk, Incident & Continuity Manager capabilities not served by Skills England

This role is the only one with zero surplus, meaning that every capability described by the apprenticeship for Resilience and Emergencies Professional is captured within the role's capability requirements: **Resilience and emergencies professional | Fit 39.1% | Surplus 0.0%**

In this case, the data available supports the development of CPD provision that would upskill professionals with this skillset into the specialisms required for PNT support. This is the case

for multiple of the security/defence sector roles that are identified both by this foresighting activity for PNT, and others undertaken by Satellite Applications Catapult for other emerging technologies in space.

Please also see the profile for the PNT Cyber Security Engineer, which has a low surplus match with:

- **Cyber security technologist (2021) | Fit 33.3% | Surplus 17.4%**

RF Hardware Engineer (PNT)
Role Level: Professional/Tactical Specialist

Key Tasks: Develop low-cost resilient GNSS antennas; prototype multi-source GNSS/5G receivers; build SDR-based adaptive PNT processing; integrate multi-constellation/multi-frequency GNSS; install and test radionavigation reference stations; implement multipath mitigation for urban accuracy; design PNT semiconductor IP; deliver multi-source user equipment for critical infrastructure; plan hardware redundancy for PNT systems; run functional subsystem tests; develop multi-constellation satellite receivers; automate PNT device validation; install spacecraft subsystems; design low-SWaP satellite payloads.
Aligned to supply chain partners: RTO/COI – Research & Innovation Organisations, Original Equipment Manufacturers (OEMs), Primes, Tier-1s, Small to Medium Enterprises (SMEs), Infrastructure Operators and Government

In FOP vs Provision there was a 50.0% Fit with Astronautics and Space Engineering MSc (combination of modules). The unmatched FOP capabilities are shown in the table below:

Function Area	Capability Statement
DESIGN	Prototype multi-source receivers to integrate GNSS, 5G, and other signals for robust positioning.
DESIGN	Direct installation and testing of remote sensing hardware or software, such as radionavigation reference stations, to ensure operational readiness.
DESIGN	Design semiconductor intellectual property to support development of indigenous PNT equipment.
DESIGN	Conduct functional tests of PNT subsystems to verify compliance with performance standards.
DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.
IMPLEMENT	Implement multipath mitigation techniques in GNSS receivers to improve positioning accuracy in built-up environments.
SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.

Table 14 RF Hardware Engineer (PNT) capabilities not served by Skills England

These specific industry requirements above are not currently addressed in existing education programmes. The best fit available in the survey undertaken in this study was from Cranfield's Astronautics & Space Engineering MSc:

- **Astronautics and Space Engineering MSc (combination of modules) | Fit 50.0% | Surplus 91.7%.**

Therefore, the inclusion of relevant modules or industry-specific CPD programmes focusing on these capabilities could be beneficial for future education and training initiatives.

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

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

1. **Informing / Guiding understanding of 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 provide a practical framework for how education must evolve to support that transformation. Tags associated with capabilities that align well with current educational provisions may also reveal shifts in KSBs. Capabilities introduced during the cycle will also have the 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 the visualisation tool for a more detailed and interactive engagement with the data. 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.

2.3.3 Most frequent tags

The following graphic 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.

Most frequent Knowledge Tags

Tag	Tag Frequency
Global Positioning System (GPS)	27
Satellite Engineering	26
Geopositioning	25
Radio Navigation	25
Information Security	18
Regulatory Compliance	17
System Testing	15
Cyber Threat Intelligence	13
Radar Systems	13
Risk Management	12
Supply Chain Security	12
Space Domain Awareness	11
System Integration	11
Business Continuity Planning	10
Disaster Recovery	10
Communication Resilience	9
Computer Security	8
Reliability Engineering	8
Security Engineering	8
Security Testing	8
Communications system security	7
Computer And Information Security	7
Electronic Signals Intelligence	7
precision time protocols	7
Software Testing	7
Supply Chain Management	7
Conformance Testing	6
Design For Space Environment	6
Functional Testing Software	6
Radio Receivers	6
Signal Processing	6
Assembly integration and testing (AIT)	5
Geomatics	5
Network Engineering	5
Network Monitoring	5
PNT Systems	5
Procurement	5
Security Policies	5
Signal Transmission	5
Simulation Software	5

Table 15 Most frequent Knowledge Tags

Most frequent Skills Tags

Tag	Tag Frequency
Operate satnav systems	27
Identify and manage cybersecurity threats	26
Conduct cyber security risk assessments	25
Integrate systems and software	25
Plan and implement technical emergency plans	18
Analyse signal integrity	17
Operate remote sensing equipment	15
Create and maintain business continuity plans	13
Manage multi-frequency wireless signal distribution	13
Monitor organisational compliance with regulations	12
Operate emergency communication systems	12
Test performance of equipment and instruments	11
Use Radio Frequency (RF) monitoring equipment	11
Manage disaster recovery plans	10
Monitor satellites	10
Secure infrastructure operations	9
Manage organisational supply chains	8
Test mechanical systems and equipment	8
Update cyber security policies	8
Design and simulate spacecraft systems	8
Research engineering applications of emerging technologies	7
Review operational compliance with regulatory requirements	7
Develop information security policies	7
Develop NDT technologies	7
Gather and analyse cyber threat intelligence	7
Implement supply chain traceability systems	7
Interpret design or operational testing data	6
Monitor manufacturing compliance with industry regulations	6
Use safety critical communication protocols	6
Conduct dynamic risk assessments	6
Develop alternative supply chains	6
Develop guidelines for system implementation	5
Evaluate system and service performance metrics	5
Operate radar equipment	5
Plan supply chain logistics	5
Prepare regulatory or compliance documentation	5
Produce ultra-precision mechanical systems	5
Provide advice on cyber security	5
Conduct supplier audits	5
Develop antenna modelling	5

Table 16 Most frequent Skills Tags

This data serves as a starting point to identify emerging knowledge and skill areas that may not be traditional 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 to examine the knowledge, skills, and behaviours (KSBs) unique to a specific capability or Future Occupational Profile (FOP), enabling more informed decision-making.

2.4 Priority evaluation of underserved and high demand capability themes

Educators conducted a targeted review of capability statements and Future Occupational Profiles (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

A number of themes emerged from the clustering of capability statements with high demand and low provision. These themes reflect 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. **PNT System Resilience & Alternative Positioning Solutions.**
2. **PNT Infrastructure Development & Integration.**
3. **Regulatory Frameworks, Standards & Certification.**
4. **Cybersecurity, Threat Mitigation & National Security Assurance.**
5. **PNT Technology Innovation & Research.**
6. **Service Assurance (Spectrum Management, Signal Assurance and Equipment & Services Testing).**

These themes were identified within the cycle workshops from the large gaps presented by the coverage of apprenticeships standards for PNT training but were then cross-checked against the 25 capabilities still remaining uncovered even with a much more complete capability mapping with the addition of data from higher education institutions.

Meeting these six priority PNT capability themes demand a workforce shift toward specialised PNT expertise, developed through new training pathways, integrated into adjacent engineering and cyber disciplines, and reinforced through targeted upskilling and reskilling to close critical technical and systems-integration gaps. Addressing these gaps will require coordinated efforts between educators, industry partners, and curriculum designers to ensure future professionals are equipped for evolving occupational demands.

Insight

1. **Perception and Application;** embedding PNT use-cases in earlier education. In order to begin students on pathways that lead into PNT technology areas, we need to raise awareness amongst students about PNT applications as a potential future career path, and encourage that understanding through use cases which inspire students with the real-life implications & power of PNT systems, both to create efficiencies and unlock technologies that benefit society, and also therefore how crucial it is for those services to be protected.

   This could be done through curriculum change at lower years including practical applications of PNT technologies, or also the promotion of summer schools (like that run by ESA) or student competitions which drive awareness and interest into challenge areas.

   There is a reflection of this piece to be made not for prospective students of PNT, but for more general awareness that establishes a wider understanding of how critical this field is, and how much it underpins so many systems that we as a society have come to take for granted. Once this understanding grows, the interest in support PNT systems from young people will logically follow.

2. **Module design for University Courses**
   Many of the priority capability themes could be adequately covered with revision or addition of just a few key modules per Higher Education degree course, rather than the creation of a specific PNT degree, though it is likely enough material could be developed to support one. This would mitigate the concern that specialist degree courses – especially without perception change as discussed above – do not see enough uptake to represent sufficient future workforce coverage.

3. **Specialisms – is a PhD always required?**
   Currently, it is recognised that often specialised study for PNT requires at the very least master's level postgraduate study, and very often a PhD. While it is recognised that some of the areas explored in this cycle may require the intensity of study of a PhD, it would be beneficial for the diversity of this field to reduce the financial burden of study and promote routes to PNT specialisation that can be learned at work.

4. **Upskilling from 'non-PNT' degrees & apprenticeships**
   There was also an assessment that for some capability themes – especially those around cybersecurity and the protection of national security – a non-PNT or even non-space specialist education could potentially be accepted by recruiters, if the candidate were to hold training which was strategically designed to upskill them in PNT.

5. **Accreditation and certification as a driver for Universities**
   A major driver of course reform would be course sponsorship, accreditation, and potentially also the certification of career pathways into PNT. The suggestion was made that this might be driven from stakeholders within regulation and government to intercede and establish these standardisations in workforce readiness for this field. Such accreditation standards could be applied to those professional training courses that seek to upskill the workforce, as well as those preparing future cohorts. It would be the recommendation of this study for such accreditation to flow through an entity such as the Royal Institute of Navigation.

