Workforce Foresighting Hub

Robotic and Autonomous System and Operations and Maintenance in UK Offshore Wind

System Of Systems and Interoperability

A Workforce Foresighting Hub report.

Date: July 2024

Innovate UK

Right skills, right time, right place

Acknowledgements

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

IfATE – Institute for Apprenticeships and Technical Education, England

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

ONet – Occupational Networks Online, USA

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

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

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

This report was produced following workshops undertaken February – April 2024 using the data set and tools available at that time.

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1.0 Executive Summary

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Introduction

The Offshore Renewable Energy Catapult (OREC) Findings Report for July 2024 outlines critical insights and recommendations for the integration of Robotic and Autonomous Systems (RAS) in the operations and maintenance (O&M) of the UK's offshore wind sector. The report, developed by the Workforce Foresighting Hub, provides an in-depth analysis based on data from international datasets and workshops conducted from October to December 2023.

The report emphasises the necessity for significant advancements in robotic and autonomous systems to meet the UK's ambitious net-zero targets by 2050. Offshore wind capacity must increase more than sevenfold, necessitating operations in deeper, more remote waters.

The report underscores the critical role of RAS in the future of offshore wind O&M. By addressing technological and workforce challenges, and aligning educational provision with future occupational needs, the UK can achieve its net-zero targets and ensure the sustainable growth of its offshore wind sector.

1.1 Foresighting subject selection and stakeholders

The workshops and analysis provided key insights into the future organisational and occupational changes necessary to meet the evolving demands of the Offshore Wind economy. The findings highlighted the need for enhanced design, implementation, and logistics functions, as well as the identification of future occupational profiles for various roles within the value chain.

Overall, the foresighting process emphasised the importance of aligning future workforce capabilities with strategic priorities and industry requirements. It also underscored the need for ongoing collaboration among stakeholders to ensure that training and education programs evolve to meet the emerging demands of the sector.

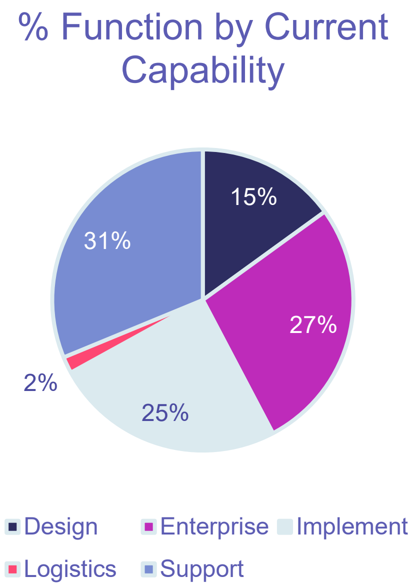
A range of stakeholders were engaged from across technology, academia, industry and government to ensure the process comprehensively addressed the future needs of the sector.

1.2 Organisational change

To implement RAS effectively, organisations must adapt their current capabilities and distribute these changes across their value chain partners. This includes adopting new capabilities and adjusting the distribution of knowledge and skills within their workforce.

The findings of the workshops and analysis provide key insights into the future organisational and occupational changes required.

Future organisational capabilities suggest an increased requirement for design, implementation, and logistics function requirements compared to current functions



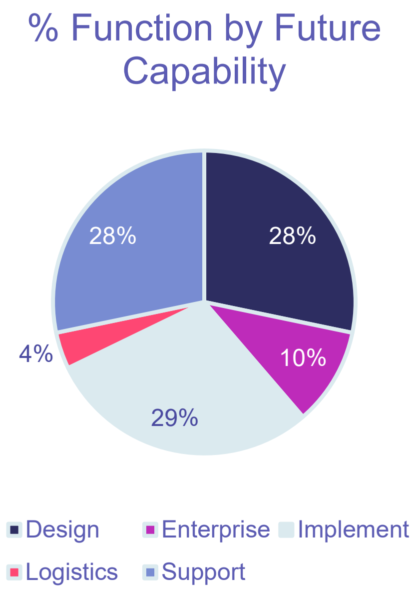


Figure 1: Current and Future Supply Chain - Capability Functions summary by %

1.3 Future Occupational Profile Highlights

The foresighting process has generated a set of FOPs that outline how current occupations will evolve. These profiles are derived from capability classifications and workshop data, helping to identify necessary changes in education and training provision to align with future workforce needs.

Working with inputs from the expert groups and global data, the workforce foresighting process intelligently outlines a range of Future Occupational Profiles (FOPs) for each role family, describing the duties and Knowledge, Skills and Behaviours (KSBs) of potential future occupations.

1.4 Specific areas of concern

The slow adoption of advanced robotic technology is primarily due to high costs and limited field-testing opportunities. To overcome these challenges, there is a need for more repeatable and accurate testing and validation, alongside the development of new workforce strategies to address skill gaps.

The table below highlights the FOPs that have:

- High Suitability Scores – where the FOPs are well provided for by the current IfATE standards. – For this cycle there are no FOPs with a good suitability score from the current provision
- Low Suitability Scores – the FOPs need development as the capabilities identified cannot be met by the current IfATE standards. Action to be taken to ensure the identified future workforce can be upskilled

To Summarise:

Use the Future Occupational Profiles to:

- To address skills gaps, leverage Future Occupational Profiles (FOPs) to update standards and provide CPD courses for current and transitioning workers.
- Advocate for revised standards aligned with future workforce needs.

The report highlights the importance of RAS for maintaining efficiency and safety in offshore wind operations. It projects the market size for RAS in O&M services to reach approximately £341 million annually by 2030, emphasizing benefits such as wider weather windows, faster reaction times, increased inspection frequencies, and enhanced operational safety.

The recommendations in this report emphasise the importance of immediate and coordinated efforts by educators, employers, and other stakeholders to address the anticipated skills gap in the sector. The actions are divided into short-term and mid-term strategies.

1.5 Recommended Next Steps

Use the Future Occupational Profiles to:

- To address skill gaps, leverage Future Occupational Profiles (FOPs) to update standards and provide CPD courses for current and transitioning workers.
- Advocate for revised standards aligned with future workforce needs.
- Addressing these gaps will enable the skilled workers of the future to support the UK's overall adoption and infrastructure goals.

The recommendations in this report emphasise the importance of immediate and coordinated efforts by educators, employers, and other stakeholders to address the anticipated skills gap in the sector. The actions are divided into short-term and mid-term strategies.

	Topic	Actions	Who	When	Result
Short term actions	Reskilling and upskilling current workforce	Tailor course content to match new capabilities with existing occupational standards, focusing on design and other early lifecycle activities.	Educators, Awarding Bodies, Employers	Prepare ahead of the scale-up need	Availability of short-term training for the current workforce to meet immediate technology demands.
	Recruitment from other industries	Identify and reskill individuals with transferable	Employers, Training Providers	Immediate	Mitigation of workforce shortages in

		skills from other sectors, particularly for high-demand roles such as Maintenance and Operations Engineering Technicians.			high-demand areas through targeted recruitment and training initiatives.
Medium term actions	Integration of future skills training	Formalise changes to occupational standards and training programs for new entrants, integrating future skills requirements defined by the Future Occupational Profiles (FOPs).	Educators, Awarding Bodies, Employers	As soon as possible for prioritised FOPs	Develop training programs that meet both current and future skills needs, reducing lead time for new workforce entrants.
	Modular approach to course updates	Implement modular changes to existing courses rather than complete redesigns, facilitating quicker adaptation to evolving skills requirements.	Educators, Training Providers	Ongoing	Flexibility in educational programs, enabling rapid response to industry needs.
General actions for educators	Assessment and feedback	Review Institute for Apprenticeships and Technical Education (IfATE) standards and relevant qualifications with employers, providing feedback and identifying gaps.	Educators, Employers	Ongoing	Comprehensive understanding of current training provisions and identification of areas for improvement.
	Commissioning new Continuing	Evaluate existing CPD provisions, commission new	Educators, Training Providers	Short-term	Enhanced CPD offerings to upskill current

	Professional Development (CPD) courses	courses where necessary, and facilitate collaboration to maintain a unified approach.			workforce members across all role levels.

1.6 Table of abbreviated recommendations

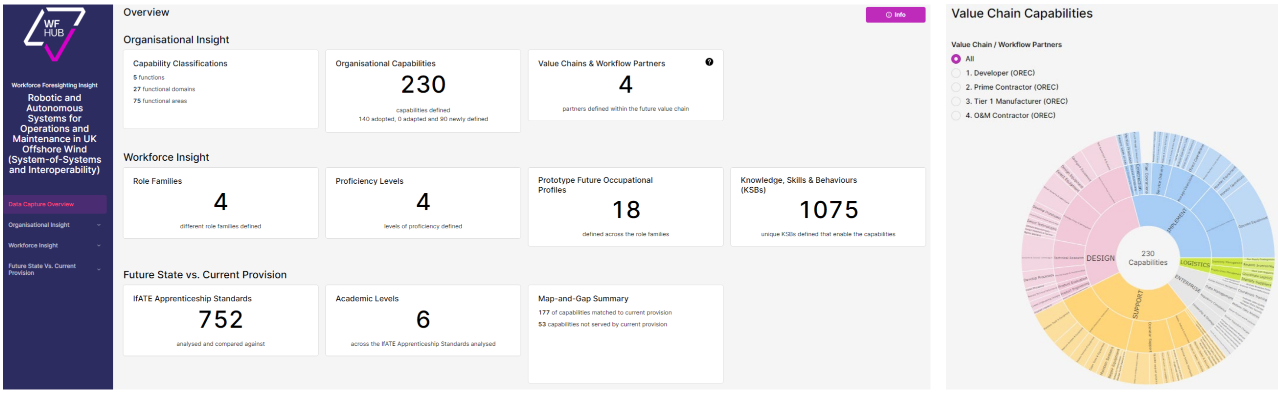
A Dissemination of Findings	Convener and Sponsor to set up working group to take the recommendations and create an action plan and advance through the Skills Value Chain to cause action. It is essential to share the findings widely among stakeholders, industry groups, and local skills bodies. This will promote access to the insights gained and influence the strategic direction of workforce development initiatives.
B Short-term action	As part of the working group, educators and employers should collaborate to deliver timely short term training solutions for the future workforce. This includes developing and offering Continuing Professional Development (CPD) courses that address immediate skills gaps and ensure workers are equipped with the necessary competencies.
C Mid-term actions	The ongoing working group mid-term action planning should include a concerted effort to integrate new skills and knowledge into existing training programs. Educators and employers need to update curricula and training standards to reflect the evolving demands of the sector, ensuring that both current employees and new entrants are adequately prepared.
D Enabling action	Employers and educators must work together to review and influence the update of IfATE standards and relevant qualifications. This involves using the insights from the foresighting process to inform the development of new standards and qualifications that align with future workforce needs. This will contribute to the working group skills framework.
E Further foresighting subjects	The working group should seek additional sponsors and propose further subjects for foresighting. This continuous cycle of foresighting will help to stay ahead of emerging trends and technologies, ensuring the workforce remains adaptable and prepared.
F Lesson Learnt	The working group, supported by the Workforce Foresighting Hub should promote the value gained from participation in workshops. Sharing lessons learned will help to refine the foresighting process and enhance the quality of future outputs

1.7 Introducing the Visualisation Tool

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

The data is generated by the foresighting cycles, integrating the expertise of technologists/domain specialists, employers and educators. The data informs the development of future curriculum and course content as determined by the action plan. Using AI tools validated by human oversight, and by linking to external data sources, the tool identifies differences at the level of occupation/role as well as detailed changes required to knowledge, skills and behaviours thus delivering insights for learners, providers, creators and assurers of skills.

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



2.0 Aligning the Challenge and Solutions with National Priorities

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2.1 Positioning and context of national challenge

Robotics and Autonomous Systems (RAS) are crucial for the future of offshore wind. The Offshore Renewable Energy Catapult (OREC) outlines three main reasons for this:

1. Net Zero Targets: The UK's offshore wind capacity needs to increase more than sevenfold by 2050 to meet net zero targets. This expansion will push operations into deeper, more remote waters with narrower weather windows for human access.

2. Maintenance Efficiency: Robotics can handle routine maintenance tasks, such as inspecting turbine blades and checking bolts, which will improve pre-emptive maintenance and control over these assets.

3. Component Longevity: Enhanced pre-emptive maintenance can extend the lifetime of components and turbines, promoting a circular, zero-waste economy.

National Strategy

Offshore wind power is essential for the UK's energy security and CO2 reduction targets. The UK aims for 50GW of offshore wind power by 2030. As wind farms move into deeper and more treacherous waters, the transition from human to robotic solutions for operation and maintenance (O&M) becomes increasingly beneficial in terms of safety and cost. Tasks include inspecting turbine blades and testing bolt integrity.

OREC's report highlights the market size for RAS in offshore wind O&M services, forecasted to be around £341 million annually by 2030. Benefits of robotic solutions include:

- Wider weather windows
- Faster reaction to weather windows
- Increased inspection frequencies
- Higher quality data collection
- Reduced maintenance needs
- Lower personnel deployment costs
- Enhanced operational safety
- Reduced CO2 emissions

Due to high costs and limited field-testing opportunities, the adoption of advanced robotic technology is currently slow. Successful adoption requires repeatable and accurate testing and validation, necessitating additional skills across the offshore wind and RAS sectors.

