Workforce Foresighting Hub

# Autonomous Robotics Systems for Operations in Space

## A workforce foresighting study

| **Authors:** | |
|---|---|
| Cycle Sponsor: | **Amentum, UK Space Trade Association, Space Solar & Voyager Technologies** |
| Centre of Innovation: | Vicky Jewell, Debbi Sonko, Jeremy Hadall, **Satellite Applications Catapult** |
| Workforce foresighting Hub: | Satchin Semage **Workforce foresighting Hub** |

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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

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 2026 Q1 using the data set and tools available at that time.

# Executive Summary

This report outlines findings from the Workforce foresighting cycle focussing on Autonomous Robotics Systems for Operations in Space. This industry challenge was sponsored by Amentum, UKspace, Voyager Technologies and Space Solar, 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**[1]a dashboard providing access to the full dataset collected, curated and analysed by participants in this study.

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

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

## Strategic context and purpose for Workforce Foresighting

The UK space sector is at a pivotal stage, where aligning national strategy with industry is essential to meet emerging challenges. The National Space Strategy sets out the UK's ambition to become a global leader in space technology, prioritising sustainability, innovation, and collaboration. Space infrastructure assembly and serviceability depend on both the construction of new structures in orbit and the maintenance and upgrade of existing infrastructure. These activities will ultimately extend to in-space manufacturing, almost all of which will rely on autonomous robotic operations. This includes ambitious applications such as building solar panels and power generation systems in space, alongside capabilities such as rendezvous and proximity operations, refuelling, regulatory compliance, and advanced robotics.

And so, the cycle **Autonomous Robotics Systems for Operations in Space** was developed to assess what skills needs would be required in order to support such a goal with a workforce that holds the right skillset at the right time.

The cycle has uncovered four priority themes of capabilities that will be required and are not well-served by existing training provision, plus nine priority future occupational roles, that represent archetypes for the future job roles that might be employed within this sector.

These core roles will make up the teams of people that will design the systems to make these ambitions a reality, that will unlock a huge potential economy for the UK and facilitate the development of technologies within in-orbit manufacturing and microgravity research.

This cycle was completed with the participation of a host of stakeholders from across industry and academia, and we thank every attendee for their time, insight, and lively debate.

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

## Participants and Stakeholders

Cycle carried out by Satellite Applications Catapult

| Sponsors | Technologist / Industry Participants | Educator / Skills Participants | Government & Networks |
|---|---|---|---|
| Amentum Global | Airbus | Cranfield University | UK Space Agency (DSIT) |
| UKspace trade association | Astroscale | Hertfordshire University | UK Atomic Energy Authority |
| Voyager Technologies | Clearspace | University of Leicester | STFC (UKRI) |
| Space Solar | GMV | University of Lincoln | UK-Beyond Earth Network (BEN) connected capability network |
|  | LMO Space | University of Manchester | Space North West England Space Cluster |
|  | Orbit Fab | University of the West of England |  |
|  | Orbit Rise | Space Skills Alliance |  |
|  | Space Forge |  |  |

*Table 1: Participants and stakeholders*

## Summary of Findings:

### *The Autonomous Robotics Cycle at a glance*

The study identifies 61 future capabilities, of which 39 are entirely new, reflecting the transformative nature of autonomous robotics in space. These capabilities are unevenly distributed, with approximately 70% concentrated in design-related activities, highlighting the early-stage and pioneering nature of the sector.

Four priority capability themes emerge as critical and currently underserved:

- **Software, Communications and Security** including AI-driven autonomy, cyber-secure systems, and advanced sensing.
- **Simulation and Validation** encompassing digital-twin solutions, hardware-in-the-loop testing, and verification of autonomous behaviours.
- **Systems Integration** integrating complex, multi-agent robotic systems under operational constraints.
- **Regulatory, Compliance and Safety** assurance frameworks, standards, and governance for safe and interoperable operations.

Despite some overlap with existing provision, the average alignment with current training is only around 59%, and 15 critical capabilities are not adequately covered at all. These gaps are especially acute in areas such as radiation-tolerant computing, fault-tolerant autonomy, multi-agent coordination, and real-time anomaly detection.

### Future Workforce Structure and Roles

The analysis defines 21 Future Occupational Profiles, nine of which are prioritised as critical to sector growth. These include:

Simulation & Modelling Engineer
Systems Integration Engineer
Autonomous Operations Lead
Mission Design Architect
Robotics Development Engineer
Autonomy & Perception Engineer
Autonomous Systems Engineer
AI Governance Lead
Robotics Standards and Governance Specialist

These roles span three levels, and together represent the multidisciplinary teams required to design, deploy, and govern autonomous systems in orbit. A key insight is that many of these roles require a layered specialisation, combining expertise in robotics or AI with deep knowledge of space environments, or interfacing between software systems and the realities of hardware mechanics. This significantly narrows the available talent pool and intensifies competition with other high-demand sectors such as defence, nuclear, and advanced manufacturing.