2.5 Summary of Key Recommendations

The identified themes in capabilities that are not well covered by existing training provision span the PNT system landscape and underscore the scale of the skills issue that those working in PNT industries will have often experienced.

That the capabilities that do experience the best matches exist within logistics and support reflects the heritage and maturity of this sector, building on strong foundations of infrastructure that would utilise these adaptations without too many significant skills challenges. Where potential pressure points are evident is predominantly in design and implementation, where new technologies will need to be modelled, tested, and then integrated into the existing networks. Not only will this require skills in innovation, and the problem-solving behaviours to solve the challenge of interoperability of these multiple systems, but it will require an agile, adaptable, and engaged regulatory landscape, where standardisation and governance is encouraged to keep pace with both national and international collaboration.

The priority future occupational profiles, and their closest matches in existing provision, highlight the vulnerabilities in this skills landscape, demonstrating that there is a wide range of highly specialised roles required to enable this emergent technology area.

The Foresighting challenge has also thrown into sharp relief the reliance upon university education for the capabilities matched in this cycle – while it is initially encouraging that there is good provision in some areas, it is recognised that:

A. The capabilities uploaded as part of a HE courses include all module options; therefore, it is not feasible for one singular individual to receive training on every capability.

B. Many of these HE courses have low course sign-up, and the likely outcome for either highly specialised, or simply ‘unpopular’ courses with low uptake is for institutional pressures to result in the cancellation or generalisation of courses. This means that this crucial provision is both underutilised by incoming students, and at risk of succumbing to pressures within the HE system.

C. True resilience in this sector will be the result of multiple training pathways into the sector. It is already the case that often in order to achieve the specialisation required for many PNT roles, individuals undertake PhD studies. We must encourage alternative routes into PNT that encourage FE career pathways, degree apprenticeships, and CPD training that allows existing workforce to develop their specialist skills without requiring further postgraduate study, and therefore without incurring higher training costs that might dissuade workforce from preparing to enter into roles in PNT.

To address **the six key capability gaps** identified, the following headline recommendations were proposed:

- **Apprenticeships for PNT** – a rethink of alternate routes into PNT
  If routes for apprentices to head into PNT are desired, we need considerable development of new standards. This must also recognise that many of the capabilities that are matched are at high levels (6-8), and
  therefore additional apprenticeship standards would likely lend themselves to degree apprenticeships.

- **Higher Education course provision** – promotion & protection
  University course subject matter is overall a good match for the education required, but the numbers attending these courses are not enough, or those taking up these courses are not then finding their way into PNT job roles. This means more career pathway development is required to encourage more students into PNT, be that either through university or through apprenticeships. This underscores
  a perception issue common across much of telecommunications
  and would benefit from more information being made available about these courses and future careers, to encourage more uptake of the courses already available. We would also suggest that in those cases where job roles represent a sovereign risk, or at least one of interest to national security, but not necessarily requiring a large standing workforce, courses are protected against the pressures Universities are currently under which tends to encourage the generalisation of course design, rather than protecting key specialisms.

- **Proactive Upskilling** – Professional development of both existing and incoming workforce
  If we must accept that not all prospective applicants for these roles will have received PNT specialist training, we must prepare to upskill individuals from more generalist courses, and prepare them for work in PNT, without the perceived requirement to specialise via PhD studies. This involves the reinvigoration of CPD courses for PNT that upskill existing workforce.

- **Targeted Security Interventions**
  Where there are specific roles that represent pressure points for national security, increased collaboration with defence partners could encourage the training of specialists in key positions.

4.

3. Conclusion & Next Steps

3. Conclusions and Next Steps

To drive meaningful, efficient, and effective interventions which help to close the skills gap for the future workforce in this technology area, we must have a cohesive approach. Strategic investment must be driven with a deep understanding of the emerging innovations in this field, and Satellite Applications Catapult thanks all the experts who attended the workshops to embed that knowledge into the data that underpins this report.

This understanding has then been formulated into a skills requirement that is both granular (listing key capability statements for each future occupational profile) and thematic (identifying key areas and the responsibilities for each part of the supply chain).

More than many other challenges on the horizon, creating resilient PNT systems either through more robust GNSS or through contingency with alternative PNT signals, is a task that will require drive from across the future supply chain, with clear need for leadership to steer us forward using a holistic approach.

There are multiple government stakeholders and infrastructure operators associated with government who are already cognizant of the challenge, and a clear awareness of the urgency of the problem. There is already some great work begun in skills development in this field, but the scale of the skills issues is large, from deep specialisms like quantum and geodetics, to the at-scale challenge of changing perceptions about careers in PNT. What is clear is that we must train a future workforce, from technicians to systems engineers, who can adapt, create and operationalise this system of systems into a network which ensures the secure and dependable service that many millions of people and pounds sterling are reliant upon.

This 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.

Future Capabilities & Roles: 145 future capabilities were identified, leading to **20 Future Occupational Profiles (FOPs)** across **5 supply chain partners**. This was compared against 830 Skills England Apprenticeship standards and a sample of Higher Education course provision, with the result that 121 of those future capabilities were addressed by a match above a semantic matching threshold of 48%, while 24 capabilities were not considered to be appropriately served.

These capability themes were prioritised because they directly address the most pressing challenges and gaps within the cross-section of critical needs and the lowest coverage of critical skills.

1. **PNT System Resilience & Alternative Positioning Solutions.**
2. **PNT Infrastructure Development & Integration.**
3. **Regulatory Frameworks, Standards & Certification .**
4. **Cybersecurity, Threat Mitigation & National Security Assurance .**
5. **PNT Technology Innovation & Research .**
6. **Service Assurance (Spectrum Management, Signal Assurance and Equipment & Services Testing).**

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, though the full list of the cycle can also be found in the appendix:

- **PNT Signal Integrity Engineer.**
- **Quantum Technologies Systems Engineer.**
- **PNT Strategy & Programme Lead.**
- **Geodesy & Reference Frame Specialist.**
- **PNT Simulation Specialist.**
- **PNT Systems Architect.**
- **PNT Test & Validation Engineer.**
- **Timing Network Integration Engineer.**
- **PNT Risk, Incident & Continuity Manager.**
- **RF Hardware Engineer (PNT).**

Education provision gaps:
As discussed in above section 2.4 (**2.4 Priority evaluation of underserved and high demand capability themes**) in more detail, the key strategies for addressing these areas vary depending on the capability theme that we might seek to address, here we highlight three:

1. **Perception and Career paths**; embedding PNT use-cases in earlier education
   Changing the perception of career pathways into PNT to drive more workforce into appropriate training and increase the appeal of careers in this area. This is the slowest activity, but the most impactful for long term change.

2. **Upskilling from 'non-PNT' degrees & apprenticeships**
   The most immediate change will be seen from addressing the existing workforce,

including those making career switches or not long out of education themselves. This study hopes to equip decision-makers and course designers with the information to make efficient CPD or short courses utilising apprenticeship levies which specialise those with a more generalist background into an appropriate PNT specialist skillset.

3. **Module design for University Courses**
   Adapt and build upon existing courses. While the ideal would be a specialist PNT course to address the specialist skills required for PNT, significant impact would be made by adapting existing modules with some of the insights provided in the visualisation tool.

Key Conclusions

The visualisation tool and the findings discussed above give a comprehensive map of both the overall scale of the problem, and the detail required to develop targeted responses to each of these challenges.

It highlights that:

- **There is not a one-size-fits-all response to the skills challenge.** Effective interventions could be made to address the different thematic areas, or to suit the resources available to make change, but the workforce challenge for PNT requires a cohesive strategy if the UK is to meet the potential growth of this technology area without future skills issues. These different areas could include:
- **Proactive Upskilling**, to support professional development of both existing and incoming workforce as this report identifies a key role type which could be served quickly in this way, and this could be done in a targeted manner to address specific security concerns.
- **Promotion & protection of Higher Education course provision**, as this report confirms that Higher Education provision would only require module-level adaptation, but these courses are under-subscribed and under pressure.
- **New apprenticeships for PNT**, as this report highlights that existing standards are not sufficient in most cases to prepare an individual for a career in PNT.

3.2 What this means for Industry

Earlier in the report, the distribution of capabilities highlighted that while we are building upon a mature communications landscape, much of the requirements around interoperability that are key for this resiliency to be effective fall under design work to create the layers of systems that could act in parallel or as contingencies, and new direction around that implementation from infrastructure operators and government. Further, as with many areas of the space sector many of the contracts that will drive the adoption of these systems will be commissioned by government contracts or at least steered by the direction set out in the latest strategic decisions.

The UK PNT market already has strong connections with its government stakeholders via fora like the PNT Committee meeting facilitated by TechUK and UKSpace, and this report would support the continued conversation around the skills challenge in spaces like those which convene together industry stakeholders to collaborate on the challenge ahead.
In other sectors, large businesses with the capacity to do so are more comfortable in 'overskilling' – supporting training programmes to increase the proportion of workforce with the appropriate skillsets, with the confidence that this will improve the overall talent pool from which they may then select. The space sector is made up of a strong majority of SMEs, and many of these skills challenges will be felt most keenly there, where workforce shortages

can have marked impact, and where resources to invest in counter strategies are more stretched.