2.2 Potential and prioritised technology solutions to the challenge

Technology/Solution: Systems-of-Systems and Interoperability

RAS have a growing role in offshore wind farms. Current focus areas include aerial visual inspection using drones and subsea inspection. However, there is a need for a cross-industry approach to ensure interoperability within future offshore wind farms.
Challenges:

- Confidentiality and intellectual property concerns among industry actors.
- The need for a 'system of systems' approach to ensure interoperability.
- Supply Chain Impacts:
- Encouraged participation to assure interoperability.
- A 'tipping point' where RAS maturity and availability push towards fully remote O&M.
- Adoption and Workforce:
- Early adopters include companies like HonuWorx and MarineTech.
- Workforce-related bottlenecks are anticipated without sufficient skill development.

2.3 Workforce foresighting for chosen prioritised technology solution

To effectively prioritise cycle foresighting topics, it is essential to consider solutions that address the most pressing challenges in offshore wind farm operations and maintenance (O&M). This involves evaluating the potential impact, feasibility, and readiness of various technological advancements.

1. **Robotics and Autonomous Systems (RAS)**

Robotics and Autonomous Systems (RAS) are crucial for the future of O&M in offshore wind farms. The adoption of RAS can lead to significant improvements in efficiency and safety by reducing the need for human intervention in hazardous environments. Key areas for prioritisation include:

- Platform Design, Manufacture, and Assembly: Developing robust RAS platforms that can withstand harsh offshore conditions.
- Power Storage and Management: Implementing efficient energy storage and management systems, such as advanced batteries and solar charging, to ensure continuous operation of RAS.
- Motive and Propulsive Sub-systems: Enhancing the mobility of RAS through advanced motors, thrusters, and crawler systems.
- Software and Controls: Utilising artificial intelligence and machine learning to enable RAS to adapt to their environment, process data, and perform autonomous operations.

- Sensing and Touch/Intervention Tooling: Equipping RAS with advanced sensors and tools for inspecting and maintaining wind turbines.
- Data and Communications: Developing reliable data collection, processing, and transmission systems to support remote operations and beyond-visual-range control.
- Interoperation and Symbiotic Systems of Systems Approaches (SSoSA): Ensuring interoperability between different RAS platforms and promoting human-machine collaboration.

2. Systems-of-Systems and Interoperability

The integration of RAS into a cohesive system-of-systems framework is vital for achieving interoperability within offshore wind farms. This involves designing systems that can communicate and collaborate effectively to achieve mission goals. Prioritising this topic will address several challenges:

- Design and Certification: Ensuring that RAS platforms are designed for interoperability and can self-certify for autonomous operations.
- Reliability and Assurance: Developing systems that can reliably operate autonomously under varying conditions.
- Human-Robot Collaboration: Facilitating safe and efficient co-working between human operators and autonomous systems.

3. Addressing Workforce Challenges

To support the deployment of advanced RAS technologies, it is crucial to address workforce challenges by:

- Developing New Workforce Strategies: Collaborating with industry and government to create strategies that meet future skills needs.
- Education and Engagement: Engaging young people and focusing on critical occupations to build a skilled workforce.
- Technology Transfer: Leveraging expertise from other sectors, such as offshore oil and gas, to fill workforce gaps in the offshore wind industry.
- By prioritising these foresighting topics based on the solutions they offer, the offshore wind sector can advance towards more efficient, safe, and sustainable operations.

2.4 Current and predicted scale of technology deployment in UK

Current solutions are mostly at the prototyping stage and have not reached commercialisation. Without adequate skills and capabilities, RAS solutions may not mature to meet the offshore wind sector's needs. Human operations will continue in hazardous conditions if RAS adoption is slow, impacting the availability of generating capacity.

2.5 Key Stakeholders in industry and government

Key stakeholders include:

- Offshore Wind Sector Deal
- Offshore Wind Industry Council (OWIC) Skills Group
- Net Zero Technology Centre
- ORCA Hub
- Offshore Renewable Energy Catapult (OREC)
- National Robotarium

2.6 Sponsor, Convener, and participating organisations

This foresighting study is sponsored by RenewableUK represented by Jane Cooper, Director of Offshore Wind and Scott Young, Head of Skills for Renewables.

The challenge convener is the Offshore Renewable Energy Catapult ('OREC'). OREC is represented by Andrew Esson, Future Skills Lead, supported by Paul Hatchett, Future Skills Consultant.

Organisations participating in the study included:

- The Offshore Renewable Energy Catapult
- Marshall Futureworx
- Soil Machine Dynamics
- GE Vernova
- The National Robotarium
- The Manufacturing Technology Centre
- Cranfield University
- Honuworx
- Air Control Entech
- Perceptual Robotics
- Newcastle University
- Durham University
- Education Partnership Northeast (EPNE)

2.7 Background information and reference

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3.0 Results – Findings, Data and Insight

3.0 Results – Findings, Data and Insight

3.1 Findings, methodology and presentation

This section describes the future organisational capabilities that will be required to meet the Challenge using the proposed Solution (technology) and which occupations are likely to change to deliver these capabilities.

Summary information is provided with a narrative based on the underlying data which is also provided using bespoke visualisations to enable greater insight and access to detail. This section of the report is aligned to the needs of those responsible for workforce planning – employers, educators, and skills providers.
The two parts interpret the data findings and contain links to the relevant visualisation elements.

Actions necessary to meet the skills and training requirements for the changed occupations are considered in Section 4 with recommendations to be considered by the Foresighting Sponsor, Convener, and others on behalf of the stakeholder and participant groups.

Organisational changes

Providing insight into Organisational Changes – this indicates how organisations will need to adapt their current capabilities in order to implement the Solutions that respond to the Challenge addressed by this foresighting project.

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

Occupational changes

A set of 'Future Occupational Profiles' (FOPs) is produced by the foresight process that demonstrates how current occupations may need to change in the future. FOPs are generated using a combination of attributes from the underlying capability classification and from data collected in the workshops. The FOP generation algorithm works to group capabilities into logical sets reflecting role families, function, proficiency and capability similarity.

As part of the foresight process the generated FOPs are reviewed, revised and distilled by the Employer group. This agreed set of FOPs are then compared with selected current education provision; the default reference is the set of Institute for Apprenticeships and Technical Education (IfATE) occupational standards; to assess which current training and education provision could be used in the future. Two bespoke metrics, match and surplus are used to evaluate the alignment of current provision with the set of FOPs proposed. Summaries are presented of the key findings related to each supply chain partner.

Findings are aimed at both Employers and Education and Training Providers and identify matches and gaps in future training needs compared with current provision to guide further detailed investigation.

Highlighted changes to future provision

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

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

Method

The Workforce Foresighting process uses a series of structured workshops and surveys to capture and summarise input from relevant sector experts – covering technology, workforce development and education. At a number of points in the workshop and analysis sequence the foresighting process utilises large language models (LLM) and artificial intelligence (AI) tools to parse and assist in the analysis of the content generated by workshop participants. For example, the AI model can compare capability statements with existing occupational standards more thoroughly and rapidly than human comparison. All AI derived outputs are reviewed and validated by the participant groups through the workshops and the integral quality assurance reviews of the foresight process.

3.2 Insight into organisational changes

Organisational insight indicates how diverse types of organisations in the value chain will need to make functional changes to align their future capabilities to those required to respond to the Challenge being addressed. This provides useful insight for these organisations and in turn, provides a data rich and well-founded basis to understand how future occupations and their skillsets may need to change to meet that challenge. This is developed in section 3.3 of this report.

Organisation functions

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

Design	The function of an organisation that focuses on activities relating to product, service, or solution design.
Implement	The function of an organisation that focuses on activities relating to producing / making / providing its products or services.

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

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

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

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

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

Identifying the Future Supply Chain Capabilities.

The following charts and graphs summarise the changes in the set of capabilities that will be required by the supply chain in the future. The pie-charts reflect the distribution of capabilities across the five functions. The future state data is captured in three Technologist workshops and the current state data is generated using information collected about current occupational standards used across the existing supply chain. This latter information is not as detailed as that produced by the workshops and is indicative and used to provide a point of comparison.

These initial pie charts illustrate the changing proportions of the five functions between the current and future. This indicates an overall relative:

- Increase of Design, Enterprise and Implementation

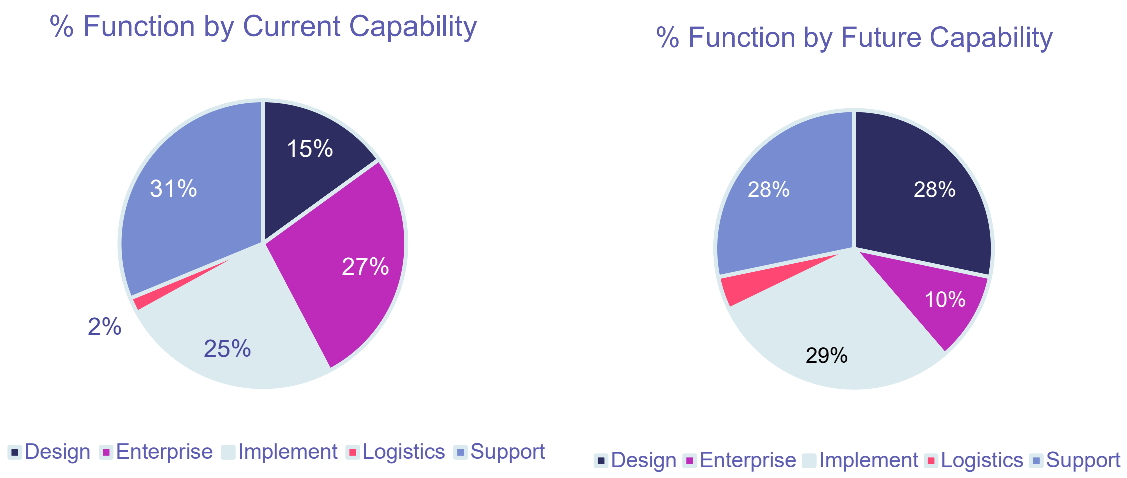

Figure 2: Current and Future Supply Chain - Capability Functions summary by %

This information is useful to indicate relative changes, but the underlying change will be a result of future scale as well as how functions change relative to each other. To gain more detailed insight, these overall comparisons of functional areas are analysed using the current and future capability counts within each function using the next level of classification architecture – Functional Domain.

The graphs show the change in capabilities at domain level within each of thew five main Functions. The domain data is ranked with greatest change at top of the list. These graphs provide insight into both the relative importance of each domain and scale of the changes that will be required from the current state.

The charts that highlight the domain changes across different cycles, will have some variability and empty rows due to the nature of the data.

Design Domains:

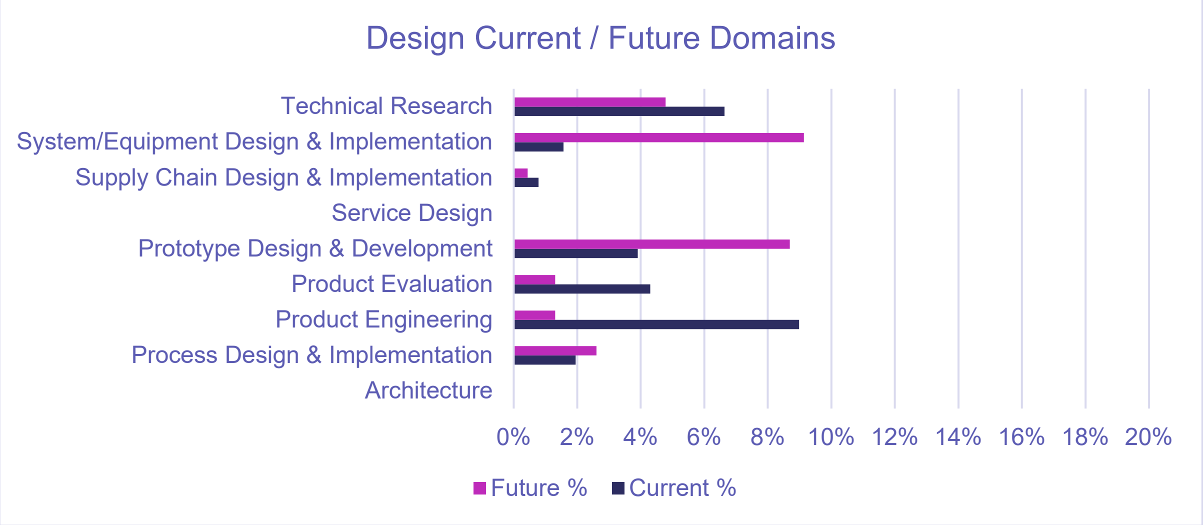

Figure 3: Design Function - Current to Future - Domain changes

The current / future comparison for Design reflects the foresighted transition to an increase in new products, engineering and evaluation ahead of the development and implementation phase.