### Education and Training Provision

The study finds that current education and training pathways are insufficient to meet future demand. While higher education provision increases **overall capability coverage to 75.4%,** it is heavily reliant on a small number of postgraduate programmes, notably robotics MSc courses.

Apprenticeship provision is unfortunately limited, with two standards providing adequate alignment, but recent funding changes to Level 7 apprenticeships further constraining access to those channels. Continuing professional development (CPD) opportunities are also scarce, with only a small number of robotics-specific training options available to the space sector. This creates a structural risk: the talent pipeline is narrow, geographically constrained, and dependent on a limited set of institutions. Access barriers - financial, academic, and geographic - further reduce inclusivity and scalability.

### The gap and the problem

Going into this report, the need felt quite clear, with the ISAM community clear on the demand for a solution to the workforce pressures they experience, where many companies struggle to hire the robotics specialists they need for the present challenges, let alone the anticipated need.

However, over the course of the study, it became clear that the need is more nuanced. Training in autonomous robotics for non-space applications, is sufficient for a basic understanding of the skills needed but lacks the nuance to allow that workforce to delivery immediately for those projects that require specialisation to space applications. Robotics courses, on the whole, will likely have to expand the number of students they can support to match demand not only from this sector, but also adjacent sectors that will likely experience parallel needs for the utilisation of autonomous robotics. As such, with demand increasing for roboticists and autonomous systems across the board, space roles may suffer from representing an extra layer of specialisation.

Not only that, but the skills required will change, moving from engineers with practical skills, to those who not only have a comprehensive knowledge of the physical requirement, but can also parse that knowledge into an agentic future model, where tasks are carried out autonomously, guided by a human controlled system of checks and balances. Future specialists will need to understand and manipulate the interface between simulation and reality.

Many of our conclusions also focus on the need for hands-on training, and the fact that experience in this area, both in terms of problem-solving and troubleshooting, and the breadth of understanding required to design these new solutions is almost impossible to transmit through educational provision. This means that any training opportunity that encourages real-life applications, be that through apprenticeships, industry-backed projects at university, or post-study industrial placements, are likely to make a key impact on the preparedness of this future workforce.

## Next Steps

To address these challenges, the report outlines a coordinated set of actions for industry, educators, and policymakers. Outlined in the conclusion, this is recommended for a phased implementation approach, combining immediate action (0–6 months) with medium- and long-term structural reforms (up to 3 years). This report also outlines where each approach will be most appropriate for the specific skills gap, as not all interventions are needed for each part of the skills gap.

- **Expand** and diversify training pathways.
  Including development of new apprenticeships and modular CPD courses aligned to priority capability themes, or protecting specialist MSc programmes focused on space robotics and ISAM.
- **Strengthen** industry–education collaboration.
  Co-design curricula with employers & embed structured industrial placements and experiential learning.
- **Scale** systems engineering and integration skills.
  Promote these career pathways and increase enrolment.
- **Support** sovereign capability and domestic R&D.
  Incentivise UK-based talent development and retention.
- **Enhance** coordination across sectors and stakeholders.
  Align strategies across government, academia, and industry, and
  use shared tools, such as the foresighting visualisation dashboard, to guide decision-making.
- **Accelerate** short-term upskilling.
  Invest in targeted CPD to rapidly address immediate workforce gaps.

The transition to an autonomous, space-based robotic economy represents a significant opportunity for the UK but also a profound workforce challenge. The findings demonstrate that while the UK has strong foundations in robotics and space engineering, its current skills system is not yet configured to support the specialised, interdisciplinary demands of Autonomous Robotics for ISAM applications.

Addressing this gap requires urgent, coordinated action across the skills value chain. By aligning education, training, and workforce planning with emerging technological needs, the UK can position itself not only to participate in but to hold an influential stake in the global orbital economy.