However, where possible, this report would strongly encourage investment from businesses in the training of either existing staff or taking on the skills development of a new hire using training provision that is either already accessible via resources like the Space Skills Alliance Training Catalogue or developed using the data available in the visualisation tool.

3.3 What this means for Educators.

This report is mindful of the burden that falls on educators to adjust to the demand signals from multiple sectors, and the investment of time and effort to adapt current provision, as well as create new courses & curricula. Where possible, recommendations for change seek not to disrupt, but to build upon existing provision, with respect for the specialists already delivering training in these fields. This study instead underscores the critical importance of ensuring that skills provision for robust PNT systems are supported and protected.

The following activities are suggested:

1. **Protect or augment** those educational systems that are already serving the industry need using the data-driven evidence provided in this study to serve as a demand signal.

2. **Connect** with a consortia of educators from amongst those who contributed to this report and beyond, to continue work with the Catapult to translate the data generated by this study into the format(s) most useful to that audience to support the adaptation or generation of their education provision. This may involve collating capabilities identified from multiple Workforce Foresighting reports (both from Satellite Applications Catapult's portfolio and those across the Catapult network) to inform broader demand signals for degree courses (for example, Systems Engineering appears as a course in demand for multiple space applications).

3. **Target shorter-term interventions** in order to address the immediate need. By utilising the data included in this study, these activities could represent an efficient and effective intervention for the earliest part of the horizon window. This work would include the development of CPD courses that could be delivered to the existing workforce to augment their skillsets or to specialise individuals with more generalist skillsets into the expertise most crucially needed.

4. **Begin long-term ambitions**, like the development of new courses, apprenticeships, or larger scale outreach programmes to attract more students into this area of study. By connecting the experts involved in this study and those who interact with this report, we seek to connect industrial and academic stakeholders and embed these changes directly to ensure relevance and impact.

3.4 Summary of next steps

Communicating the outputs of this study, and the suggestions for how we might move forward on this challenge is crucial to its success, and as such this report will be presented to the PNT Committee & disseminated to as many pertinent stakeholders as possible. However, this report is merely the first in the next steps to be undertaken, and we encourage the community to engage and work with us to develop this work to best serve those addressing this challenge.

Suggested 3 - Stage Next Steps Plan for Delivering a Resilient UK PNT Workforce
Purpose This action plan provides a clear roadmap for delivering the skilled workforce required to build sovereign, resilient PNT capabilities and contingency systems. It identifies key stakeholders, outlines mechanisms for collaboration, supports curriculum alignment, and embeds a long-term foresighting cycle to ensure continuous alignment with evolving technologies.

Stage 1: Establish National Coordination & Governance (0-6 months)
Objectives

- Create a unified national approach to PNT workforce development.
- Provide leadership, funding alignment, and strategic direction.

Key Actions

1. Form a National PNT Skills Steering Group led by DSIT, National PNT Office, and Innovate UK, with representation from industry (OEMs, SMEs, Primes), academia, regulators, and end-user sectors (transport, energy, finance, defence).
2. Define national PNT workforce priorities using the 6 capability themes and 10 Priority Future Occupational Profiles identified in the report.
3. Integrate workforce planning into PNT investment programmes (eLORAN deployment, National Timing Centre developments, multi-orbit PNT R&D, quantum PNT initiatives).
4. Mandate annual reporting on workforce readiness and risks to sovereign resilience.

Key Stakeholders
DSIT, National PNT Office, Innovate UK, National Physical Laboratory (NPL), Ordnance Survey, CAA, MOD, Ofcom, Space & telecoms industry leaders, Royal Institute of Navigation (RIN), university consortia.

Stage 2: Strengthen Education Pathways & Protect Critical Courses (6–18 months)
Objectives

- Address urgent gaps in higher education and apprenticeship provision.
- Prevent the closure of critical geospatial, timing, RF engineering, and systems engineering courses.

Key Actions

1. Ring-fence funding for at-risk specialist degrees (geodesy, geospatial AI, space engineering, precision timing).
2. Develop a coordinated national curriculum framework aligned to Priority FOP capabilities.
3. Design industrial placements that facilitate sector needs
4. Create new Level 6–7 apprenticeship standards tailored to PNT Systems Engineering and PNT Resilience.
5. Introduce PNT curriculum modules into adjacent courses (cyber, RF engineering, data science, telecommunications).

6. Design CPD pathways to rapidly upskill practitioners, focusing on:
    a. Cyber-resilient PNT.
    b. Test & validation.
    c. Spectrum & signal assurance.
    d. Multi-source PNT integration.

Key Stakeholders
Skills England, universities, NPL Timing Nodes, Ofcom, RIN, Space Skills Alliance, FE providers, industry training academies.

Stage 3: Build National PNT Talent Pipelines and Embed hands on experience into educational provision (1–3 years)

Objectives

- Ensure the UK has the infrastructure and workforce capacity to support national rollout of resilient PNT solutions.
- Ensure continuous alignment between research, industry needs, and education.

Key Actions

1. Develop a National PNT Test & Evaluation Network connecting Catapult facilities, university test facilities, NPL nodes, and industry labs.
2. Embed industry placements into degree programmes and apprenticeships.
3. Create talent pipelines for priority roles, particularly where sovereign security requires UK nationals.
4. Create PNT Educator–Industry Compacts for shared curriculum development, CPD, guest lectures, and testing access.
5. Support national challenges, hackathons, and schools outreach to improve perception and awareness of PNT careers.

Key Stakeholders
Satellite Applications Catapult, National Positioning, Navigation and Timing Office (NPNTO), NPL, OEMs, SMEs, Local Skills Improvement Plans (LSIPs), DfE, regional innovation hubs.

Summary: Top Priorities for the Next 12 Months

What are the key actions:

1. **Communicate** findings to industry via the PNT Committee allowing dissemination to appropriate industry, government, and academic stakeholders.

2. **Collaborate** with government partners, including NPNTO and Defence Science and Technology Laboratory (DSTL), to align both commercial and security strategies around workforce development in this field.

3. **Encourage** (ideally through a funded programme) CPD courses which provide targeted upskilling to facilitate the specialisation of the existing or soon-incoming workforce into PNT roles most in demand.

4. **Protect,** where possible, University degree courses which support this sector, with intervention dependant on funding which could range from module design review to large scale development of a foundational PNT specific degree course.

5. **Explore** appropriate steps for apprenticeship pathways including degree apprenticeships.

6. **Embed** the breadth of career opportunities, and the ubiquitous applications of PNT technologies within outreach activities to change perceptions about the value of these roles amongst young people, including embedding application-based case-studies into curriculum design.

This three-stage plan sets out a focused and collaborative path to building the sovereign, resilient PNT workforce the UK urgently needs. By establishing strong national coordination, protecting, and modernising critical education pathways, and embedding hands-on industry experience throughout the talent pipeline, the sector can begin closing priority skills gaps while strengthening long-term capability. Success will depend on sustained partnership between government, industry, and educators, supported by targeted investment, clear communication, and proactive outreach to inspire future specialists. Together, these actions will ensure the UK develops the skilled, adaptable workforce required to secure and advance its national PNT infrastructure for decades to come.

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Appendix

Appendices

A Online Data visualisation tool

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/e869283b-4b8a-437c-973e-64ab292e5b87?token=5d597bde255085e040d570bc7f94b33d
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=5d597bde255085e040d570bc7f94b33d
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=5d597bde255085e040d570bc7f94b33d

Visualisation Tool Section	What is it and what can it be used for?
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 review and compares 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=5d597bde255085e040d570bc7f94b33d
Future 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=5d597bde255085e040d570bc7f94b33d

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=5d597bde255085e040d570bc7f94b33d
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=5d597bde255085e040d570bc7f94b33d

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=5d597bde255085e040d570bc7f94b33d
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 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=5d597bde255085e040d570bc7f94b33d
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=5d597bde255085e040d570bc7f94b33d

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=5d597bde255085e040d570bc7f94b33d
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=5d597bde255085e040d570bc7f94b33d

Table 17: Online Data Visualisation Tool.

B Functional Cycle Capabilities Currently Not Served mapped educational provision

Out of the 145 future capabilities identified for this cycle to adopt this technology across the supply chain, 24 are not currently well matched with any duty statements found in existing apprenticeship standards.

Table Key: supply chain partners

1. Infrastructure Operators and Government.
2. Original Equipment Manufacturers (OEMs), Primes, Tier-1s.
3. RTO/COI – Research & Innovation Organisations.
4. Regulators.
5. Small to Medium Enterprises (SMEs).