Enterprise Domains:

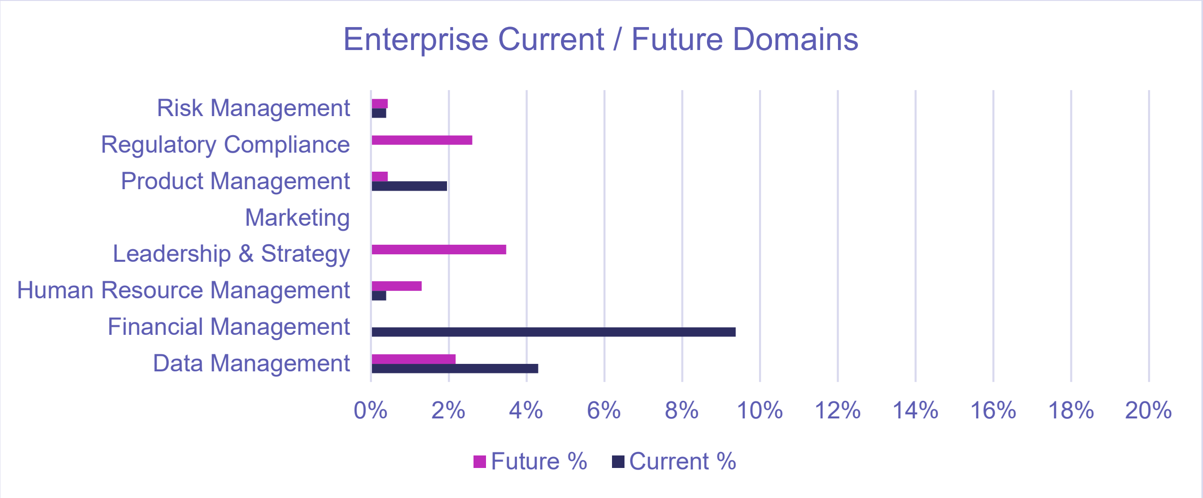

Figure 4: Enterprise Function - Current to Future - Domain changes

The current / future comparisons in the Enterprise area show the increased need associated with a maturing and competitive regulated market and the need to increase human resources.

Implementation Domains:

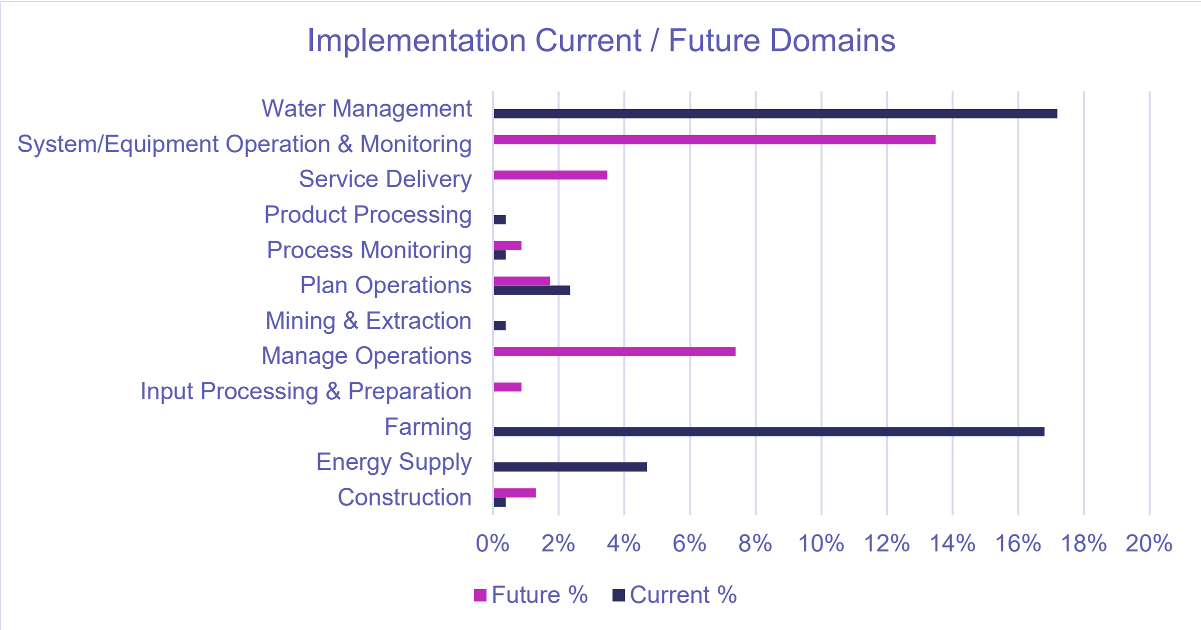

Figure 5: Implement Function - Current to Future - Domain changes

The current / future comparison of implementation functions reflects the changes associated with greater adoption and product sales volume.

Logistics Domains:

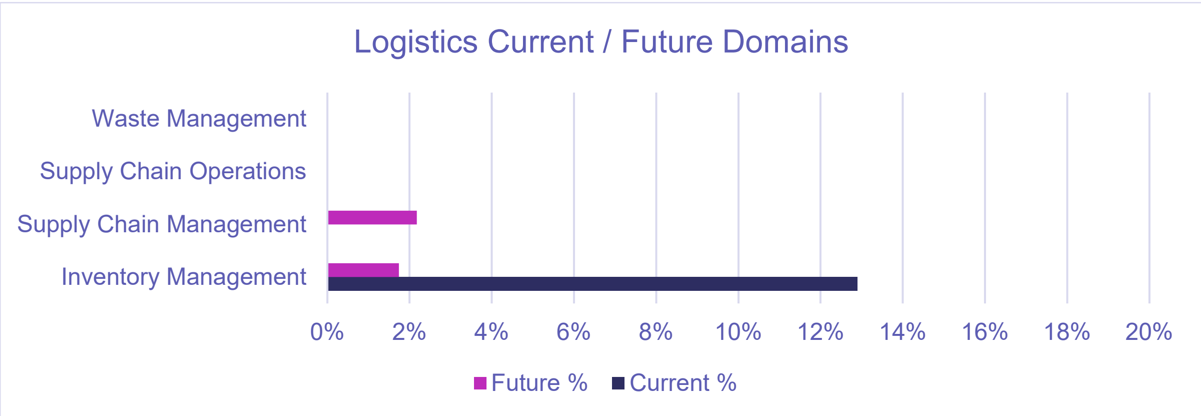

Figure 6: Logistics Function - Current to Future - Domain changes

The current and future comparison for logistics is as expected for organisations gearing up to work at a higher scale of production.

Support Domains:

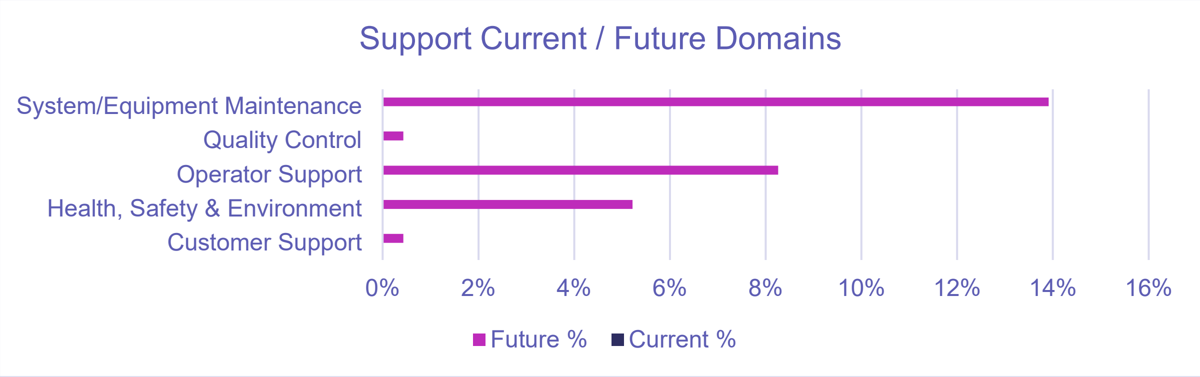

Figure 7: Support Function - Current to Future - Domain changes

The current and future support comparison reflects the current prominent levels of Health and Safety – reducing proportions may be due to omissions during the data gathering and analysis.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Organisational Capabilities	*Generally, the data presented here can provide an indication of how well served the sector is.* *This page provides a high-level summary of each capability statement generated in the cycle.* *The capability statement describes the depth and nature of each capability within an Organisation against a defined reference.* *The page also provides a way of reviewing the capabilities through the lens of the Capability Classification Framework (Design/Implement/Logistics/Support/Enterprise). This information can be used to provide insight about the types of capabilities and their distribution across the classification framework.* *This can be used to identify which capabilities may be supported by existing provision, and where there may be gaps that require new development to support.*

3.3 Occupational change insight

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

Please note that this report is based on the functionality of the Visualisation report from July 2024 - However due to the Foresighting Hub continued development of the system / processes and tools the visualisation tool, there may be additional tabs / information that has been developed following this report publication.

Following the publication of the report new standards may have come about which will not feature in this data set.

If you have any questions, please contact the Workforce Foresighting Hub.

Supply chain partner organisation types

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

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

1. Developer (OREC)
2. Prime Contractor (OREC)
3. Tier 1 Manufacturer (OREC)
4. O&M Contractor (OREC)

This categorisation enables the analysis and reporting of the major areas of occupational change by business function for each partner, recognising that each will have distinctive characteristics and requirements.

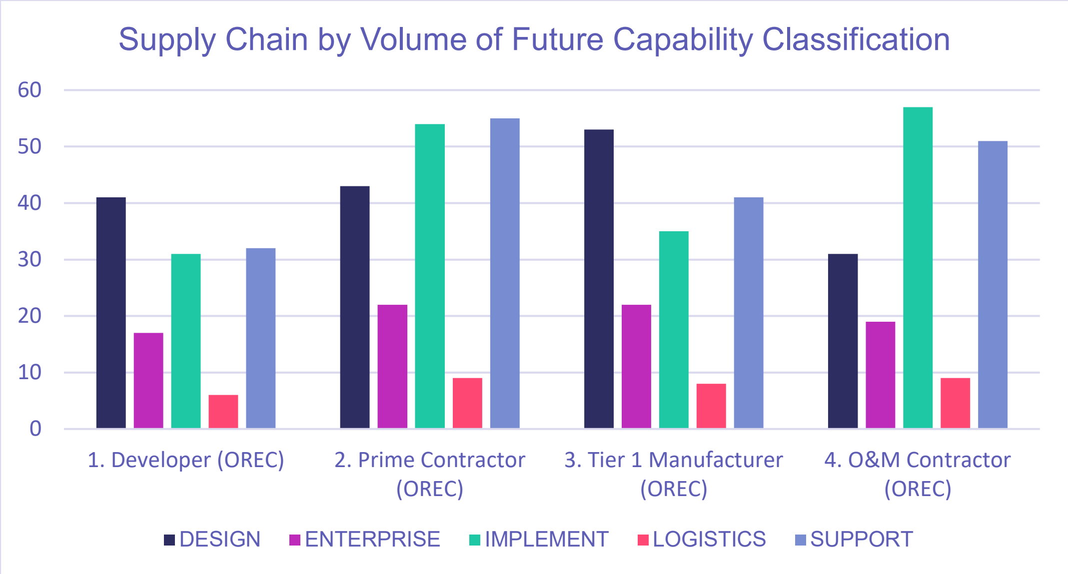

Figure 8: Value Chain by Volume of Future Capability Classification

This graph illustrates the distribution of capabilities by function across the Value Chain Partners. These capability sets are used to form the set of Future Occupational Profiles within each Role Level.

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
Value Chain Capabilities	This page 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.

Role Levels

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

For this cycle, the following Role Levels were determined through the workshops:

1. Junior Technician / Operator
2. Senior Technician / Operator
3. Junior Engineer / Supervisor
4. Senior Engineer / Supervisor

Proficiencies

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

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

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

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

In the workshops participants apply their insight to assign proficiency for each role group to each capability. Individual responses are aggregated by the system to arrive at a consensus. A summary of the distribution of required proficiency for the role families in this cycle are:

	1. Qualified/Skilled Operator	2. Technician	3. Engineer	4. Senior Engineer
Awareness	28%	14%	8%	3%
Practitioner	71%	45%	87%	16%
Expert	1%	42%	5%	81%

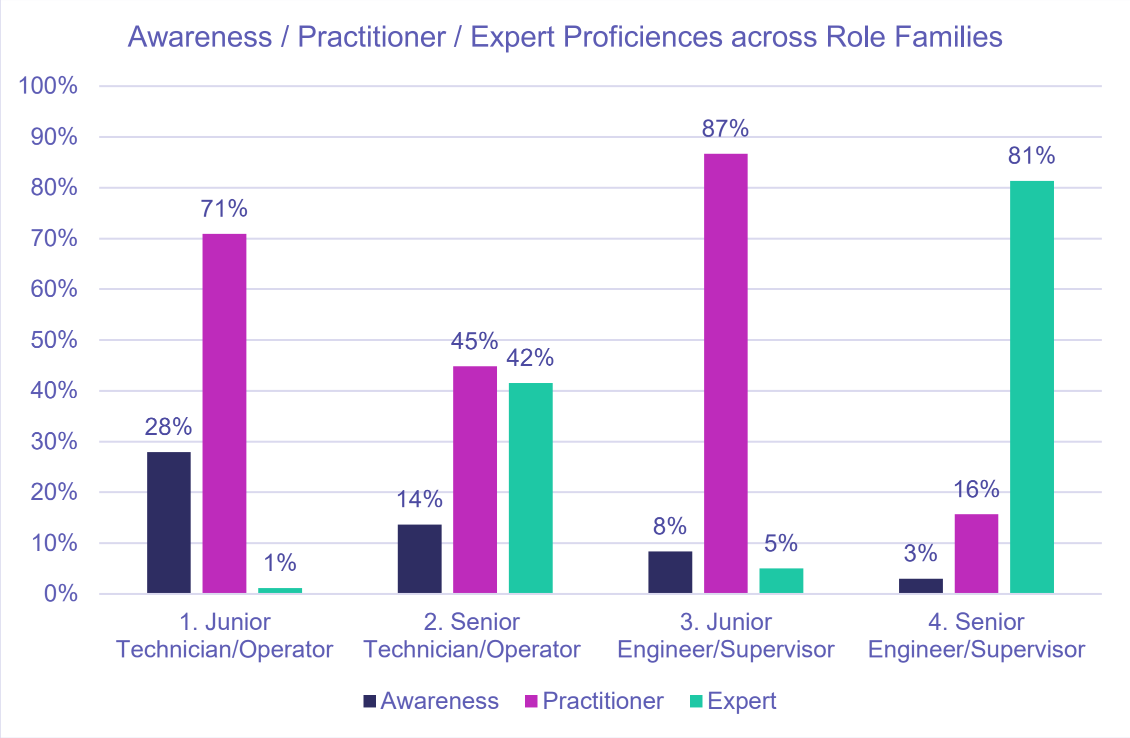

Figure 9: Proficiency details by Role Family

Future Occupational Profiles

The FOPs (Future Occupational Profiles) are a construct created and used during workforce foresighting workshops and analysis to capture future skills needs in a form that may be compared with current occupation definitions – typically occupational standards.