# Glossary

| Term | Definition |
|---|---|
| AI/ML | Artificial Intelligence / Machine Learning |
| 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 |
| GNC | Guidance, Navigation & Control; Directs spacecraft movement and orientation |
| Future Competency Set | The KSB output from the Educator workshop for each Role Group |
| ISAM | In-Orbit Servicing, Assembly & Manufacturing, the umbrella term for all important operations that are involved in building and maintaining satellites, spaceships and structures around the orbit of Earth, the Moon and eventually other planetary bodies |
| 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 |

| Term | Definition |
|---|---|
| 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 |
| RPO | Rendezvous & Proximity Operations; manoeuvres for docking or close approach |
| Technologies | The technology that could be used to address the challenge |
| TRL | Technology Readiness Levels (TRLs) assess the maturity of a technology on a scale from TRL 1 (basic principles observed) to TRL 9 (system proven in operational environment), supporting consistent comparison across development stages. |
| V&V | Verification & Validation; Ensures systems meet requirements and function as intended |
| 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

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## 1.1 Introduction to Workforce foresighting

Workforce foresighting is essential in addressing the skills challenge, by aligning the skills value chain—from early education through to advanced training—with the demands of emerging technologies. By identifying future 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 *Autonomous Robotics Systems for Operations in Space***. The study is sponsored by UK Space, Amentum Technologies, Space Solar and Voyager Technologies. The study has been conducted by ***Satellite Applications Catapult,*** in collaboration with the Workforce Foresighting Hub, an Innovate UK initiative, and has gratefully received input and insight from industry and academic stakeholders across the space sector. This report is designed to support strategic decision making and inform the next steps on the Skills Value Chain

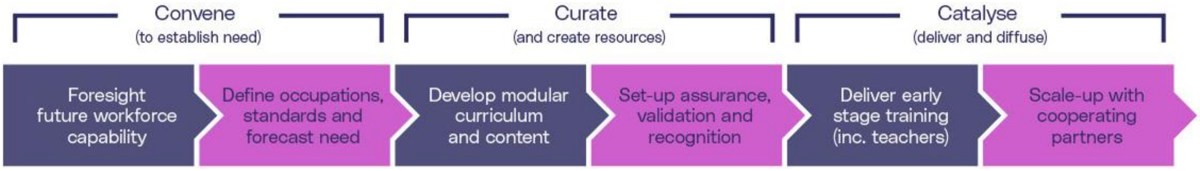

*Figure 1: Skills Value Chain (SVC)*

## 1.2 Defining the Workforce Foresighting Topic/Challenge

This cycle will identify the converging skillsets across robotics, AI/ML, software-defined autonomy, and systems integration. It will inform future education pathways and technical training to ensure the UK remains a global leader in intelligent ISAM (In-Orbit Service & Manufacturing) operations and space robotics.

For this cycle, we are sponsored by a collection of organisations, led by the UKspace Trade Association and Amentum, where we are supported by their Principal Consultant for Space, Chris Brunskill. This cycle is also supported by two organisations for whom the future of in-space robotics will be key to the construction of future infrastructure, Voyager Technologies and Space Solar. All sponsors have been engaged in the review and assessment of the outputs of this project.

Key areas of focus include autonomous robotic control architectures, multi-agent collaboration, fault-tolerant behaviours, and software-driven decision-making in uncertain conditions. Simulation technologies—digital twins, hardware-in-the-loop environments, and physics-based modelling—will be central to the development and validation of these systems. As human presence extends further into orbit and infrastructure becomes more complex, robotic operations will be the frontline enabler of resilience, repair, and commercial expansion.

This challenge directly supports the UK National Space Strategy (2021)[2], which prioritises resilient infrastructure, in-orbit services, and sustainability. It also reflects key findings from the UK Space Agency's Skills Survey (2023)[3], highlighting shortages in satellite servicing, robotics, and data systems. Similarly, Scotland's National Strategy for Economic Transformation [4] and the Wales Innovation Strategy[5] emphasise the importance of skills-led innovation and advanced manufacturing for regional tech growth. UKRI and the Satellite Applications Catapult also identify In-Orbit Servicing, Assembly, and Manufacturing (ISAM) as a strategic innovation frontier. This aligns with government-backed investments in space sustainability, defence, and commercial LEO operations.

Upon approaching this challenge, we considered the size of the applicable workforce for this area of development, and whether these technologies are appropriate for the timeline (or 'horizon') that we are considering for this report, of 2-5 years before considerable changes to the workforce will be required.

When thinking about the applications for Autonomous Robotics for space, we predominantly consider ISAM use-cases. While the existing economy for ISAM in the UK is still comparatively small, it's growth and potential, as evidenced by exciting progress discussed at both the 2024 and 2025 ISAM Conferences, exhibited by companies such as Space Forge, Astroscale and Clearspace, and supported by a dedicated UK Space convened committee, could have a huge impact on the UK economy. The Space Exploration Technology Roadmap, published by UKSA in 2023, discusses Robotic applications in Space, and confirms that projects in this area will "rely heavily on robotic systems for the various processes that occur during the manufacturing of materials for space exploration or commercial ventures back to Earth."[6]

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[2] https://www.gov.uk/government/publications/national-space-strategy

[3] https://www.gov.uk/government/publications/space-sector-skills-survey-2023/space-sector-skills-survey-2023-report