Function	Capability statement	1	2	3	4	5
DESIGN	Develop techniques for miniaturisation and scalable manufacture of quantum-enabled PNT devices to ensure practical deployment.		✓	✓		✓
DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.	✓	✓	✓		✓
DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.	✓	✓	✓		✓
DESIGN	Engage regulators to maintain alignment with evolving PNT technologies through timely updates and collaboration.	✓		✓		✓
DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.	✓	✓	✓	✓	✓
DESIGN	Develop and implement terrestrial eLORAN systems to provide resilient backup positioning and navigation services.	✓	✓	✓		✓
IMPLEMENT	Establish national test facilities to support the safe and efficient introduction of new PNT technologies.	✓	✓	✓		✓
IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.	✓		✓		✓
IMPLEMENT	Collaborate with cybersecurity and software stakeholders to design adaptive regulatory and risk frameworks addressing emerging spoofing and jamming threats to UK infrastructure.				✓	
IMPLEMENT	Ingest augmentation data via web services to validate position and signal intelligence.	✓	✓			✓
LOGISTICS	Collaborate with OEMs and SMEs to set up manufacturing lines for PNT technologies, enhancing supply chain resilience.		✓	✓		✓
ENTERPRISE	Implement strategic communication plans to inform stakeholders about the national security and economic benefits of resilient PNT systems.	✓				
ENTERPRISE	Conduct economic impact assessments to quantify potential losses from PNT disruptions and inform mitigation strategies.	✓		*		
ENTERPRISE	Develop policy to address social, economic, and fiscal impacts of PNT disruption.	✓				
ENTERPRISE	Identify PNT priorities for different sectors, such as timing for finance and positioning for logistics.	✓		✓	✓	

ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.	✓	✓			✓
SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.	✓	✓	✓		✓
SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	✓		✓	✓	✓
SUPPORT	Develop certification pathways to ensure compliance with UK standards for resilient Positioning, Navigation, and Timing (PNT) systems.	✓		✓	✓	✓
SUPPORT	Develop and enforce regulatory frameworks to strengthen the cyber defences and resilience of critical infrastructure sectors.	✓			✓	✓
SUPPORT	Audit subsystem infrastructures to identify and address single-point failure dependencies.	✓	✓	✓	✓	✓
SUPPORT	Develop secure firmware to safeguard PNT systems against cyber threats, malicious damage, and environmental risks.		✓	✓		✓
SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.	✓	✓	✓	✓	✓
SUPPORT	Maintain early warning defence systems to support national security objectives.	✓	✓			✓

Table 18 Functional Cycle Capabilities Currently Not Served by Skills England.

C List of full FOPs by Role Level including capabilities and proficiency

Strategic Management - PNT Strategy & Programme Lead

ID	Function	Capability Statement	Proficiency
321608	DESIGN	Prototype multi-source receivers to integrate GNSS, 5G, and other signals for robust positioning.	Awareness
321705	DESIGN	Develop risk management plans to mitigate supplier disruptions and maintain continuity of critical services.	Expert
322024	IMPLEMENT	Establish national test facilities to support the safe and efficient introduction of new PNT technologies.	Practitioner
322026	IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.	Practitioner
321578	IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.	Expert
321561	IMPLEMENT	Implement data pipelines to integrate diverse PNT data sources, enhancing system resilience and reliability.	Practitioner
321626	IMPLEMENT	Integrate multi-constellation and multi-frequency GNSS receivers to enhance signal resilience.	Expert
321711	IMPLEMENT	Design architectures that switch to alternative PNT sources when GNSS signals fail to maintain continuous service delivery.	Awareness
321724	LOGISTICS	Identify and qualify secure, compliant suppliers to meet customer requirements and organisational standards.	Practitioner
321544	LOGISTICS	Collaborate with OEMs and SMEs to set up manufacturing lines for PNT technologies, enhancing supply chain resilience.	Awareness
321729	LOGISTICS	Coordinate with suppliers to align on requirements, deadlines, and delivery expectations.	Expert
321635	SUPPORT	Develop interoperability frameworks to integrate Positioning, Navigation, and Timing (PNT) with sector-specific systems, enhancing resilience and efficiency.	Expert
321717	SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.	Expert
321712	SUPPORT	Develop secure firmware to safeguard PNT systems against cyber threats, malicious damage, and environmental risks.	Expert
321758	ENTERPRISE	Manage delivery of defined political or organisational priorities to achieve strategic objectives.	Expert
321636	ENTERPRISE	Implement strategic communication plans to inform stakeholders about the national security and economic benefits of resilient PNT systems.	Practitioner
321761	ENTERPRISE	Develop strategies to integrate new technologies that maintain business relevance, improve operational efficiency, and support threat analysis.	Expert
321764	ENTERPRISE	Develop policy to address social, economic, and fiscal impacts of PNT disruption.	Expert
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Expert
321667	ENTERPRISE	Integrate PNT resilience strategies into existing governance and risk management frameworks.	Expert
321767	ENTERPRISE	Engage key operator stakeholders to identify and communicate specific resilience factors essential for operational continuity.	Expert
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
301026	ENTERPRISE	Anticipate, assess, and prioritise risks, threats, and potential consequences to support organisational resilience.	Expert
300835	ENTERPRISE	Analyse business impacts and risks to determine recovery time periods and resource requirements.	Expert

Table 19 Strategic Management - PNT Strategy & Programme Lead FOP.

Strategic Management - PNT Systems Architect

ID	Function	Capability Statement	Proficiency
321618	DESIGN	Deploy low Earth orbit satellite constellations to enhance PNT signal resilience and coverage.	Expert
321557	DESIGN	Develop and implement multi-layered PNT systems to ensure continuous service during GNSS disruptions.	Expert
321509	DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.	Expert
321642	DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.	Expert
321703	DESIGN	Conduct integration testing for distributed PNT systems to ensure interoperability and performance.	Practitioner
322026	IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.	Practitioner
321560	IMPLEMENT	Develop fault-tolerant architectures to ensure continuous operation of critical infrastructure during PNT disruptions.	Expert
321711	IMPLEMENT	Design architectures that switch to alternative PNT sources when GNSS signals fail to maintain continuous service delivery.	Expert
321635	SUPPORT	Develop interoperability frameworks to integrate Positioning, Navigation, and Timing (PNT) with sector-specific systems, enhancing resilience and efficiency.	Expert
321686	SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	Expert
321648	SUPPORT	Develop and enforce regulatory frameworks to strengthen the cyber defenses and resilience of critical infrastructure sectors.	Practitioner
321717	SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.	Practitioner
321669	SUPPORT	Assess and enhance infrastructure to improve resilience against PNT disruptions.	Expert
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Practitioner
321667	ENTERPRISE	Integrate PNT resilience strategies into existing governance and risk management frameworks.	Expert
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321720	ENTERPRISE	Implement multi-layered security protocols to protect PNT data and communications from malicious and accidental threats.	Expert

Table 20 Strategic Management - PNT Systems Architect FOP.

Strategic Management - PNT Procurement Manager

ID	Function	Capability Statement	Proficiency
321705	DESIGN	Develop risk management plans to mitigate supplier disruptions and maintain continuity of critical services.	Expert
322032	IMPLEMENT	Regulate risk management plans to mitigate supplier disruptions and ensure continuity of critical services.	Practitioner
322037	IMPLEMENT	Advise on regulations and protocols, including trade embargoes and supply chain monitoring, to ensure compliance and secure operations.	Expert
321725	LOGISTICS	Negotiate with international suppliers that meet UK security standards to ensure suitability for use in indigenous systems and secure supply chains.	Expert
321724	LOGISTICS	Identify and qualify secure, compliant suppliers to meet customer requirements and organisational standards.	Expert
321544	LOGISTICS	Collaborate with OEMs and SMEs to set up manufacturing lines for PNT technologies, enhancing supply chain resilience.	Practitioner
321730	LOGISTICS	Develop specialist shipping solutions for precision timing equipment to ensure safe handling and timely delivery across global destinations.	Practitioner
321729	LOGISTICS	Coordinate with suppliers to align on requirements, deadlines, and delivery expectations.	Practitioner
321690	LOGISTICS	Identify suitable alternatives for system components to maintain service continuity and operational resilience.	Practitioner
321688	LOGISTICS	Secure essential product and service supply chains including identifying sovereign requirements and nationally separable alternatives.	Expert
321689	LOGISTICS	Maintain supply chains to ensure continuous availability of essential products and services for uninterrupted operations.	Expert
302828	LOGISTICS	Select suitable replacements when items are unavailable to maintain service continuity.	Practitioner
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321775	ENTERPRISE	Adapt to changing national regulatory and compliance requirements.	Expert
321777	ENTERPRISE	Develop and maintain policies and procedures that comply with government requirements to ensure legal and regulatory adherence.	Practitioner

Table 21 Strategic Management - PNT Procurement Manager FOP.

Operational Leadership - PNT Risk, Incident & Continuity Manager

ID	Function	Capability Statement	Proficiency
322032	IMPLEMENT	Regulate risk management plans to mitigate supplier disruptions and ensure continuity of critical services.	Awareness
321748	IMPLEMENT	Implement business recovery protocols to maintain operations during disruptions to PNT services.	Expert
321723	LOGISTICS	Identify assets and facilities critical to national security to implement appropriate protection measures.	Practitioner
321553	LOGISTICS	Design and implement contingency protocols to mitigate GNSS vulnerabilities and ensure continuous operation of essential systems.	Expert
321650	LOGISTICS	Develop automated continuity workflows to enable rapid failover to alternative PNT sources during GNSS outages.	Practitioner
321690	LOGISTICS	Identify suitable alternatives for system components to maintain service continuity and operational resilience.	Practitioner
302828	LOGISTICS	Select suitable replacements when items are unavailable to maintain service continuity.	Practitioner
321750	SUPPORT	Develop software security contingency plans to protect PNT systems from cyber threats, malicious damage, and environmental risks.	Practitioner
321752	SUPPORT	Develop human-factor contingency plans to ensure resilience of PNT systems from cyber threats, malicious damage, and environmental risks.	Expert
321751	SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.	Awareness
322028	SUPPORT	Study the effects of space weather on space-based PNT systems to inform development of more resilient solutions.	Awareness
321757	SUPPORT	Design resilience protocols based on emergency scenario tests to assess and enhance the resilience of critical infrastructure systems.	Expert
321716	SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.	Practitioner
321714	SUPPORT	Develop early warning defence systems to support national security objectives.	Practitioner
321715	SUPPORT	Maintain early warning defence systems to support national security objectives.	Practitioner
321667	ENTERPRISE	Integrate PNT resilience strategies into existing governance and risk management frameworks.	Expert
321767	ENTERPRISE	Engage key operator stakeholders to identify and communicate specific resilience factors essential for operational continuity.	Practitioner
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321654	ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.	Practitioner
321773	ENTERPRISE	Build contingencies for human-driven and machine-learning risk alert systems.	Practitioner
301026	ENTERPRISE	Anticipate, assess, and prioritise risks, threats, and potential consequences to support organisational resilience.	Expert
300835	ENTERPRISE	Analyse business impacts and risks to determine recovery time periods and resource requirements.	Expert
321592	ENTERPRISE	Develop protocols for rapid recovery and re-establishment of PNT services following disruptions.	Expert

Table 22 Operational Leadership - PNT Risk, Incident & Continuity Manager FOP.