The familiar nature and structure of 'FOP's assists with their evaluation and validation by employers and educators and enables the analytical comparison that results in useful indications of matches, surplus and gaps of future skills needs compared with current state. This then allows recommendations for action to be made based on future need and current fit to those needs.

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

Educators can review current occupational standards against the requirements of the FOPs and interpret which need to be changed to fill the gaps between the current and future state.
Employers can consider existing apprenticeship standards and make a judgement on adapting an existing apprenticeship standard to upskill their workforce to meet the requirements of a particular FOP.
Educators may react to these specified skill requirements from Industry by editing, adapting, or creating new content.

FOPs and indicative skills need

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

1. Junior Technician / Operator Role Level FOPs:

In this cycle the Technician / Operator role family was defined as occupations and roles requiring Level 3 qualifications or apprenticeships.

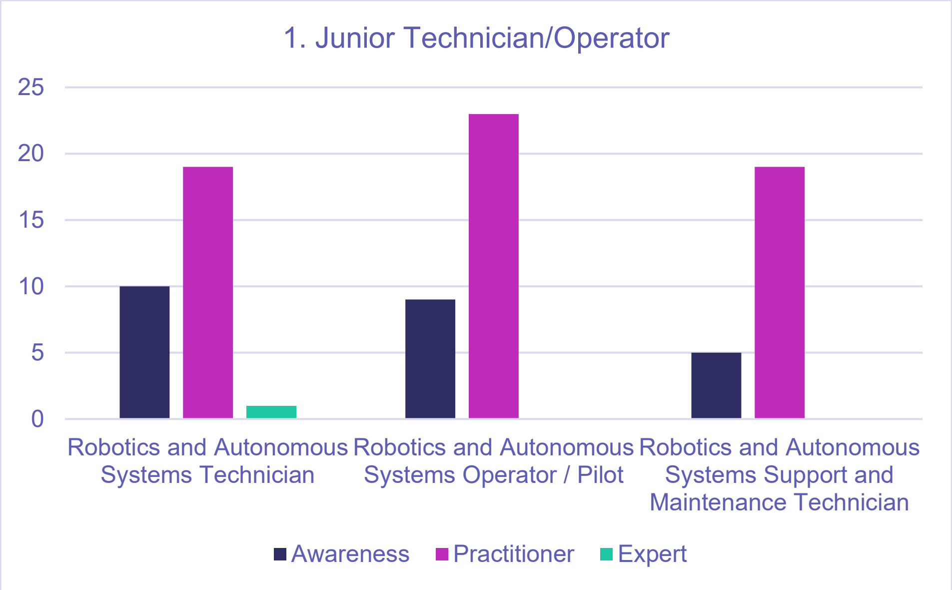

Figure 10: Priority FOPs – Junior Technician / Operator Role Family

2. Senior Technician / Operator Role Level FOPs:

In this cycle the Engineer role family was defined as occupations and roles requiring Level 4/5 qualifications or apprenticeships.

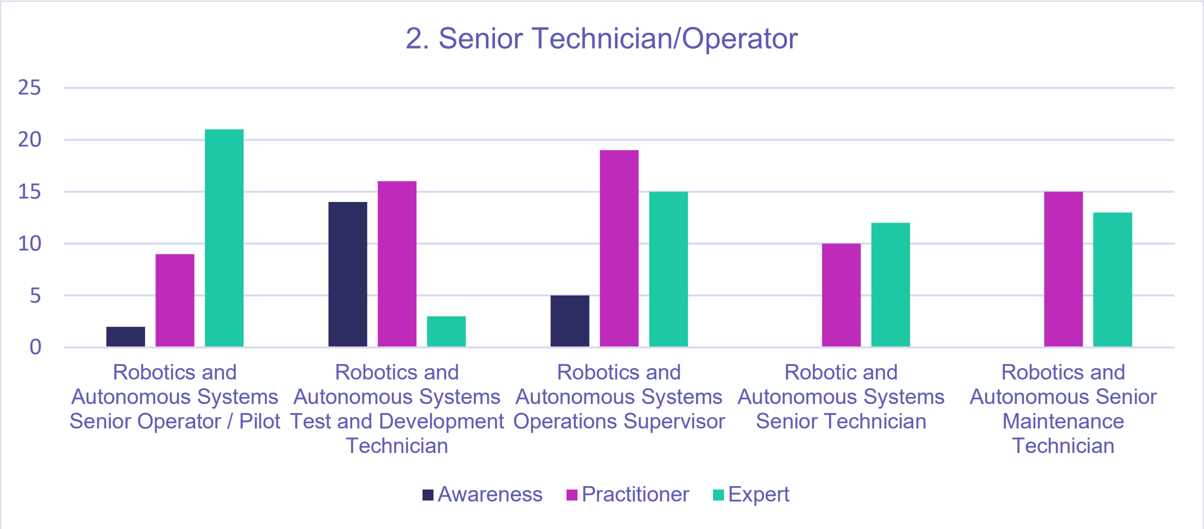

Figure 11: Priority FOPs – Senior Technician / Operator Role Level

3. Junior Engineer / Supervisor Role Level FOPs:

In this cycle the Senior Engineer role family was defined as occupations and roles requiring Level 5/6 qualifications or apprenticeships.

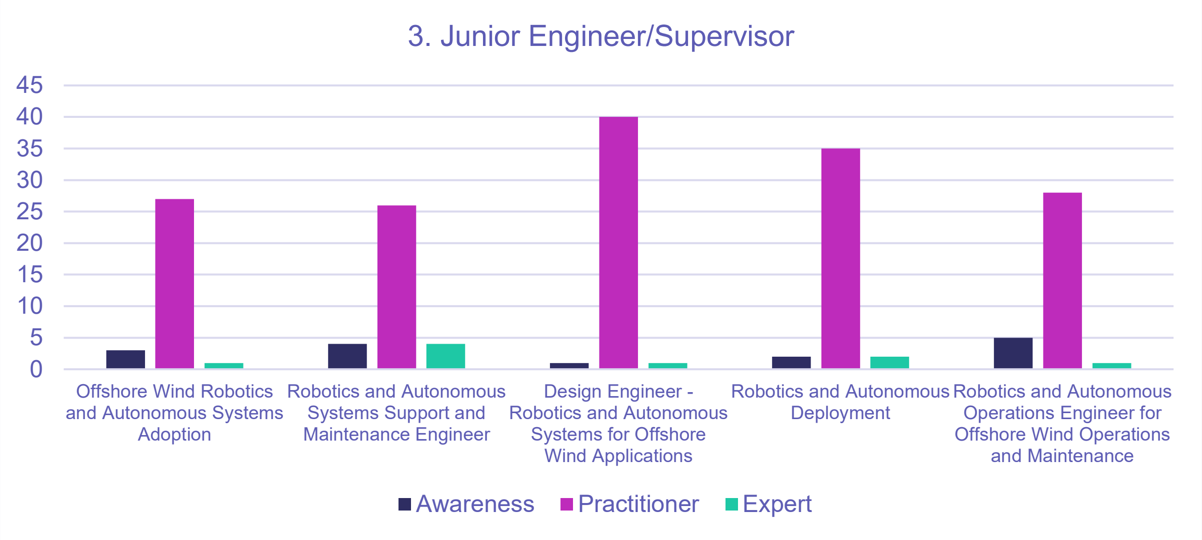

Figure 12: Priority FOPs - Junior Engineer / Supervisor Role Level

4.Senior Engineer / Supervisor Role Family FOPs:

In this cycle the Senior Engineer role family was defined as occupations and roles requiring Level 5/6 qualifications or apprenticeships.

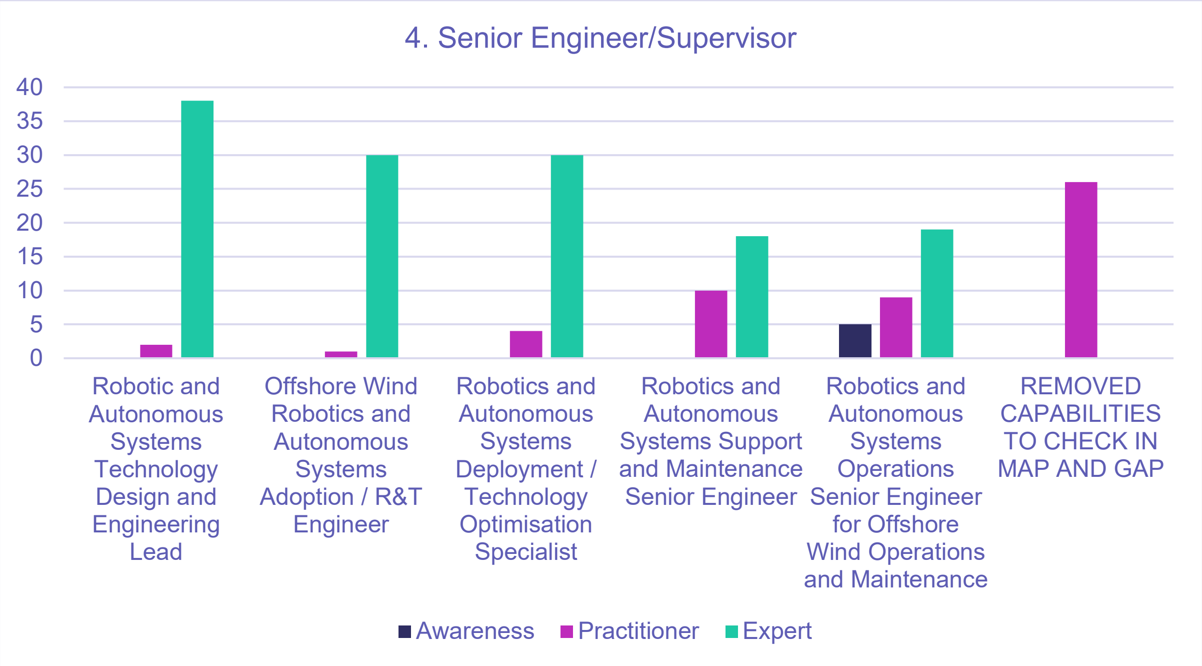

Figure 12: Priority FOPs - Senior Engineer / Supervisor Role Family

Visualisation Instructions

Detailed instructions can be found in the appendix.

Visualisation Data Link	What is it and what can it be used for?
P-FOP Matrix	This page provides a detailed breakdown of future occupational profiles that could be required in the future workforce. These were generated using a combination of attributes collected through the workshops and an algorithm. These suggested profiles were then reviewed and ratified by small groups of employers who were able to add/remove capabilities and uprate/downrate proficiency levels required. You can view all the P-FOPs in a role family by selecting one (or more) of these from the drop down. This will then allow you to select the P-FOPs aligned to that role family. The populated table allows you review and compare different P-FOPs within or across role families. You can view the capabilities in each P-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.

3.4 Future Occupational Profiles compared with current provision

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

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

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

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

By looking at how current occupational standards fit the Future Occupational Profiles, the most suitable and efficient route for change can be determined, e.g. a fit factor of less than 33% probably indicates that the current standard is unlikely to a good candidate for change, however a fit factor of 66% suggests that less adaptation will be necessary to meet future needs.

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

Factor scores

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

Suitability Grid

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

Figure 13: Fit Factor scores and Suitability Grid

For this foresighting cycle, it was found that a higher threshold on surplus factor is more useful in filtering out the less relevant IfATE standards, whilst a slightly lower threshold on fit factor is useful to ensure relevant standards might be included.

Using this score and indicated ‘RAG status’ the following interpretation can be made:

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

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

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

FOP findings compared with current standards

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

Using 4. Robotic Equipment Supplier as an example, all four role families are represented, and from looking at the data extracted we can identify that there is some coverage of Future Occupations in the role of Robotics System Design and Implementation Engineer based on the current IFATE standards.