[4] https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/

[5] https://www.gov.wales/innovation-strategy-wales

[6] https://assets.publishing.service.gov.uk/media/64ff28391886eb00139770ef/Space_Exploration_Technology_Roadmap_v2.pdf; specifically page 30

| Global Exploration Roadmap Critical Technologies (Summary Table) | Today ISS & Spaceflight Heritage | Near-Future Moon Vicinity/Surface | Future Mars Vicinity/Surface |
|---|---|---|---|
| **Propulsion, Landing, Return** | | | |
| In-Space Cryogenic Acquisition & Propellant Storage | Spacecraft: CPST/eCryo demo | u-G vapor free liquid tank to propulsion transfer, Efficient low-power LOx & $H_2$ storage >1 Yr (Mars) | |
| Liquid Oxygen/Methane Cryogenic Propulsion | | Throttleable Regen Cooled Engine for Landing (Lunar Scale) | Throttleable Regen Cooled Engine for Landing (Mars Scale) |
| Mars Entry, Descent, and Landing (EDL) | Spacecraft: MSL class (~900 kg) | Demonstration of advanced technology in deep space environment | Large Robotics >1000 kg; Human ~40,000 kg |
| Precision Landing & Hazard Avoidance | Spacecraft: Lunar & Mars Landers State-of-the-Art | ~100 m accuracy, 10's cm hazard recognition, Support all lighting conditions | |
| Electric Propulsion & Power Processing | Spacecraft: 2.5 kW thruster (Dawn) | ~10 kW per thruster, High Isp (2000 s) (for some mission options) | ~30-50 kW per thruster (for some mission options) |
| **Autonomous Systems** | | | |
| Autonomous Vehicle System Management | ISS: Limited On-Board Mgmt functions, < 5 s comm delay | On-Board Systems Mgmt functions (handles > 5 s comm delay) | On-Board Systems Mgmt functions (handles > 40 min comm delay) |
| AR&D, Proximity Operations, Target Relative Navigation | ISS: Autonomous docking | High-reliability, All-lighting conditions, Loiter w/ zero relative velocity | |
| Beyond-LEO Crew Autonomy | ISS: Limited Autonomy | Automate 90% of nominal ops<br>Tools for crew real-time off-nom decisions | |
| **Life Support** | | | |
| Enhanced Reliability Life Support | ISS: MTBF <10 E-6, Monitored/operated by GC | More robust & reliable components (eliminate dependence on Earth supply logistics)<br>Increased systems autonomy, failure detection capabilities, and in-flight repairability | |
| Closed-Loop Life Support | ISS: 42% $O_2$ Recovery from $CO_2$, 90% $H_2O$ Recovery | Demonstration of advanced technology in deep space environment | $O_2$/$CO_2$ Loop closure; $H_2O$ Recovery further closure; Solid Waste, reduce volume/storage |
| In-Flight Environmental Monitoring | ISS: Samples to Earth | On-Board Analysis for Air, Water, Contaminants | |
| **Crew Health & Performance** | | | |
| Long-Duration Spaceflight Medical Care | ISS: First Aid+, return home | Demonstration of advanced technology in deep space environment | Training (pre & in-flight) for medical aspects<br>Continuous monitoring & decision support |
| Long-Duration Behavioral Health & Performance | ISS: Monitoring by Ground | Demonstration of advanced technology in deep space environment | Cognitive performance monitoring<br>Behavioral health indicators & sensory stim. |
| Microgravity Counter-Measures | ISS: Large treadmills, other exercise equipment | Demonstration of advanced technology in deep space environment | Compact devices to assess/limit disorders<br>Reduced weight/vol, aerobic & resistive eqpt. |
| Deep Space Mission Human Factors & Habitability | ISS: Large crew volume, food & consumables regular resupply | Demonstration of advanced technology in deep space environment | Assess human cognitive load, fatigue, health<br>Optimized human systems factors/interfaces |
| **Infrastructure & Support Systems** | | | |
| High Data Rate (Forward & Return Links) | Ground (DSN): 256 kbs Forward, 10 Mbs Return Link | Demonstration of advanced technology in deep space environment | Forward: 10's Mbps; Return: Optical > 1Gb/s |
| Adaptive, Internetworked Proximity Communications | ISS: Limited capabilities | Demonstration of advanced technology in deep space environment | >10's of Mbps simultaneously between users<br>Multiple Modes; Store, Forward & Relay |
| In-Space Timing & Navigation | ISS: Limited to GPS range<br>Spacecraft: DSN Ranging | Demonstration of advanced technology in deep space environment | Provide high-spec Absolute & Relative pos'n<br>Space-Qualified clocks 10x-100x beyond SOA |
| Low Temperature & Long-Life Batteries | ISS: Lithium-ion (-156 C short duration), ~167 Wh/Kg | Lunar night temperatures and duration | |
| Comprehensive Dust Mitigation | Apollo: limited 3 day crew ops<br>Rovers: limited mitigation | Multiple Active & Passive technologies required<br>Significant advances in Life cycle | |
| Low-Temperature Mechatronics | ISS: +121 to -157 C | Operations to -230 C (cryo compatible); multi-year life | |
| ISRU: Mars In-Situ Resources | | Potential Test-Bed for Mars Forward, and enhance lunar missions | $O_2$/$CH_4$ generation from atmosphere<br>LOX/$LH_2$ generation from soil |
| Fission Power (Surface Missions) | | Potential Test-Bed for Mars Forward, and enhance lunar missions | Fission Reactor (10's of kWe) |
| **EVA/Mobility/Robotic** | | | |
| Next Generation Surface Mobility | Spacecraft: Lunar and Mars Rovers State-of-the-Art | Autonomous & Crewed capability, less Ground Control<br>Extended range, speed, payload; navigate soft/steep varying soils | |
| Tele-robotic Control of Robotic Systems with Time Delay | ISS: <1-10 Sec delay for GC Ops<br>Spacecraft: Lunar/Mars Rovers | Few seconds to 10's of seconds<br>Dynamic environments w/variable delays & LOC | Up to 40 Minutes |
| Robots working side-by-side w/ crew | ISS: Limited (Robotic support to EVA) | EVA control robots w/ no reliance on Ground Control<br>International standard & protocols | |