Professional/Tactical Specialist - PNT Cyber Security Engineer

ID	Function	Capability Statement	Proficiency
321611	DESIGN	Develop algorithms to detect and mitigate GNSS spoofing and jamming attacks.	Expert
321660	DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.	Expert
321557	DESIGN	Develop and implement multi-layered PNT systems to ensure continuous service during GNSS disruptions.	Practitioner
321697	DESIGN	Ensure security by design in all system development processes to protect against cyber and physical threats.	Expert
319590	DESIGN	Test security measures for final acceptance.	Expert
321740	IMPLEMENT	Implement security operations control systems to ensure resilience against PNT threats and hazards.	Practitioner
321553	LOGISTICS	Design and implement contingency protocols to mitigate GNSS vulnerabilities and ensure continuous operation of essential systems.	Expert
321688	LOGISTICS	Secure essential product and service supply chains including identifying sovereign requirements and nationally separable alternatives.	Practitioner
321750	SUPPORT	Develop software security contingency plans to protect PNT systems from cyber threats, malicious damage, and environmental risks.	Expert
321752	SUPPORT	Develop human-factor contingency plans to ensure resilience of PNT systems from cyber threats, malicious damage, and environmental risks.	Expert
305502	SUPPORT	Design and maintain secure network infrastructure solutions.	Expert
321713	SUPPORT	Maintain cyber security protocols to support effective responses to cyber incidents.	Expert
321647	SUPPORT	Establish cybersecurity simulation platforms to test and improve the security measures of critical infrastructure systems.	Practitioner
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Practitioner
321685	SUPPORT	Conduct comprehensive audits of PNT systems to identify vulnerabilities and enhance resilience against GNSS disruptions.	Expert
321756	SUPPORT	Audit subsystem infrastructures to identify and address single-point failure dependencies.	Expert
321757	SUPPORT	Design resilience protocols based on emergency scenario tests to assess and enhance the resilience of critical infrastructure systems.	Practitioner
321712	SUPPORT	Develop secure firmware to safeguard PNT systems against cyber threats, malicious damage, and environmental risks.	Expert
321506	SUPPORT	Monitor GNSS signals to detect and respond to spoofing and jamming attempts, ensuring resilient UK connectivity and infrastructure protection.	Expert
321714	SUPPORT	Develop early warning defence systems to support national security objectives.	Awareness
214067	ENTERPRISE	Collect cyber intelligence to detect and address vulnerabilities.	Expert
321720	ENTERPRISE	Implement multi-layered security protocols to protect PNT data and communications from malicious and accidental threats.	Expert
321775	ENTERPRISE	Adapt to changing national regulatory and compliance requirements.	Practitioner
321592	ENTERPRISE	Develop protocols for rapid recovery and re-establishment of PNT services following disruptions.	Practitioner

Table 23 Professional/Tactical Specialist - PNT Cyber Security Engineer FOP.

Professional/Tactical Specialist - PNT Signal Integrity Engineer

ID	Function	Capability Statement	Proficiency
321695	DESIGN	Implement 5G localisation techniques to augment GNSS and provide alternative positioning, navigation, and timing.	Expert
321694	DESIGN	Develop AI-driven algorithms to enhance resilience and performance of positioning, navigation, and timing systems.	Expert
321693	DESIGN	Implement sensor fusion techniques to combine GNSS and alternative PNT sources, improving navigation accuracy in GNSS-denied environments.	Expert
321611	DESIGN	Develop algorithms to detect and mitigate GNSS spoofing and jamming attacks.	Expert
321731	DESIGN	Develop new algorithms for classical positioning to provide resilient GNSS independent navigation.	Expert
322021	DESIGN	Develop and apply technologies to utilise non-navigational signals of opportunity to deliver alternative backup PNT for critical operations.	Expert
321722	DESIGN	Develop and implement a nationally separable terrestrial timing infrastructure to ensure national resilience against GNSS disruptions.	Practitioner
321660	DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.	Expert
321608	DESIGN	Prototype multi-source receivers to integrate GNSS, 5G, and other signals for robust positioning.	Expert
321735	DESIGN	Design integrity solutions to ensure safety-critical PNT applications operate reliably.	Expert
321736	DESIGN	Install resilient PNT systems in critical infrastructure to maintain operations during GNSS disruption.	Awareness
321741	IMPLEMENT	Monitor ionospheric perturbations to improve the reception of signals from space.	Practitioner
321743	IMPLEMENT	Maintain a national geodetic reference frame to ensure the accuracy of position and time signals for the UK.	Practitioner
321745	IMPLEMENT	Provide position signal augmentation services to enable accurate data transformation across the UK.	Expert
321747	IMPLEMENT	Develop multi-source user equipment combining GNSS and alternative signals to improve resilience of critical infrastructure.	Expert
322041	IMPLEMENT	Monitor PNT signal paths to maintain service delivery.	Expert
321521	IMPLEMENT	Develop monitoring platforms to assess GNSS signal integrity and detect potential disruptions.	Expert
321711	IMPLEMENT	Design architectures that switch to alternative PNT sources when GNSS signals fail to maintain continuous service delivery.	Expert
321650	LOGISTICS	Develop automated continuity workflows to enable rapid failover to alternative PNT sources during GNSS outages.	Practitioner
322028	SUPPORT	Study the effects of space weather on space-based PNT systems to inform development of more resilient solutions.	Awareness
321685	SUPPORT	Conduct comprehensive audits of PNT systems to identify vulnerabilities and enhance resilience against GNSS disruptions.	Expert
321506	SUPPORT	Monitor GNSS signals to detect and respond to spoofing and jamming attempts, ensuring resilient UK connectivity and infrastructure protection.	Expert
321763	ENTERPRISE	Define implementation pathways for alternative positioning and timing solutions to improve national resilience against GNSS disruption.	Practitioner
321654	ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.	Expert
322040	ENTERPRISE	augment PNT systems with AI analytics to reduce and manage disruption impacts, ensuring consistent and reliable PNT services.	Expert

Table 24 Professional/Tactical Specialist - PNT Signal Integrity Engineer FOP.

Operational Leadership - PNT Standards & Regulatory Affairs Officer

ID	Function	Capability Statement	Proficiency
322023	DESIGN	Engage regulators to maintain alignment with evolving PNT technologies through timely updates and collaboration.	Expert
321698	DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.	Awareness
321704	DESIGN	Implement resilience analysis tools to evaluate and enhance robustness of interconnected infrastructure networks.	Awareness
322032	IMPLEMENT	Regulate risk management plans to mitigate supplier disruptions and ensure continuity of critical services.	Expert
321560	IMPLEMENT	Develop fault-tolerant architectures to ensure continuous operation of critical infrastructure during PNT disruptions.	Awareness
322033	IMPLEMENT	Evaluate and review system function tests to ensure regulations and protocols remain effective and fit for purpose.	Expert
321725	LOGISTICS	Negotiate with international suppliers that meet UK security standards to ensure suitability for use in indigenous systems and secure supply chains.	Practitioner
322039	SUPPORT	Develop regulatory policies for augmenting PNT systems with AI analytics to mitigate and manage impacts of PNT disruption.	Expert
321754	SUPPORT	Comply with standards and processes to maintain product quality and reliability.	Practitioner
322036	SUPPORT	Define and enforce standards for supply chain compliance checks to maintain system integrity and ensure consistent regulatory performance.	Expert
321686	SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	Expert
321536	SUPPORT	Develop certification pathways to ensure compliance with UK standards for resilient Positioning, Navigation, and Timing (PNT) systems.	Expert
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Expert
321669	SUPPORT	Assess and enhance infrastructure to improve resilience against PNT disruptions.	Awareness
321762	ENTERPRISE	Assist critical national infrastructure (CNI) operators to evaluate GNSS reliance and implement alternatives for resilience.	Practitioner
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Expert
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321771	ENTERPRISE	Define service standards for accurate product descriptions.	Expert
321776	ENTERPRISE	Develop standards for monitoring PNT signals to detect interference and protect critical use cases.	Expert

Table 25 Operational Leadership - PNT Standards & Regulatory Affairs Officer FOP.