The IFATE standards provision is slightly stronger for the Shipbuilder role groups than for Ship Designer or Systems Integrator, however there is not a truly leading role group and there are no 'Good suitability's'.

The data below presents the initial headlines and demonstrates that the overall information illustrates that the Future Occupational Profiles are not well supported by the current IFATE Standards. There is therefore an opportunity to develop new course content by apprentice training providers /universities providing supplementary learning opportunities to existing courses and CPD provision

Supply Chain Partner – 1. Developer

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
3. Junior Engineer/Supervisor	Offshore Wind Robotics and Autonomous Systems Adoption	Low Suitability
4. Senior Engineer/Supervisor	Offshore Wind Robotics and Autonomous Systems Adoption / R&T Engineer	Low Suitability

Detailed breakdown:

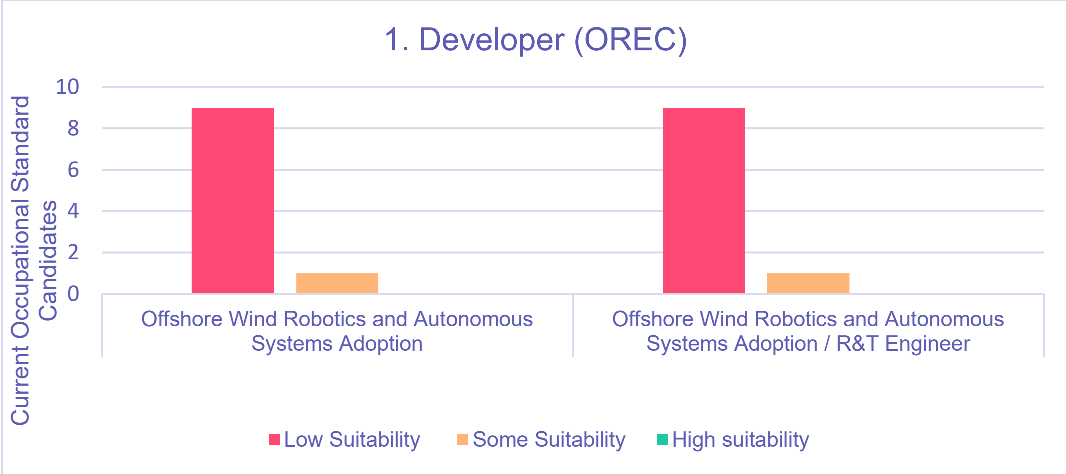

Figure 14: 1. Developer (OREC) - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner – 2. Prime Contractor

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
3. Junior Engineer/Supervisor	Robotics and Autonomous Deployment	Low Suitability
4. Senior Engineer/Supervisor	Robotics and Autonomous Systems Deployment / Technology Optimisation Specialist	Low Suitability

Detailed breakdown:

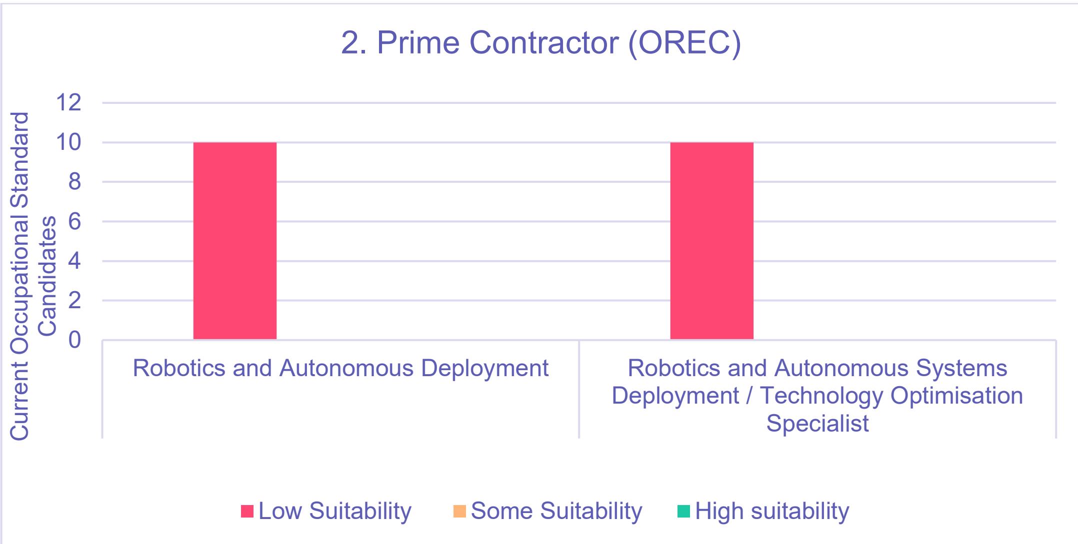

Figure 15: 2. Prime Contractor (OREC) - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner – 3. Tier 1 Manufacturer

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
1. Junior Technician/Operator	Robotics and Autonomous Systems Technician	Low Suitability
2. Senior Technician/Operator	Robotic and Autonomous Systems Senior Technician	Low Suitability
2. Senior Technician/Operator	Robotics and Autonomous Systems Test and Development Technician	Low Suitability
3. Junior Engineer/Supervisor	Design Engineer - Robotics and Autonomous Systems for Offshore Wind Applications	Low Suitability
4. Senior Engineer/Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Some Suitability

Detailed breakdown:

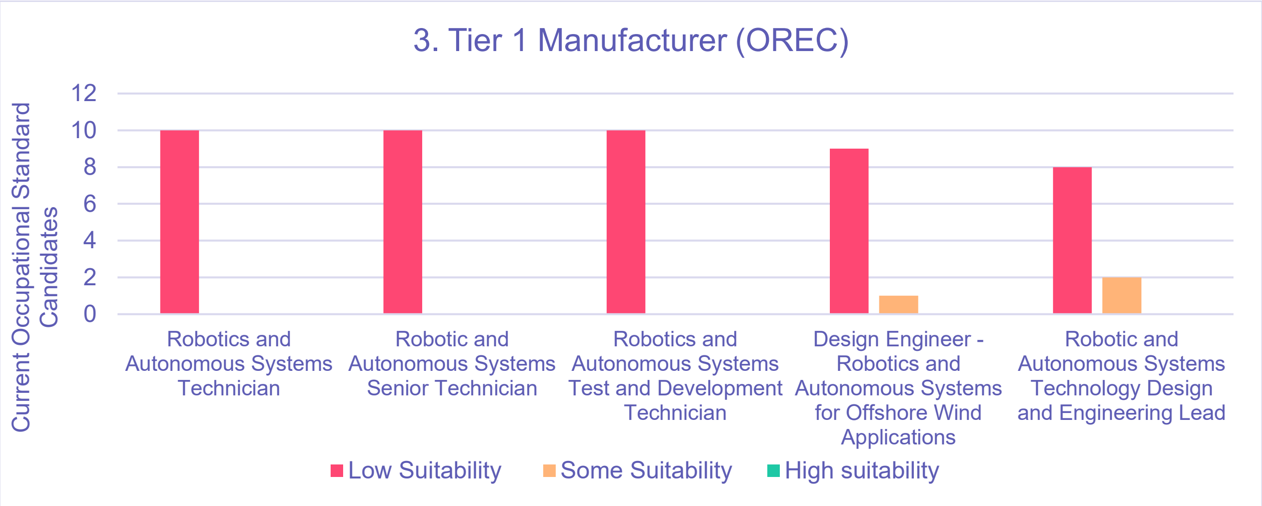

Figure 16: 3. Tier 1 Manufacturer (OREC) - Count of current provision (IfATE Standards) and suitability to FOPs

Supply Chain Partner – 4. O&M Contractor

Role Family	Selected Future Occupational Profiles	Current Suitability Summary
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Some Suitability
1. Junior Technician/ Operator	Robotics and Autonomous Systems Operator / Pilot	Low Suitability
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Some Suitability
2. Senior Technician/ Operator	Robotics and Autonomous Systems Senior Operator / Pilot	Low Suitability
2. Senior Technician/ Operator	Robotics and Autonomous Systems Operations Supervisor	Low Suitability
3. Junior Engineer/ Supervisor	Robotics and Autonomous Operations Engineer for Offshore Wind Operations and Maintenance	Low Suitability
3. Junior Engineer/ Supervisor	Robotics and Autonomous Systems Support and Maintenance Engineer	Low Suitability
4. Senior Engineer/ Supervisor	Robotics and Autonomous Systems Support and Maintenance Senior Engineer	Low Suitability
4. Senior Engineer/ Supervisor	Robotics and Autonomous Systems Operations Senior Engineer for Offshore Wind Operations and Maintenance	Low Suitability

Detailed breakdown:

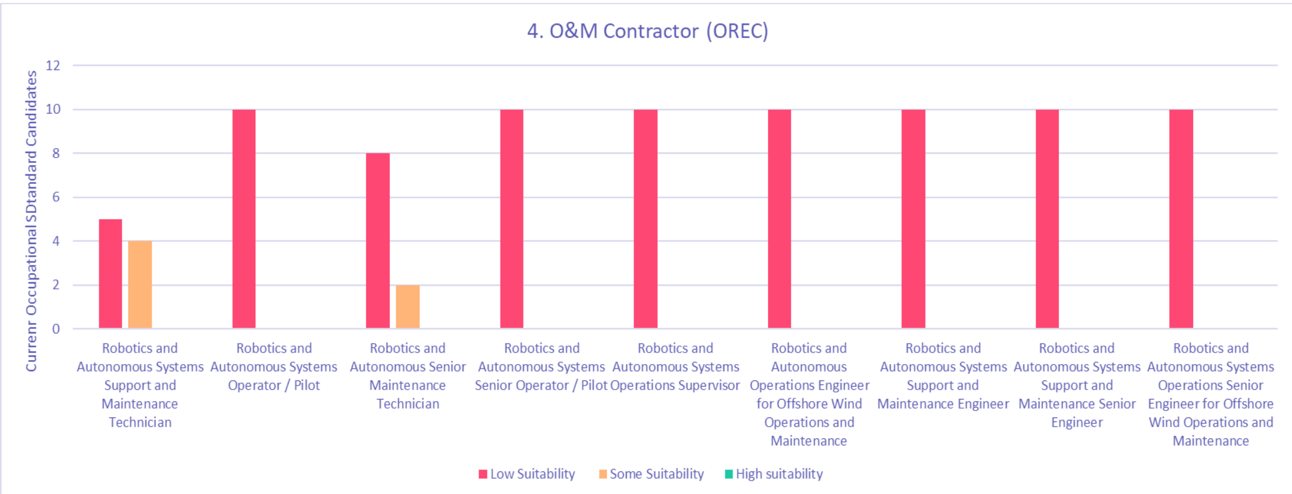

Figure 17: 4. O&M Contractor (OREC) - Count of current provision (IfATE Standards) and suitability to FOPs

3.5 Summary of findings

The below table counts the number of IFATE standards by Suitability score for each FOP.

Role Family	Primary Value Chain / Workflow Partner	Future Occupation Profiles	Low Suit-ability	Some Suit-ability	Good Suit-ability	Overall Suitability RAG
4. Senior Engineer/ Supervisor	1. Developer (OREC)	Offshore Wind Robotics and Autonomous Systems Adoption / R&T Engineer	9	1	0	Low Suitability
3. Junior Engineer/ Supervisor	1. Developer (OREC)	Offshore Wind Robotics and Autonomous Systems Adoption	9	1	0	Low Suitability
4. Senior Engineer/ Supervisor	2. Prime Contractor (OREC)	Robotics and Autonomous Systems Deployment / Technology Optimisation Specialist	10	0	0	Low Suitability
3. Junior Engineer/ Supervisor	2. Prime Contractor (OREC)	Robotics and Autonomous Deployment	10	0	0	Low Suitability
2. Senior Technician/ Operator	3. Tier 1 Manufacturer (OREC)	Robotics and Autonomous Systems Test and Development Technician	10	0	0	Low Suitability
1. Junior Technician/ Operator	3. Tier 1 Manufacturer (OREC)	Robotics and Autonomous Systems Technician	10	0	0	Low Suitability
4. Senior Engineer/ Supervisor	3. Tier 1 Manufacturer (OREC)	Robotic and Autonomous Systems Technology Design and Engineering Lead	8	2	0	Some Suitability
2. Senior Technician/ Operator	3. Tier 1 Manufacturer (OREC)	Robotic and Autonomous Systems Senior Technician	10	0	0	Low Suitability
3. Junior Engineer/ Supervisor	3. Tier 1 Manufacturer (OREC)	Design Engineer - Robotics and Autonomous Systems for Offshore Wind Applications	9	1	0	Low Suitability
1. Junior Technician/ Operator	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Support and Maintenance Technician	5	4	0	Some Suitability
4. Senior Engineer/ Supervisor	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Support and Maintenance Senior Engineer	10	0	0	Low Suitability
3. Junior Engineer/ Supervisor	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Support and Maintenance Engineer	10	0	0	Low Suitability
2. Senior Technician/ Operator	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Senior Operator / Pilot	10	0	0	Low Suitability
1. Junior Technician/ Operator	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Operator / Pilot	10	0	0	Low Suitability

2. Senior Technician/ Operator	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Operations Supervisor	10	0	0	Low Suitability
4. Senior Engineer/ Supervisor	4. O&M Contractor (OREC)	Robotics and Autonomous Systems Operations Senior Engineer for Offshore Wind Operations and Maintenance	10	0	0	Low Suitability
2. Senior Technician/ Operator	4. O&M Contractor (OREC)	Robotics and Autonomous Senior Maintenance Technician	8	2	0	Some Suitability
3. Junior Engineer/ Supervisor	4. O&M Contractor (OREC)	Robotics and Autonomous Operations Engineer for Offshore Wind Operations and Maintenance	10	0	0	Low Suitability

Top Fits

From a FOP perspective and utilising the suitability grid we can determine which of the groups of current occupational standards are more applicate than others.