(ISECG) GER Extract: Technologies of interest for UK capabilities.

*Figure 2: Screenshot from the UK Space Agency Technology Roadmap, 2023*

Other space-enabled applications of Autonomous Robotics include satellite-enabled Autonomous vehicles, especially drones and other UAVs. While the ISAM opportunity is the primary focus of the following capabilities in this report, the majority of those capabilities also apply to any unmanned and autonomous robotic apparatus, which naturally has many applications that cover both civil and defence spheres. These applications have much more immediate implications for both that technological development opportunity, and the need for a readily available sovereign, secure, and equipped workforce to undertake those tasks enabled by these future capabilities.

Furthermore, we need to recognise that the industries reliant on a workforce with skills in autonomous robotics extend beyond those of space. This cycle could easily be distilled into an investigation of the skills required for the utilisation of robotics systems in hostile environments, and while our focus is on the hostile environment of space, this could apply equally to other environments not favourable to manned operation, service & maintenance; be that undersea, high radiation, or inaccessible locations. These applications and their respective industries will each require a similar workforce, and as skills issues – even those in space – do not exist in a vacuum, we must recognise that even should the training provision provided in the UK match the requirements of this sector, competition with other similar workforce demands may mean that the skills shortage is felt more acutely.

In the analysis of this report, then, we will consider three aspects of the skills provision challenge:

1. Scale – where there is a large gap in appropriate training provision, that will affect a large number of future job roles in this area.
2. Critical weaknesses – where there are critical infrastructure requirements or a need for sovereign workforce that make a potentially small gap acute.
3. Cross-sector competition – where this skills gap is likely to be common to multiple applications, and therefore the space sector will need to compete with other industries for the same workforce, exacerbating the requirement for a niche skillset.

## 1.3 Positioning & context: Skills activities around Autonomous Robotics

Autonomous Robotics has seen steadily increasing attention from those considering the skills gap for nearly ten years. From research papers that begun to ask the question about how automation might affect jobs, or how robotics could change both job roles and productivity, to nationally commissioned studies into how the UK can maintain its competitiveness in a global market, there is a large number of reports within this space[[7]].

Not only this, but we must recognise the large number of experts, both from research centres, universities and from within the innovation teams of cutting-edge industry, that have been guiding this area forward. Both these voices, and the reports and assessments made to date, not least the UK-RAS white paper on Skills and Education for Robotics & Autonomous Systems, agree and emphasise the point that the skills gap in this area is both critical for the immediate future, and growing for the longer term:

"The reach and capability of autonomous systems is growing rapidly, displacing and creating employment chances at an accelerating rate. For the UK to take advantage of such an opportunity, it is vital that policies and resources, including educational and training systems, are put in place quickly to help the workforce adapt and prepare for the future workplace."[8]

We can also draw parallels to the ways in which this challenge is being addressed internationally, looking to European strategy in this area, or to the ways in which the US robotics industry is approaching their own challenges.[[9]] These explore familiar topics, like talent attraction and retention, scaling challenges, embedded infrastructure challenges and the rate technology adoption outpacing the workforce skills development. The World Economic Forum's Future of Jobs report predicts a change of core workforce skills of around 39% by 2030, with emphasis on systems thinking and applications of machine learning.10 All of these contribute to a landscape that makes clear that this is a challenge for which it is the

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[7] For example, see: Bessen, J. (2016) *How Computer Automation Affects Occupations: Technology, jobs, and skills;* Oxford Economics (2019) *How robots change the world: what automation really means for jobs and* productivity; Shafique, A. & Dent, A. (2019) *Adopting global skills innovation for the UK*

[8] UK-RAS (2021) *Preparing the workforce for 2030: Skills and Education for Robotics & Autonomous Systems*. This report covers the skills gap through multiple lenses, looking at the tension around technical skills, management skills, and diversity of the future workforce. It assesses open and digital learning resources, and makes recommendations for addressing the challenge ahead.