Professional/Tactical Specialist - RF Spectrum Specialist (PNT)

ID	Function	Capability Statement	Proficiency
321692	DESIGN	Develop multi-constellation and multi-frequency satellite receivers to better assure positioning, navigation, and timing services.	Awareness
321656	IMPLEMENT	Implement context-aware spectrum management systems to dynamically adapt to environmental factors.	Expert
321738	IMPLEMENT	Deliver monitoring stations to triangulate positional signals and monitor interference.	Practitioner
321739	IMPLEMENT	Maintain monitoring stations to triangulate positional signals and monitor interference.	Expert
321626	IMPLEMENT	Integrate multi-constellation and multi-frequency GNSS receivers to enhance signal resilience.	Practitioner
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Awareness
321766	ENTERPRISE	Identify specific frequency ranges and allocate them for exclusive alternative positioning, navigation, and timing applications.	Expert
321719	ENTERPRISE	Coordinate spectrum access for alternative PNT systems to provide space-based and terrestrial backup for GNSS services.	Practitioner

Table 26 Professional/Tactical Specialist - RF Spectrum Specialist (PNT) FOP.

Professional/Tactical Specialist - PNT Field Operations Engineer

ID	Function	Capability Statement	Proficiency
321736	DESIGN	Install resilient PNT systems in critical infrastructure to maintain operations during GNSS disruption.	Expert
321699	DESIGN	Direct installation and testing of remote sensing hardware or software, such as radionavigation reference stations, to ensure operational readiness.	Expert
321700	DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.	Expert
321701	DESIGN	Conduct functional tests of PNT subsystems to verify compliance with performance standards.	Awareness
321739	IMPLEMENT	Maintain monitoring stations to triangulate positional signals and monitor interference.	Expert
321690	LOGISTICS	Identify suitable alternatives for system components to maintain service continuity and operational resilience.	Expert
302828	LOGISTICS	Select suitable replacements when items are unavailable to maintain service continuity.	Practitioner
321752	SUPPORT	Develop human-factor contingency plans to ensure resilience of PNT systems from cyber threats, malicious damage, and environmental risks.	Awareness
321751	SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.	Awareness
321749	SUPPORT	Configure tailored support systems to meet specific customer requirements and ensure seamless integration with client operations.	Practitioner
305502	SUPPORT	Design and maintain secure network infrastructure solutions.	Awareness
229350	SUPPORT	Design, test, and install new systems to monitor system performance post-commissioning.	Expert
321541	SUPPORT	Operate and maintain PNT systems daily to provide accurate and resilient positioning, navigation, and timing services across the UK.	Expert
321654	ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.	Expert
321770	ENTERPRISE	Respond to customer feedback on quality and implement amendments to maintain consistent delivery and meet service standards.	Expert

Table 27 Professional/Tactical Specialist - PNT Field Operations Engineer FOP.

Professional/Tactical Specialist - PNT Simulation Specialist

ID	Function	Capability Statement	Proficiency
321660	DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.	Awareness
321509	DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.	Practitioner
321698	DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.	Practitioner
321700	DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.	Practitioner
321642	DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.	Awareness
321702	DESIGN	Test spacecraft systems under simulated operational conditions to confirm reliability and resilience.	Practitioner
321601	DESIGN	Model and simulate PNT system performance to identify potential vulnerabilities and optimize design.	Expert
321707	IMPLEMENT	Simulate diverse environmental conditions to assess PNT device performance under realistic adverse scenarios.	Expert
322029	SUPPORT	Develop digital twins of UK PNT infrastructure and GNSS to support scenario planning and resilience testing.	Expert
321647	SUPPORT	Establish cybersecurity simulation platforms to test and improve the security measures of critical infrastructure systems.	Practitioner
321716	SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.	Awareness

Table 28 Professional/Tactical Specialist - PNT Simulation Specialist FOP.

Professional/Tactical Specialist - Quantum Technologies Systems Engineer

ID	Function	Capability Statement	Proficiency
322022	DESIGN	Develop free-space optical and quantum-based ranging and time transfer technologies to enable robust terrestrial and space-based PNT systems.	Expert
321517	DESIGN	Develop quantum-enabled PNT systems to provide resilient, GNSS-independent timing and navigation solutions.	Expert
321733	DESIGN	Develop high-accuracy time transfer and ranging methods to enable distributed PNT systems.	Expert
321734	DESIGN	Design quantum components to support production of quantum-enabled PNT devices.	Expert
322027	DESIGN	Develop techniques for miniaturisation and scalable manufacture of quantum-enabled PNT devices to ensure practical deployment.	Expert
321737	DESIGN	Calibrate PNT systems, including atomic clocks and RF subsystems, to ensure high accuracy.	Expert
321578	IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.	Expert

Table 29 Professional/Tactical Specialist - Quantum Technologies Systems Engineer FOP.

Professional/Tactical Specialist - PNT Regulatory Compliance Specialist

ID	Function	Capability Statement	Proficiency
322031	DESIGN	Collaborate with PNT technology stakeholders to inform the design of agile regulatory and risk management frameworks that adapt to innovation.	Expert
321701	DESIGN	Conduct functional tests of PNT subsystems to verify compliance with performance standards.	Expert
321705	DESIGN	Develop risk management plans to mitigate supplier disruptions and maintain continuity of critical services.	Practitioner
322037	IMPLEMENT	Advise on regulations and protocols, including trade embargoes and supply chain monitoring, to ensure compliance and secure operations.	Practitioner
322035	IMPLEMENT	Advise and support timely implementation of monitoring protocols to ensure regulatory systems remain efficient and effective.	Expert
322038	IMPLEMENT	Collaborate with cybersecurity and software stakeholders to design adaptive regulatory and risk frameworks addressing emerging spoofing and jamming threats to UK infrastructure.	Expert
322039	SUPPORT	Develop regulatory policies for augmenting PNT systems with AI analytics to mitigate and manage impacts of PNT disruption.	Awareness
321754	SUPPORT	Comply with standards and processes to maintain product quality and reliability.	Practitioner
322036	SUPPORT	Define and enforce standards for supply chain compliance checks to maintain system integrity and ensure consistent regulatory performance.	Practitioner
322034	SUPPORT	Maintain capacity to conduct spot checks on regulatory activities, including functional and security testing, to assure compliance and system integrity.	Expert
321686	SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	Expert
321536	SUPPORT	Develop certification pathways to ensure compliance with UK standards for resilient Positioning, Navigation, and Timing (PNT) systems.	Practitioner
321684	SUPPORT	Establish national policies and strategies to secure and protect critical infrastructure connectivity.	Awareness
321648	SUPPORT	Develop and enforce regulatory frameworks to strengthen the cyber defenses and resilience of critical infrastructure sectors.	Expert
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Practitioner
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Awareness
321775	ENTERPRISE	Adapt to changing national regulatory and compliance requirements.	Expert
321777	ENTERPRISE	Develop and maintain policies and procedures that comply with government requirements to ensure legal and regulatory adherence.	Expert
321776	ENTERPRISE	Develop standards for monitoring PNT signals to detect interference and protect critical use cases.	Practitioner
321778	ENTERPRISE	Support enforcement activities by collaborating with relevant authorities to detect and prevent crime.	Practitioner

Table 30 Professional/Tactical Specialist - PNT Regulatory Compliance Specialist FOP.

Professional/Tactical Specialist - PNT ML/Data Engineer

ID	Function	Capability Statement	Proficiency
321695	DESIGN	Implement 5G localisation techniques to augment GNSS and provide alternative positioning, navigation, and timing.	Awareness
321694	DESIGN	Develop AI-driven algorithms to enhance resilience and performance of positioning, navigation, and timing systems.	Expert
321693	DESIGN	Implement sensor fusion techniques to combine GNSS and alternative PNT sources, improving navigation accuracy in GNSS-denied environments.	Practitioner
321611	DESIGN	Develop algorithms to detect and mitigate GNSS spoofing and jamming attacks.	Expert
321561	IMPLEMENT	Implement data pipelines to integrate diverse PNT data sources, enhancing system resilience and reliability.	Expert
321746	IMPLEMENT	ingest augmentation data via web services to validate position and signal intelligence.	Expert
321521	IMPLEMENT	Develop monitoring platforms to assess GNSS signal integrity and detect potential disruptions.	Practitioner
321650	LOGISTICS	Develop automated continuity workflows to enable rapid failover to alternative PNT sources during GNSS outages.	Practitioner

Table 31 Professional/Tactical Specialist - PNT ML/Data Engineer FOP.

Operational Leadership - AI Ops Manager

ID	Function	Capability Statement	Proficiency
321694	DESIGN	Develop AI-driven algorithms to enhance resilience and performance of positioning, navigation, and timing systems.	Expert
321740	IMPLEMENT	Implement security operations control systems to ensure resilience against PNT threats and hazards.	Expert
321561	IMPLEMENT	Implement data pipelines to integrate diverse PNT data sources, enhancing system resilience and reliability.	Practitioner
322041	IMPLEMENT	Monitor PNT signal paths to maintain service delivery.	Practitioner
321749	SUPPORT	Configure tailored support systems to meet specific customer requirements and ensure seamless integration with client operations.	Practitioner
321541	SUPPORT	Operate and maintain PNT systems daily to provide accurate and resilient positioning, navigation, and timing services across the UK.	Practitioner
321713	SUPPORT	Maintain cyber security protocols to support effective responses to cyber incidents.	Practitioner
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Awareness
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321769	ENTERPRISE	Use customer feedback and failover testing to continuously improve product performance and ensure reliable service delivery.	Practitioner
321771	ENTERPRISE	Define service standards for accurate product descriptions.	Awareness
321720	ENTERPRISE	Implement multi-layered security protocols to protect PNT data and communications from malicious and accidental threats.	Expert
321773	ENTERPRISE	Build contingencies for human-driven and machine-learning risk alert systems.	Practitioner
321592	ENTERPRISE	Develop protocols for rapid recovery and re-establishment of PNT services following disruptions.	Expert

Table 32 Operational Leadership - AI Ops Manager FOP.