There are no FOPs with good suitability, however, the FOPs with some suitability score resulting from their comparison with current IFATE standards and provision are:

1. Robotic and Autonomous Systems Technology Design and Engineering Lead
2. Robotics and Autonomous Systems Support and Maintenance Technician
3. Robotics and Autonomous Senior Maintenance Technician

Suitable standards are listed in the table below:

Role Family	Future Occupation Profiles	IfATE Apprenticeship Standard	Suitability RAG
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Creative industries production technician	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Utilities engineering technician	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Maintenance and operations engineering technician	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Multi-skilled mechatronics maintenance technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Creative industries production technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Utilities engineering technician	

4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Robotics engineer - degree	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Advanced robotics engineer	

This is a wide-ranging field so use of the data visualisation tool is recommended to access the next layer of detail and review the specific standards that have been identified as having Good Suitability / Some Suitability or Low Suitability.

As a comparison we can also list the standards that score lowest against the required FOPs. This suggests that there is very little suitable in the IFATE standards to support these Future Role Profiles.

FOPs with the lowest scores are:

Role Family	P-FoP	IfATE Apprenticeship Standard	Suitability Grid
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Footwear manufacturer	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Engineering operative	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Maritime mechanical fitter	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Science industry maintenance technician	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Food and drink maintenance engineer	
1. Junior Technician/ Operator	Robotics and Autonomous Systems Support and Maintenance Technician	Land-based service engineer	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Footwear manufacturer	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Lead engineering maintenance technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Maintenance and operations engineering technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Multi-skilled mechatronics maintenance technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Engineering operative	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Maritime mechanical fitter	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Science industry maintenance technician	
2. Senior Technician/ Operator	Robotics and Autonomous Senior Maintenance Technician	Food and drink maintenance engineer	

4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Automation and controls engineering technician	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Electro-mechanical engineer	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Post graduate engineer	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Embedded electronic systems design and development engineer (degree)	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Aerospace engineer	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Aerospace software engineer	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Process automation engineer (degree)	
4. Senior Engineer/ Supervisor	Robotic and Autonomous Systems Technology Design and Engineering Lead	Building services design engineer (degree)	

Visualisation Instructions

Visualisation Data Link	What is it and what can it be used for?
P-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 P-FOP in the two available drop-downs. The table in the lower section of the page will then be populated with all relevant capabilities. The search control above the table allows you to filter content of any of the columns of data. A key piece of functionality in this table is the presence of the KSB tags associated with the capabilities.
Future KSBs Summary	This page provides a view of the complete set of capabilities within the cycle along with all of the associated KSB tags which are linked to them. It is, essentially, the superset of all details displayed on the P-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.
P-FOP Distribution	This page allows provides a breakdown of the Capabilities within the selected Cycle and how they are distributed across the P-FOPs with the addition of a distribution chart showing the required proficiency across those P-FOPs. Clicking the "View P-FOPs" button alongside each capability will provide a list of the proficiencies (EPA) with the P-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
Capabilities Matched to Current Provision	This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard. You can select individual capabilities to review their specific matches. These matches are shown in the bottom panel, including the Standard, the Level and the Duty Statement this is matched to. You can filter in several ways to focus your review: • By the Capability Classification Framework (left-hand panel). • By capabilities that **are** served by the reference mapping framework – the default is Institute for Apprenticeships and Technical Education (IfATE) provision. • By capabilities that **are not** served by the reference mapping framework, e.g., IfATE provision – these are capabilities required in the future that may require new/bespoke training and CPD materials to be developed to upskill/re-skill the workforce. This page can be used to identify where existing provision may exist across the broad spectrum of 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.
Fit & Surplus Factors	This page allows you to review the 'Fit' and 'Surplus' of Prototype Future Occupation Profiles (P-FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). It is possible for the 'Fit' and 'Surplus' comparison to total over 100%, as they are two separate calculations based on a two-way comparison.
Fit & Surplus Matrix	This page is a visual representation of the 'Fit and Surplus Factor' insight. You can visually review 'Fit' and 'Surplus' of Prototype Future

	Occupation Profiles (P-FOP) against existing training provision e.g. Institute for Apprenticeships and Technical Education (IfATE). This can help you identify which provision may align strongest, or which may require adaptation, to provide the suitable provision fit for each future role. It will help you focus in on which provision to focus your attention for analysis.
P-FOP Capability Matches	This page allows you to view the matches between Capabilities and Institute for Apprenticeships and Technical Education (IfATE) Duty Statements. Clicking the arrow next to a number in the 'Matches' column will open a popup with more detail for each Capability. Each capability also includes Knowledge, Skill and Behaviour Tags, to support with scaffolding future education provision. You can review individual Prototype Future Occupational Profiles (P-FOPS) or review all P-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, IfATE apprenticeship standards) it is possible to interrogate the data and identify specific statements in standards that align to enable identification of existing training materials and activities that could be used or adapted to meet future requirements. This can be used to review the capability requirements for Role Families and P-FOPs, from Job / Occupation level through to Knowledge, Skill and Behaviour level

4.0 Appendices

4.0 Appendices

4.1 Mission – What is workforce foresighting?

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.

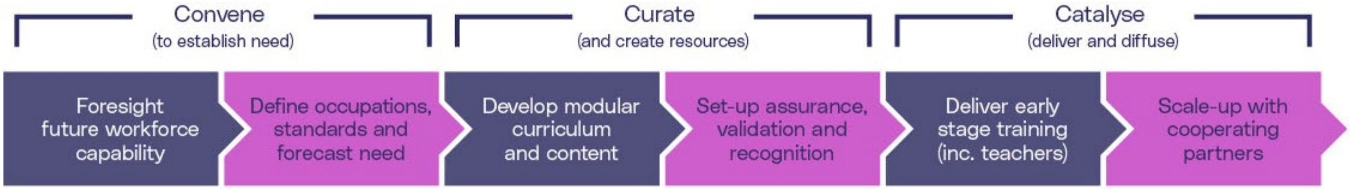

Figure 1: The Skills Value Chain

Workforce foresighting

Using the Skills Value Chain approach, the UK can 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.

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

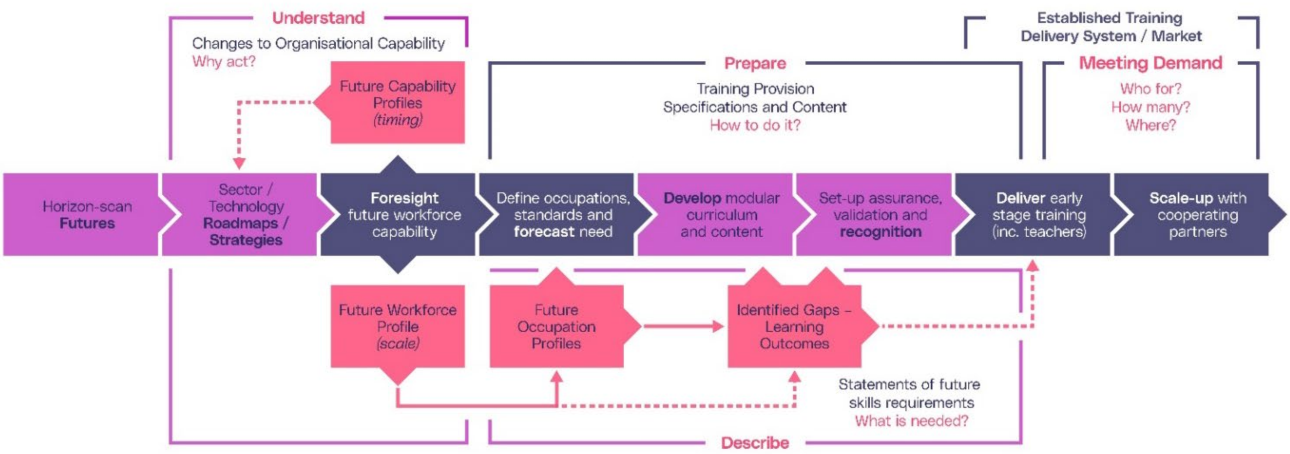

Figure 2: Workforce Foresighting & Skills Value Chain

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 Workforce Foresighting Hub 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 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

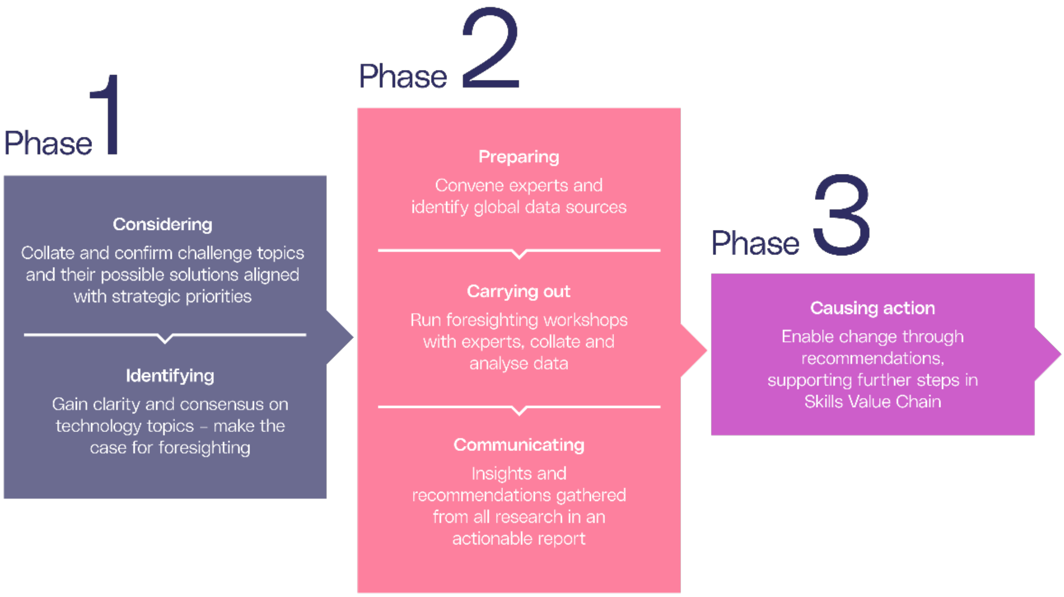

Figure 3 - The workforce foresighting process

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 fulfill 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 Workforce Foresighting Hub 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 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.

4.2 List of Participants

Organisation	Technologist Group	Employer Group	Educator Group	Leads / QA Group
OREC	o	o		o
Marshall Futureworx	o	o		o
Soil Machine Dynamics	o	o		
GE Vernova	o			
The National Robotarium	o			
The Manufacturing Technology Centre	o			
Cranfield University	o			
Honuworx	o			o
Air Control Entech		o		
Perceptual Robotics		o		
Newcastle University			o	o
Durham University			o	
Education Partnership Northeast (EPNE)			o	

4.3 Cycle timeline

This cycle started the workshops as part of the Carry Out phase in February 2024. The Carry Out phase workshops completed at the end of April 2024; sensemaking and data validation took place in May 2024. This report was prepared and published in July 2024.