[9] For example: EU Robotics (2024) *A Unified Vision for European Robotics: A Strategy for Innovation, Growth and Societal Impact*, recommendation both a cohesive European skills framework and the need for improved societal awareness for the need for robotics; European Commission Robotics policy overview; US ARM Institute (2024) *Future of Work Report* which discusses both location based challenges, talent supply and demand, and forecasts future requirements; US National Robotics Association (2025) *State of Robotics 2026*, which warns that there were 340,000 unfilled robotics positions in the US in 2025.

[10] World Economic Forum (2025) *The Future of Jobs Report 2025*, especially chapter 3: *Skills outlook*.

right time – if not yesterday – to address the skills issues that create a bottleneck for this industry’s growth.

Skills activities specifically for Autonomous Robotics have begun to be stimulated in the UK, with the recent Innovate & DSIT funded Robotics Adoption Programme Skills development funding call, but still lags behind the embedded programmes of skills development for robotics that can be seen in the USA, for example, at the ARM Institute, US National Science Foundation, or Carnegie Mellon Robotics Academy.[[11]]

This investigation seeks to recognise these past reports, build upon their call to action, and provide the granular, data-driven evidence for what the delta is between the training provision currently available in the UK, and the specific skills required to enable this area of growth, so that we can enact targeted, cost-efficient, and impactful interventions to address the specific areas of need.

## 1.4 Technology challenge and scale of the potential disruption to the UK economy

The challenge that this Workforce Foresighting cycle seeks to address is the adoption of autonomous robotics into the field of In-orbit Servicing, Assembly and Manufacturing (ISAM). This emerging field enables spacecraft to be repaired, upgraded, assembled, or even built directly in space rather than launched fully complete from Earth. By overcoming launch constraints, ISAM unlocks larger, more capable space systems while extending mission lifetimes and reducing cost and risk. As detailed in the National Space Strategy, this emerging sub-sector is foundational to "Galactic Britain," moving beyond simple satellite deployment to an active orbital economy characterized by debris removal, refuelling, and complex assembly. [[12]]

For the space sector specifically, ISAM alone is estimated to represent a £1 billion domestic market opportunity by 2030, potentially unlocking tens of billions in wider economic value as space-based infrastructure becomes as central to the economy as terrestrial logistics. Autonomous robotics are essential to commercial ISAM because real-time human control is impractical due to communication delays, cost, crew safety and availability. High levels of autonomy enable scalable, reliable, and repeatable operations, making in-space servicing and manufacturing economically viable at scale. The rapid integration of autonomous robotics within the ISAM space sector therefore represents a critical strategic inflection point for the UK economy. The technological challenge of space-based autonomy is formidable, requiring systems that can operate in extreme environments without human intervention.

The transition to a space-based robotic economy presents a critical human capital challenge that, if unaddressed, will serve as the primary bottleneck to UK growth. While the UK space sector has seen its workforce grow to nearly 50,000, the technical composition of this talent pool is misaligned with the requirements of autonomous systems. Policy frameworks like the Smart Machines Strategy 2035 estimate that the broader robotics and autonomous systems

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[11] Robotics Adoption Programme Skills Development call: https://www.ukri.org/opportunity/robotics-adoption-programme-skills-development/; ARM Insitute Workforce Development Series (https://arminstitute.org/our-work/workforce-development-services/ ); Carnegie Mellon Robotics Academy (https://www.cmu.edu/roboticsacademy/programs/index.html); NSF Robotics Progamme (https://www.nsf.gov/focus-areas/robotics)

[12] National Space Strategy: www.gov.uk/government/publications/national-space-strategy/national-space-strategy

(RAS) sector could support 175,000 new jobs, yet the specific intersection of robotics and space creates a "double-specialism" gap.[13] The industry does not simply lack roboticists; it lacks roboticists capable of engineering for high-radiation, zero-gravity, and thermally extreme vacuum environments. Current academic pipelines are producing high-quality generalists, but industry reports a severe shortage of engineers with expertise in edge-computing for orbital AI, resilient mechatronics, manipulation, dexterity and autonomous rendezvous and proximity operations (RPO).