Professional/Tactical Specialist - Manufacturing & Qualification Engineer (PNT)

ID	Function	Capability Statement	Proficiency
314001	DESIGN	Install subsystems within spacecraft to support mission requirements.	Expert
321724	LOGISTICS	Identify and qualify secure, compliant suppliers to meet customer requirements and organisational standards.	Awareness
321544	LOGISTICS	Collaborate with OEMs and SMEs to set up manufacturing lines for PNT technologies, enhancing supply chain resilience.	Expert
321728	LOGISTICS	Conduct quality and compliance checks on all goods and supplier processes to ensure standards are met.	Practitioner
321690	LOGISTICS	Identify suitable alternatives for system components to maintain service continuity and operational resilience.	Awareness
229350	SUPPORT	Design, test, and install new systems to monitor system performance post-commissioning.	Expert
321754	SUPPORT	Comply with standards and processes to maintain product quality and reliability.	Practitioner
321770	ENTERPRISE	Respond to customer feedback on quality and implement amendments to maintain consistent delivery and meet service standards.	Practitioner
321775	ENTERPRISE	Adapt to changing national regulatory and compliance requirements.	Practitioner

Table 33 Professional/Tactical Specialist - Manufacturing & Qualification Engineer (PNT) FOP.

Operational Leadership - Geodesy & Reference Frame Specialist

ID	Function	Capability Statement	Proficiency
321742	IMPLEMENT	Create a national geodetic reference frame to underpin accurate position and time signals for the UK.	Expert
321741	IMPLEMENT	Monitor ionospheric perturbations to improve the reception of signals from space.	Practitioner
321743	IMPLEMENT	Maintain a national geodetic reference frame to ensure the accuracy of position and time signals for the UK.	Expert
322030	IMPLEMENT	Manage and protect UK geodesy infrastructure by operating the Space Geodesy Facility to ensure global positioning accuracy and reliability.	Expert
322037	IMPLEMENT	Advise on regulations and protocols, including trade embargoes and supply chain monitoring, to ensure compliance and secure operations.	Expert
321745	IMPLEMENT	Provide position signal augmentation services to enable accurate data transformation across the UK.	Practitioner
321746	IMPLEMENT	ingest augmentation data via web services to validate position and signal intelligence.	Practitioner
322041	IMPLEMENT	Monitor PNT signal paths to maintain service delivery.	Practitioner
321521	IMPLEMENT	Develop monitoring platforms to assess GNSS signal integrity and detect potential disruptions.	Expert
322028	SUPPORT	Study the effects of space weather on space-based PNT systems to inform development of more resilient solutions.	Practitioner
229350	SUPPORT	Design, test, and install new systems to monitor system performance post-commissioning.	Practitioner
321506	SUPPORT	Monitor GNSS signals to detect and respond to spoofing and jamming attempts, ensuring resilient UK connectivity and infrastructure protection.	Practitioner
321768	ENTERPRISE	Mentor new recruits by leveraging existing workforce expertise to accelerate learning and strengthen organisational capability.	Practitioner
321776	ENTERPRISE	Develop standards for monitoring PNT signals to detect interference and protect critical use cases.	Expert

Table 34 Operational Leadership - Geodesy & Reference Frame Specialist FOP.

Professional/Tactical Specialist - RF Hardware Engineer (PNT)

ID	Function	Capability Statement	Proficiency
321614	DESIGN	Develop software-defined radios to adaptively process multiple PNT signals and improve robustness.	Awareness
321692	DESIGN	Develop multi-constellation and multi-frequency satellite receivers to better assure positioning, navigation, and timing services.	Practitioner
321530	DESIGN	Develop low-cost resilient antennas to enhance GNSS signal reception and mitigate interference.	Expert
321509	DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.	Expert
321732	DESIGN	Design semiconductor intellectual property to support development of indigenous PNT equipment.	Expert
321608	DESIGN	Prototype multi-source receivers to integrate GNSS, 5G, and other signals for robust positioning.	Practitioner
314001	DESIGN	Install subsystems within spacecraft to support mission requirements.	Practitioner
321699	DESIGN	Direct installation and testing of remote sensing hardware or software, such as radionavigation reference stations, to ensure operational readiness.	Practitioner
321642	DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.	Awareness
321701	DESIGN	Conduct functional tests of PNT subsystems to verify compliance with performance standards.	Awareness
321626	IMPLEMENT	Integrate multi-constellation and multi-frequency GNSS receivers to enhance signal resilience.	Awareness
321706	IMPLEMENT	Implement multipath mitigation techniques in GNSS receivers to improve positioning accuracy in built-up environments.	Awareness
321747	IMPLEMENT	Develop multi-source user equipment combining GNSS and alternative signals to improve resilience of critical infrastructure.	Practitioner
321751	SUPPORT	Develop hardware redundancy plans to safeguard PNT systems from cyber threats, malicious damage, and environmental risks.	Expert

Table 35 Professional/Tactical Specialist - RF Hardware Engineer (PNT) FOP.

Professional/Tactical Specialist - PNT Test & Validation Engineer

ID	Function	Capability Statement	Proficiency
321660	DESIGN	Develop test protocols to assess PNT system resilience against jamming and spoofing attacks, ensuring operational integrity.	Expert
321509	DESIGN	Develop low-SWaP satellite payloads to enhance the resilience of UK PNT infrastructure.	Awareness
321698	DESIGN	Establish PNT testbeds to evaluate and validate system performance under operational scenarios and threat conditions.	Expert
314001	DESIGN	Install subsystems within spacecraft to support mission requirements.	Awareness
321699	DESIGN	Direct installation and testing of remote sensing hardware or software, such as radionavigation reference stations, to ensure operational readiness.	Expert
321700	DESIGN	Conduct regular field tests and simulations to evaluate PNT system performance under diverse threat and hazard scenarios.	Expert
321642	DESIGN	Implement automated testing frameworks to streamline PNT device validation processes.	Expert
321702	DESIGN	Test spacecraft systems under simulated operational conditions to confirm reliability and resilience.	Expert
321703	DESIGN	Conduct integration testing for distributed PNT systems to ensure interoperability and performance.	Expert
319590	DESIGN	Test security measures for final acceptance.	Expert
321701	DESIGN	Conduct functional tests of PNT subsystems to verify compliance with performance standards.	Expert
321704	DESIGN	Implement resilience analysis tools to evaluate and enhance robustness of interconnected infrastructure networks.	Expert
322033	IMPLEMENT	Evaluate and review system function tests to ensure regulations and protocols remain effective and fit for purpose.	Practitioner
321707	IMPLEMENT	Simulate diverse environmental conditions to assess PNT device performance under realistic adverse scenarios.	Awareness
321728	LOGISTICS	Conduct quality and compliance checks on all goods and supplier processes to ensure standards are met.	Practitioner
229350	SUPPORT	Design, test, and install new systems to monitor system performance post-commissioning.	Expert
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Awareness
321716	SUPPORT	Conduct GNSS denial scenario test exercises to identify system dependencies and vulnerabilities.	Expert
321654	ENTERPRISE	Conduct regular failover drills to test and validate the effectiveness of alternative PNT solutions during GNSS outages.	Expert
321769	ENTERPRISE	Use customer feedback and failover testing to continuously improve product performance and ensure reliable service delivery.	Practitioner
321770	ENTERPRISE	Respond to customer feedback on quality and implement amendments to maintain consistent delivery and meet service standards.	Awareness
321775	ENTERPRISE	Adapt to changing national regulatory and compliance requirements.	Practitioner
321777	ENTERPRISE	Develop and maintain policies and procedures that comply with government requirements to ensure legal and regulatory adherence.	Awareness

Table 36 Professional/Tactical Specialist - PNT Test & Validation Engineer FOP.