4.4 Access to output data - link and authorisation

Link to Visualisation tool

4.5 Glossary - common language

Term	Definition
Impact Domains	Innovate UK domains used as Strategic Categories to assist setting and monitoring priorities
National Challenge (Industry / Sector / Region)	A recognised technological or socio-political threat or opportunity for which there is consensus that workforce action is necessary
Challenge Response	Specific intervention aimed at the challenge
Capability (Organisation)	The collective abilities, and expertise of an organisation to carry out a function, because provision and preparation have been made by the organisation
Capability Classification	Classification provides a common, structured vocabulary to define capability
Capability Statements	Description of the depth and nature of each capability within an organisation
Capability Syntax	Common language to describe each capability application within organisation type
Competencies (Workforce / Individual)	'Proficiency, aptitude, capacity, skill, technique, experience, expertise, facility, fitness related to capability
Competency definition 'KSBs' (Knowledge, Skills and Behaviours)	Knowledge, Skills, and Behaviours are the elements used to express the required competencies for each Role Group
Competency Domain	Used during foresighting analysis to provide focus on existing and emerging competency needs
Delphi Process	Foresighting takes a Delphi approach which has come to represent consulting expert opinion. (Harking back to the Delphic Oracle of ancient Greece)
Foresight Cycle	Set of workshops, analysis and reporting that implements the Foresight Process for each subject
Foresight Process	A series of activities which are convened to understand future competence needs, the opportunities available and actions required to deliver the right skills at the right time and place
Foresighting Champion	An individual nominated within a new user organisation of foresighting to facilitate and lead the use of foresighting processes and tools with the support of the Project Team
Foresighting Subject	The application of specific technologies in the context of a given challenge and which are candidates for foresighting
Future Competency Set	The KBS output from the Educator workshop for each Role Group
Map and Gap Analysis	A combined expert and automated process that maps the Future Competency Set against a selected reference framework
Organisation Type	Simple description of nature of organisation for which capability is required
Proficiencies	Proficiencies differentiate the degree of competencies required from differing Role Groups to support capabilities
Project Sponsor	Typically, a stakeholder in the challenge being successfully met who requires information to under-write plans to act
Role Group	Role groups are a collective of roles that exist in a typical manufacturing business / industrial sector
Syntax	The way in which a statement is phrased to ensure reliable, repeatable and meaningful interpretation

Technologies	The technology that could be used to address the challenge
Working Scenario	To provide further context in relation to the subjects and used to position participants thinking during the detailed identification of future capabilities
Workshops	Online sessions used to undertake each step in the foresight process
Roadmaps	Sector, Industry, Regional view of emerging opportunities and their market entry
Participants	Technologists, Educators, Employers

4.6 – Visualisation links and Illustrations

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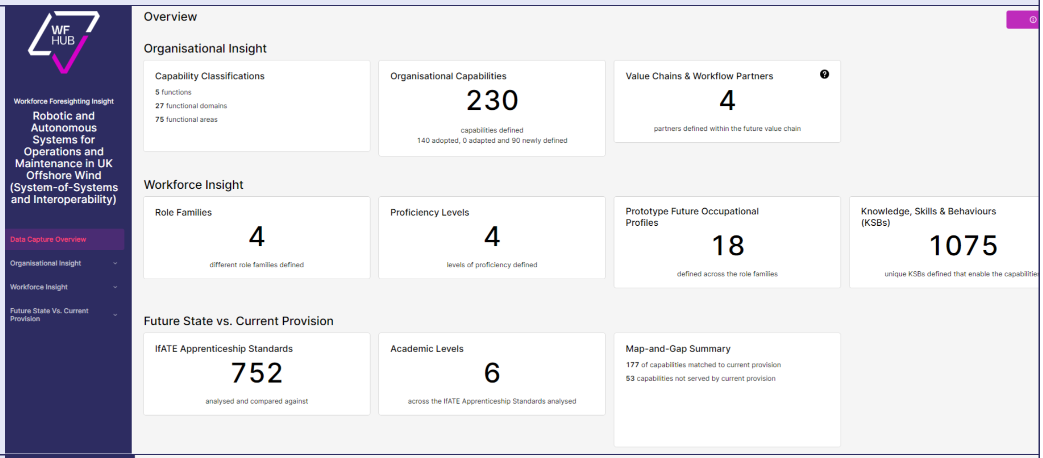
<tr><th>Link to Visualisation</th><th>View of data</th></tr>
<tr><td>Data Capture Overview</td><td>
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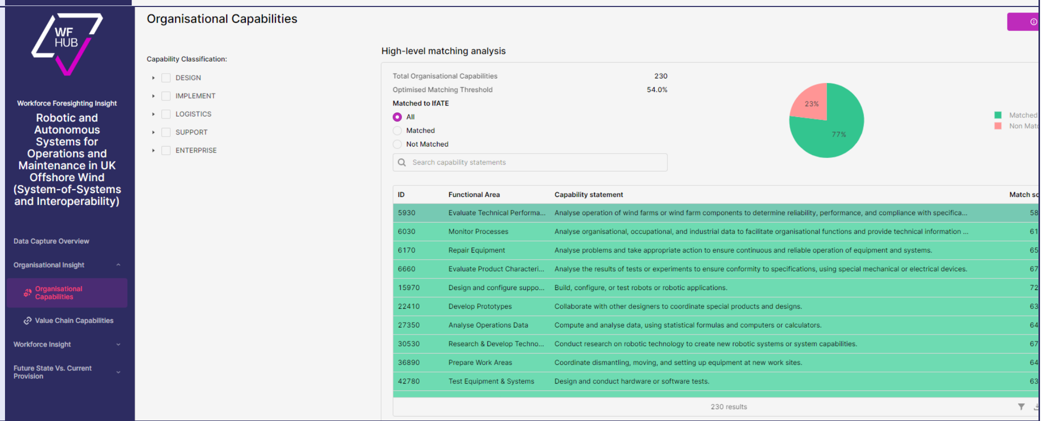
<tr><td>Organisational Capabilities</td><td>
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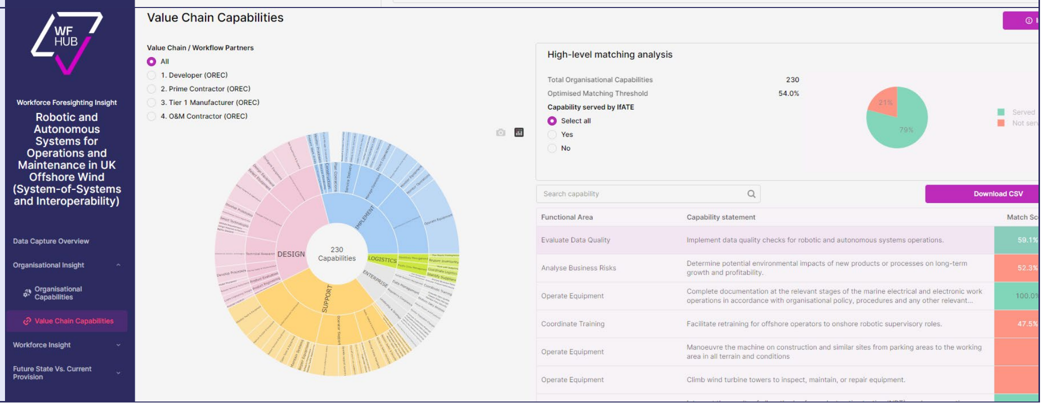
<tr><td>Value Chain Capabilities</td><td>
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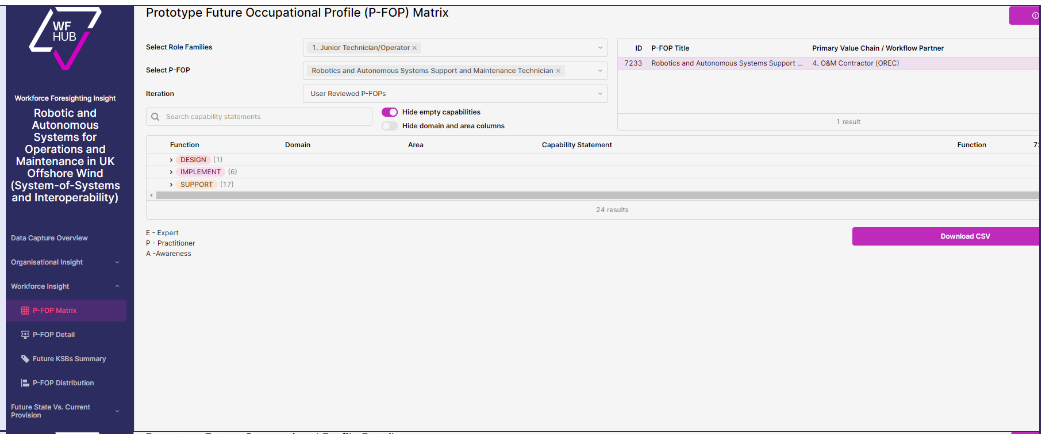
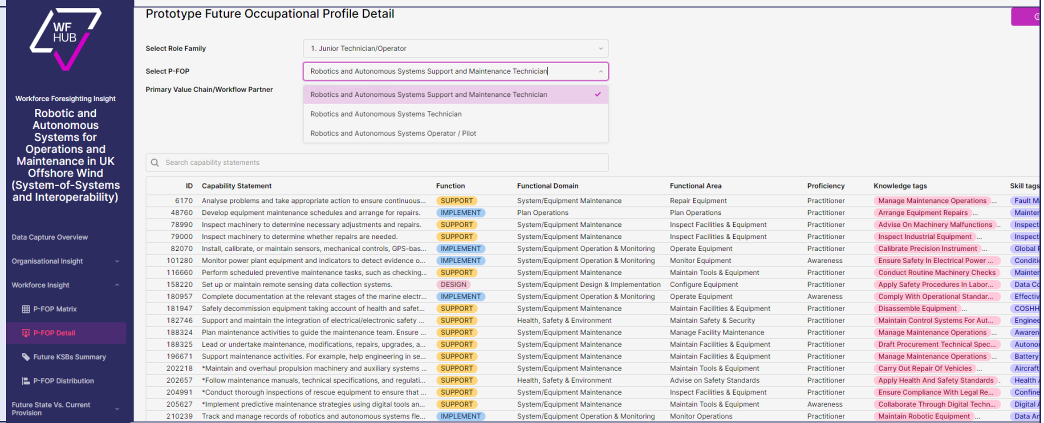
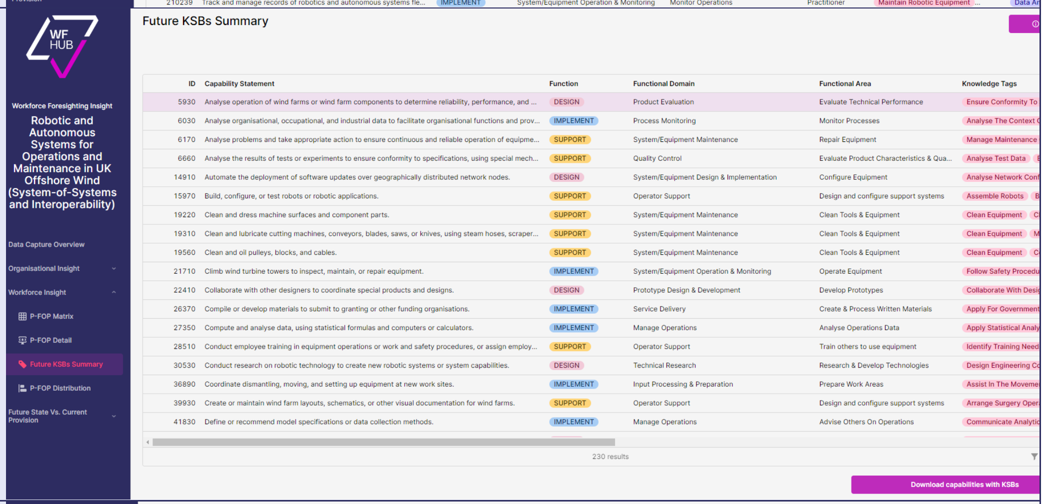
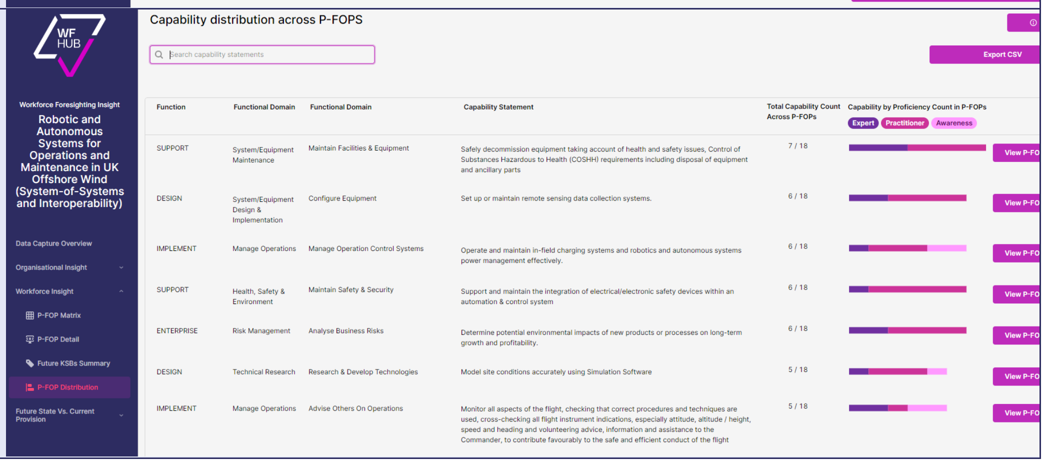
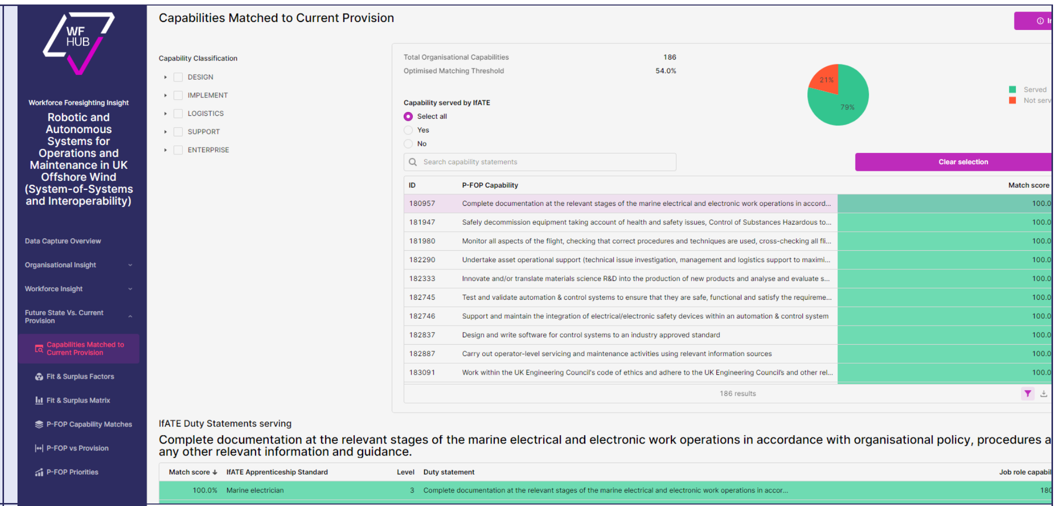
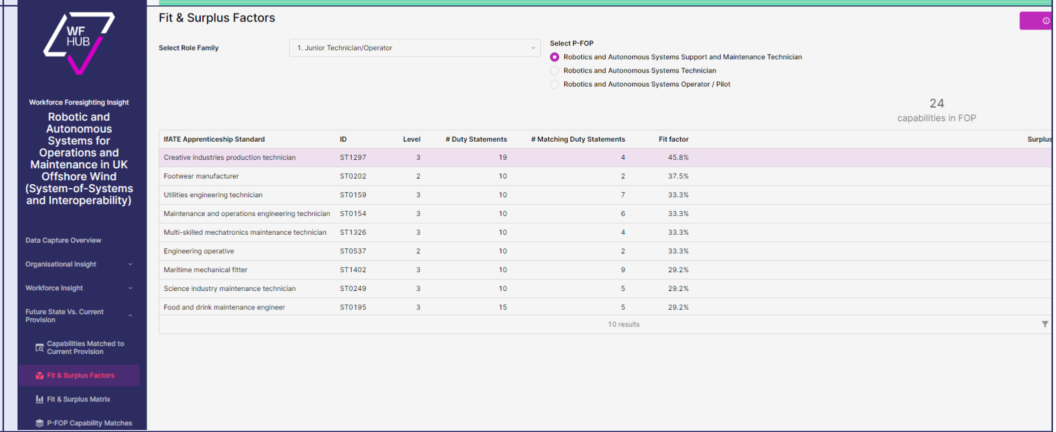
P-FOP Matrix	
P-FOP Detail	
Future KSBs Summary	
P-FOP Distribution	