This skills gap is not merely a recruitment issue but a matter of national sovereignty and economic security. As the 2024 Space Industrial Plan highlights, the UK's dependence on international talent and overseas proprietary technology for critical orbital missions creates a strategic vulnerability.[14] When the UK relies on foreign experts to maintain the autonomous robots servicing its Critical National Infrastructure (such as telecommunications and Earth observation satellites) it cedes a degree of "freedom of action." To maintain sovereign control, the UK must bridge the "Automation Abyss," a term used by the Robotics Growth Partnership to describe the risk of the UK falling behind G7 peers who are more aggressively subsidising specialised technical education.[15] The monetary value of closing this gap is immense; capturing even a fraction of the global ISAM market could contribute billions to UK GVA, but this is contingent on a workforce that can perform high-integrity systems integration that meets stringent space-safety standards.

Further, to maintain "freedom of action" in space, the UK must foster a domestic talent pipeline that balances technical prowess with the sovereign capability to design and maintain its own autonomous assets. This involves not just training large numbers of developers and operators, but ensuring the UK can manufacture and control its own "physical AI" systems to safeguard its economic and strategic interests in the orbital economy. The sensitivity of this gap is further compounded by the "brain drain" to US-based Primes and the difficulty in securing security clearances for international talent in a sector increasingly tied to national defence.

For policymakers, the intervention required is twofold: scaling the volume of graduates through targeted "Space-Robotics" apprenticeships and MSc programs, while simultaneously addressing the sensitivity of the work by incentivising domestic R&D. By aligning the UK's research excellence with a robust vocational pipeline, the UK can move from a reliance on imported autonomous solutions to a model where the UK exports the high-value expertise required to manage the orbital economy. This scenario already exists in adjacent robotics fields such as the nuclear industry. Failure to act risks a scenario where the UK's ambitious space goals are grounded not by a lack of vision, but by a lack of the specialized hands and minds required to build them.

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[13] UK Government (2023) *Smart Machines Strategy 2035*: https://www.gov.uk/government/publications/smart-machines-strategy-2035/smart-machines-strategy-2035.

[14] UK Government (2024) *Space industrial plan: From ambition to action – advancing UK space industry:* https://www.gov.uk/government/publications/space-industrial-plan

[15] Robotics Growth Partnership (2025) *Smart Machines 2035: A Strategy for UK Leadership*: https://assets.publishing.service.gov.uk/media/67aa2e965dea3871ea1ceb12/smart-machines-strategy-2035.pdf.

## 1.5 Methodology, Tools and Known Bias

This project sought the input and consultancy of stakeholders from the above organisations, from across industry, academia, and government. We recognise 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 we have attempted to preserve a balanced view of the information and views supplied by our stakeholders.

The processes behind the generation of the visualisation tool also used AI tools and agents to make suggestions from which to start debates with our 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 & human representation of the skills activities undertaken.

This study also utilised source data from national and international workforce datasets, primary amongst which we have compared our results against the bank of 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**.

Finally, the results of every Workforce Foresighting study are predicated upon a matching threshold; the value to which the convening team considered the capabilities described by the results of our capability mapping activities are 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 our requirements, only those above the threshold are considered fruitful avenues for development of training. Discussion of these matches again are returned to in the following sections.

# 1. Findings & Insights

# 2. Findings and Insights

## 2.1 Purpose of this Report

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

**Industry** - First, it explored 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 FOPs are compared against current education and training provision—using Skills England occupational standards as a benchmark—to identify where existing programmes align and where gaps exist.

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

## 2.2 Introduction to the Visualisation Tool

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

The data is generated by the foresighting cycles, integrating the expertise of technologists/domain specialists, employers, and educators. The data can be used to inform the development of future curricula and course content as determined by the action plan. Using AI tools validated by human oversight, and by linking to external data sources, the tool identifies differences at the level of occupation/role as well as detailed changes required to help update/refresh knowledge, skills and behaviours thus delivering insights for learners, providers, creators, and assurers of skills. **Link to Visualisation Tool**.[16]

**Links** Detailed instructions on how to use the Visualisation Tool can be found in the Appendix(**A Online Data visualisation** Tool)

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[16] Visualisation tool https://hvmcatapultforesighting.retool.com/embedded/public/219ff6af-36ea-4b5e-bda1-b0b989c0e3f0?token=2a668f2e63faf1dddcc400328f65e0d4

## 2.3 Industry - Identified Organisational Capabilities

### 2.3.1 Capabilities Identified

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

In the workshops which generated the data input into the visualisation tool, debates were made about the comparative state and direction of the future workforce in the UK. While the creation of the future capabilities required for the workforce, which represent tasks that are an evolution of what is currently undertaken, were broadly agreed upon quickly, the assignation of whom in the workforce was responsible for those future roles, and what that would mean for the future occupational profiles in the sector were less clear. This is reflective of the multiple applications that these skillsets could be applicable to, and the number of other unknown factors at play in the growth of the ISAM economy.