Enterprise/Strategic Leader - PNT Policy Lead

ID	Function	Capability Statement	Proficiency
321722	DESIGN	Develop and implement a nationally separable terrestrial timing infrastructure to ensure national resilience against GNSS disruptions.	Expert
322024	IMPLEMENT	Establish national test facilities to support the safe and efficient introduction of new PNT technologies.	Awareness
322026	IMPLEMENT	Support early-stage concepts and high-impact innovations to accelerate development and maximise future PNT capabilities.	Awareness
321723	LOGISTICS	Identify assets and facilities critical to national security to implement appropriate protection measures.	Expert
321688	LOGISTICS	Secure essential product and service supply chains including identifying sovereign requirements and nationally separable alternatives.	Expert
321686	SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	Expert
321684	SUPPORT	Establish national policies and strategies to secure and protect critical infrastructure connectivity.	Expert
321540	SUPPORT	Coordinate with regulatory bodies to draft and enforce standards for PNT systems, enhancing the reliability and security of critical national infrastructure.	Expert
321717	SUPPORT	Develop and implement policies to establish sovereign or nationally separable PNT systems for national security and infrastructure resilience.	Expert
321714	SUPPORT	Develop early warning defence systems to support national security objectives.	Expert
321715	SUPPORT	Maintain early warning defence systems to support national security objectives.	Expert
321759	ENTERPRISE	Determine a clear legal framework that defines liability exposure for organisational operations and partnerships.	Expert
321760	ENTERPRISE	Operate within the established legal framework to ensure compliance and manage liability across all activities.	Expert
321636	ENTERPRISE	Implement strategic communication plans to inform stakeholders about the national security and economic benefits of resilient PNT systems.	Expert
321763	ENTERPRISE	Define implementation pathways for alternative positioning and timing solutions to improve national resilience against GNSS disruption.	Expert
321762	ENTERPRISE	Assist critical national infrastructure (CNI) operators to evaluate GNSS reliance and implement alternatives for resilience.	Expert
321764	ENTERPRISE	Develop policy to address social, economic, and fiscal impacts of PNT disruption.	Expert
321718	ENTERPRISE	Conduct economic impact assessments to quantify potential losses from PNT disruptions and inform mitigation strategies.	Expert
321655	ENTERPRISE	Develop spectrum-sharing policies to enable coexistence of terrestrial and satellite networks without harmful interference.	Expert
321765	ENTERPRISE	Identify PNT priorities for different sectors, such as timing for finance and positioning for logistics.	Expert
321719	ENTERPRISE	Coordinate spectrum access for alternative PNT systems to provide space-based and terrestrial backup for GNSS services.	Expert
321720	ENTERPRISE	Implement multi-layered security protocols to protect PNT data and communications from malicious and accidental threats.	Practitioner

Table 37 Enterprise/Strategic Leader - PNT Policy Lead FOP.

Professional/Tactical Specialist - Timing Network Integration Engineer

ID	Function	Capability Statement	Proficiency
321695	DESIGN	Implement 5G localisation techniques to augment GNSS and provide alternative positioning, navigation, and timing.	Expert
321696	DESIGN	Develop hybrid optical-wireless networks to provide GNSS-independent time distribution services for critical infrastructure.	Expert
321692	DESIGN	Develop multi-constellation and multi-frequency satellite receivers to better assure positioning, navigation, and timing services.	Expert
321722	DESIGN	Develop and implement a nationally separable terrestrial timing infrastructure to ensure national resilience against GNSS disruptions.	Practitioner
322022	DESIGN	Develop free-space optical and quantum-based ranging and time transfer technologies to enable robust terrestrial and space-based PNT systems.	Expert
321526	DESIGN	Develop and implement terrestrial eLORAN systems to provide resilient backup positioning and navigation services.	Expert
321517	DESIGN	Develop quantum-enabled PNT systems to provide resilient, GNSS-independent timing and navigation solutions.	Expert
321704	DESIGN	Implement resilience analysis tools to evaluate and enhance robustness of interconnected infrastructure networks.	Expert
322025	IMPLEMENT	Implement and maintain distributed timing networks to enable ongoing research and development in advanced PNT solutions.	Expert
321578	IMPLEMENT	Integrate optical precision timekeeping systems to enhance timing accuracy across critical infrastructures.	Expert
321743	IMPLEMENT	Maintain a national geodetic reference frame to ensure the accuracy of position and time signals for the UK.	Awareness
321730	LOGISTICS	Develop specialist shipping solutions for precision timing equipment to ensure safe handling and timely delivery across global destinations.	Awareness
321688	LOGISTICS	Secure essential product and service supply chains including identifying sovereign requirements and nationally separable alternatives.	Awareness
321635	SUPPORT	Develop interoperability frameworks to integrate Positioning, Navigation, and Timing (PNT) with sector-specific systems, enhancing resilience and efficiency.	Practitioner
321541	SUPPORT	Operate and maintain PNT systems daily to provide accurate and resilient positioning, navigation, and timing services across the UK.	Expert
321686	SUPPORT	Develop compliance frameworks to ensure nationally separable PNT systems meet national security standards.	Practitioner
321536	SUPPORT	Develop certification pathways to ensure compliance with UK standards for resilient Positioning, Navigation, and Timing (PNT) systems.	Practitioner
321719	ENTERPRISE	Coordinate spectrum access for alternative PNT systems to provide space-based and terrestrial backup for GNSS services.	Expert

Table 38 Professional/Tactical Specialist - Timing Network Integration Engineer FOP.

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 we are well placed to take advantage in the UK, the Government and industry have identified that we need a workforce able to adapt to new capabilities that require 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.

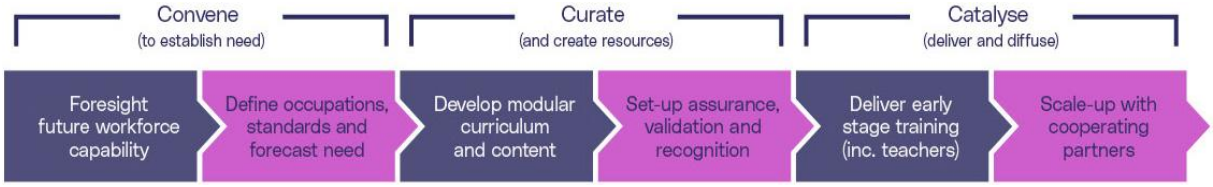

Figure 14: Skills value chain.

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 is where workforce Foresighting comes in.

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.

0At the heart of the Foresighting process is 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.

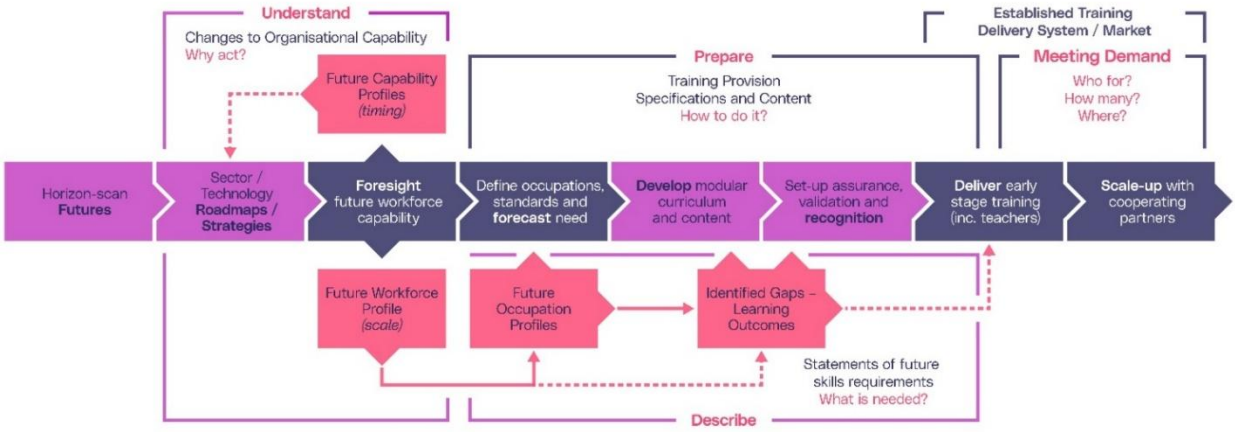

Figure 15 Workforce Foresighting & Skills Value Chain

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 Section 5.1

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. This 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 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.

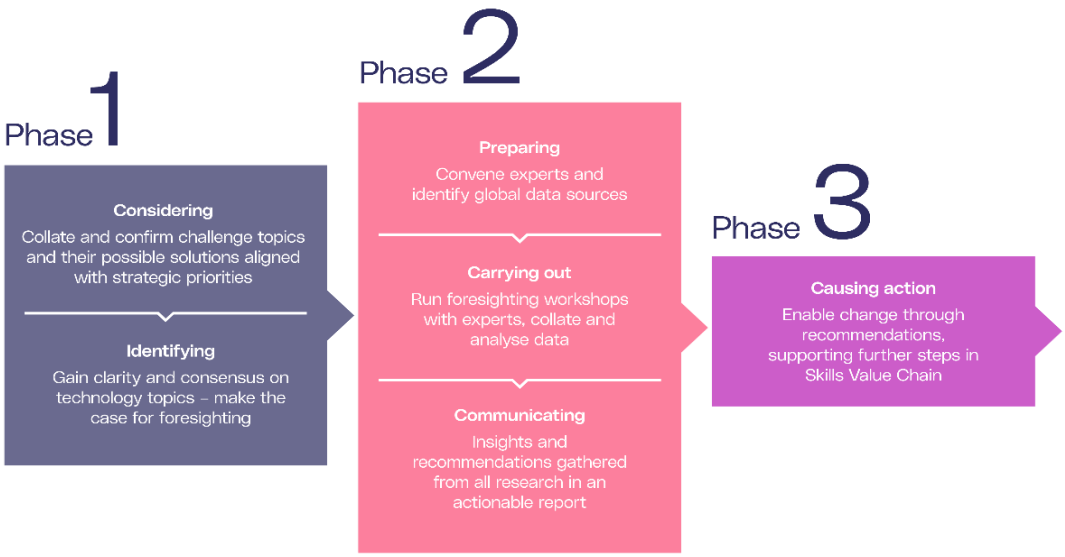

Figure 16 The workforce foresighting process.

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.