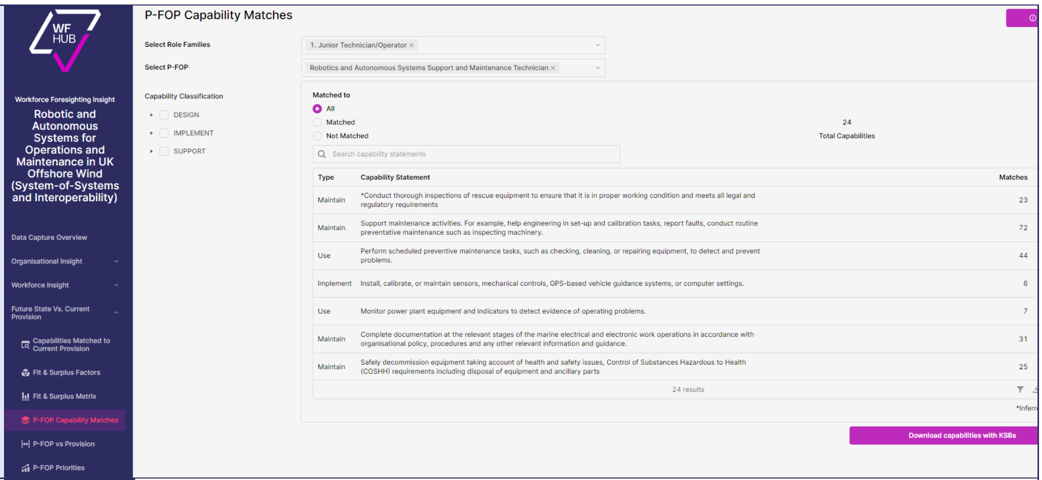
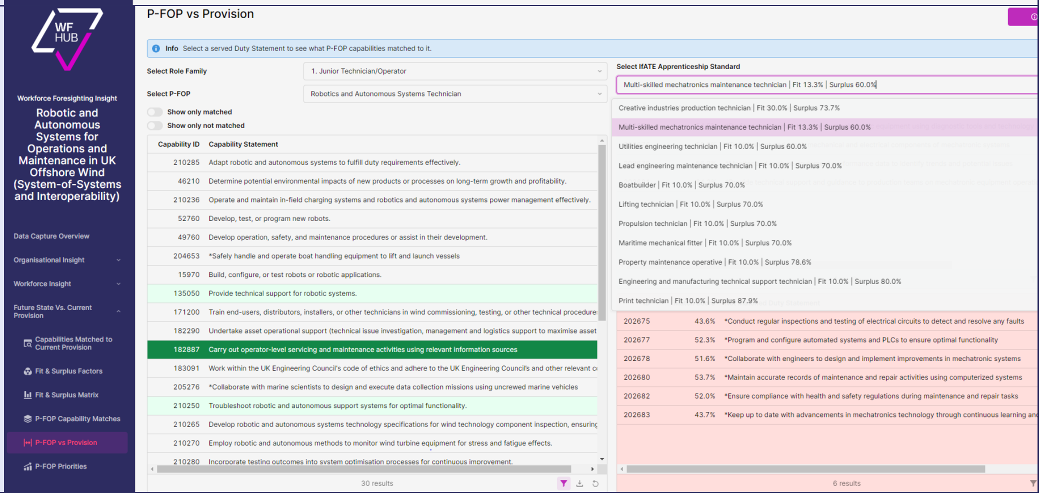
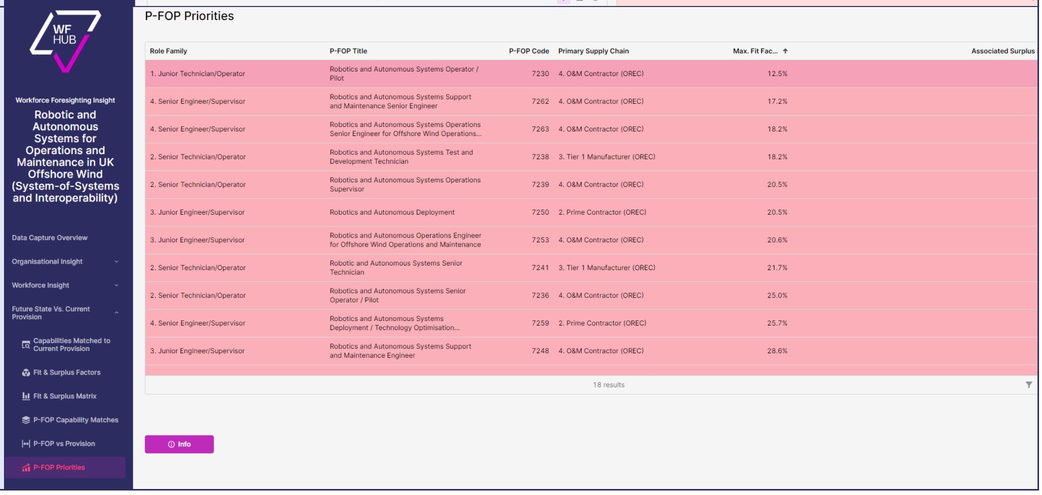
Capabilities Matched to Current Provision



Fit & Surplus Factors



Fit & Surplus Matrix

P-FOP Capability Matches	
P-FOP vs Provision	
P-FOP Priorities	

4.7 – Supply Chain Capabilities

This is an overview of the identified capabilities at a Supply Chain / Workflow Partner level and shows how the supply chain organisations' workforce structure needs to change to deliver the required capabilities.

Supply Chain Partner	Example of required change to deliver capabilities
1. Developer	To effectively meet operational demands, robotic and autonomous systems in offshore wind operations must comply with health and safety regulations, undergo rigorous risk assessments, and optimise deployment through data analysis and economic evaluation. Integrating certification processes, marine control documentation, thorough commissioning tests, techno-economic analyses, and digital twins streamlines these operations. Essential developments include mission planning tools, sensor fusion systems, novel sensor technologies, machine learning algorithms, and ground control stations to enhance versatility and minimise costs. Policies ensuring compliance, sustainable support systems, precise control software, and infrastructure compatibility are crucial. Governance frameworks, safety standards for multi-mode robot operations, and systems for battery-powered robots are vital. Unmanned autonomous vessels' logistics, robotic monitoring for stress and fatigue, infrastructure engineering, and rigorous performance testing ensure reliability. Establishing collaborative fleet management, safety protocols, and effective training for supervisors and pilots aligns with industry standards. Continuous improvement through evaluating concepts, supplier assessment, AI-based operations, cybersecurity, and strategic business diversification is key. Secure data communication, stored energy management, regulatory compliance, and maintaining in-field charging systems are indispensable for operational efficiency. Ensuring workforce adaptability, managing employee and contractor readiness, and integrating technology upgrades fosters streamlined and effective offshore wind farm management suitable for robotic maintenance.
2. Prime Contractor	Robotic and autonomous systems offer significant potential in meeting the operational needs of offshore wind farms, particularly when tailored to specific duties. Ensuring compliance with health and safety legislation and conducting thorough risk assessments are essential for deploying these systems effectively. Analysing data from remote inspections allows stakeholders to optimise wind farm economics, enhancing performance and cost-efficiency. The environmental impacts of these technologies must be rigorously assessed to maintain sustainability. Certification processes ensure the reliability and safety of systems for subsea cable inspection, repairs, and wind farm maintenance, with proper documentation and testing confirming readiness. Techno-economic analyses, digital twins, mission planning tools, and sensor fusion systems support informed decision-making and operational improvements. Deploying robotic missions from ground control stations, designing machine learning algorithms, and establishing collaboration policies enhance efficiency and capacity. Robust software, control algorithms, energy management systems, and governance frameworks are vital for the precision and viability of these technologies, while safe recovery methods add operational safety. Clear policies for mechanical operations, testing facilities, decision logic frameworks, and regulatory monitoring support system reliability. Comprehensive training programs facilitate the transition of offshore operators to onshore supervisory roles. Quality data checks, AI training in digital twins, communication protocols, safety response plans, and management of employees and contractors are crucial for systematic adoption and success. Monitoring cybersecurity vulnerabilities and ensuring in-field charging system readiness underpin uninterrupted operations. Strategic planning, ongoing enhancement of technologies, and rigorous evaluation

	frameworks are critical for integrating robotic systems into offshore wind operations, driving the industry toward greater efficiency and sustainability.
3. Tier 1 Manufacturer	Adapting robotic and autonomous systems to effectively fulfill duty requirements in offshore wind operations involves conducting risk assessments, adhering to health and safety legislation, and evaluating environmental impacts. Optimising these systems for windfarm operations requires analysing data, completing marine control system documentation, and performing commissioning tests. Certifying autonomous systems for subsea cable and wind farm inspection is crucial. Techno-economic analyses, digital twins, and mission planning tools support robust business cases and effective use of these technologies. Integrating new sensor technologies and deploying systems from ground control stations can minimise operational costs. Designing machine learning algorithms, operational data storage solutions, and software for transporting other systems enhances operational effectiveness. Sustainable systems must meet customer requirements and relevant standards, while active control algorithms and energy management systems optimise performance. Governance frameworks, safety standards, and collaboration policies ensure safe BVLOS operations. Effective robotic operations management includes directing unmanned vessels, documenting mechanical operations, and using robotics for monitoring and recovery tasks. Performance testing, compliance with safety standards, and establishing test facilities enhance functionality. Evaluating and selecting concepts, post-deployment assessments, retraining operators, and managing suppliers contribute to continuous improvement. Identifying opportunities, implementing quality checks, and influencing regulatory frameworks are essential for business strategies. Training for readiness, integrating remote systems, and managing technology upgrades foster effective change management. Specialised tasks like subsea cable location and data security support operational safety. Simulation software, cybersecurity measures, and in-field maintenance planning increase efficiency while promoting collaboration and reducing downtime. Supervising multiple systems, utilising AI tools, and systematically designing offshore wind farms ensure reliability and efficiency.
4. O&M Contractor	Adapting robotic and autonomous systems for effective duty performance in offshore wind operations is a complex task that involves a comprehensive understanding of operational requirements and compliance with health and safety regulations. It entails conducting risk assessments, leveraging data analysis from remote inspections for enhanced monitoring, and optimising windfarm economics. Certifying systems for tasks like subsea cable inspections ensures reliability while standardised documentation and commissioning tests guarantee operational readiness. Techno-economic analyses, digital twins, and mission planning tools contribute to system efficiency, while novel sensor technologies and attachment systems expand functionality. Effective control and governance frameworks are crucial for beyond visual line of sight (BVLOS) operations. Policies for human-robot collaboration, logistical planning for autonomous vessels, and stress monitoring further enhance safety and productivity. Engineering solutions for remote maintainability and validated test facilities ensure system reliability post-deployment. Supplier evaluations, continuous operator retraining, and holistic adoption strategies align with evolving regulatory frameworks. Implementing subsea docking systems, high-speed protocol integration, change management, site condition simulations, cybersecurity measures, and agile maintenance scheduling are critical for maintaining operational security and efficiency. Utilising AI tools, planning missions, and ensuring effective communication protocols allow for swift recovery and prompt incident responses, thereby streamlining operations.