**Insight**: This cycle defined **61 capabilities** that we consider to be a skills development requirement above what is currently required of workers within this field in the space sector. Of these, **39 were newly defined for this cycle,** and represent a wholly new skills requirement against the capabilities and standards.

These capabilities were identified as crucial to unlocking the potential growth of this sector, and a lack of preparedness in the workforce within this horizon window would present a significant blocker to the UK's ambitions to retain and grow their market share in In-Orbit Service & Manufacturing.

Provision mapping included both **apprenticeships standards from Skills England**, and custom entered data collected by Satellite Applications Catapult from a sample of **university courses.** Provision supplied only from apprenticeships represents some considerable gaps in education and training for the skills needed for the future Autonomous Robotics workforce in the space sector and represents therefore a need for this educational pathway to be implemented, to improve the accessible routes into the sector.

As expected due to the complexity and specialist nature of the work within this emerging technology area, the capability coverage rose considerably once the sample of Higher Education courses were entered, bringing the cycle map-and-gap analysis to an overall **75.4% coverage of the capabilities identified in this cycle.**

The sample of university courses included not only degree courses designed to prepare students for a career in the space sector, but those more generally designed for robotics. This means that while Higher Education solutions appear often to be the most applicable, very few training provision options, either from the Skills England standards or the custom review, represent specialist, space-specific skills development.

It is also worth noting that the Higher Education 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.

### 2.3.2 Future Supply Chain

To understand how supply chains must evolve in response to emerging technologies, we create a forward-looking view of what future supply chain operations will look like, compared to how they function today. This comparison helps highlight the areas where change is needed to meet new demands and opportunities.

Throughout the process, we work closely 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.

#### Technology Providers (Hardware and software)

These partners design, deliver, and integrate space-qualified robotics hardware and software-defined autonomy stacks. They build the simulation and test infrastructure that underpins development—digital twins, hardware-/software-/processor-in-the-loop benches, physics-based environments—and ensure interoperability and V&V through modular architectures, standardised interfaces, and rigorous product assurance. By aligning flight hardware, autonomy software, and ground data systems, they enable robust proximity operations and updatable on-orbit behaviours in uncertain conditions, shortening time-to-mission, reducing risk, and raising TRL (Level 6 and above) across ISAM use cases. This includes testing and verification of hardware and software.

#### Service Providers

These partners deliver end-to-end mission services that operationalise autonomous robotics in orbit: close-proximity inspection, rendezvous and docking, debris capture, refuelling and relocation, and in-orbit assembly/repair. They translate mission goals into CONOPS, safety cases, and operational playbooks, operate ground segments and autonomy toolchains, and provide “autonomy-as-a-service” (mission planning, supervision, monitoring, and updates) alongside simulation-as-a-service for rehearsal and risk burn-down. Their outputs include certified procedures, mission assurance artefacts, data products (state estimation, structural health insights), and post-mission analytics that improve fleet reliability and time – to-recover for critical assets. By coupling operational experience with robust autonomy, they de-risk first-of-a-kind ISAM missions and enable repeatable, commercial-grade proximity operations.

#### RTOs / Research & Innovation Organisations

Universities, Catapults, national labs, and innovation consortia advance the science and engineering of intelligent space robotics—from robust autonomy and multi-agent coordination to formal verification, human-robot teaming, and assurance of AI/ML in safety-critical systems. They operate open testbeds and reference digital twins, generate benchmark datasets and pre-normative research for emerging standards, and mature technologies from TRL 1–6 via lab-to-flight pipelines. As workforce engines, they create education pathways and CPD (robotics, AI assurance, V&V, radiation-tolerant compute, on-orbit manipulation), seed spin-outs, and supply specialist talent into industry. Their work reduces scientific uncertainty, validates approaches before costly flight trials, and ensures the UK’s skills base can sustain next-generation ISAM operations.

#### Regulators, Standards Bodies & Government

These stakeholders provide the policy, licensing, assurance, and funding frameworks that enable safe, sustainable, and commercially viable proximity operations. They set mission licensing and spectrum use, drive space sustainability (debris mitigation, end-of-life), and define assurance requirements for autonomy and AI in safety-critical contexts. Through standards and conformity pathways (e.g., debris mitigation norms, ECSS/ISO/CCSDS practices, safety and product assurance), they establish predictable routes to compliance and international interoperability. As convenors and strategic investors, they deploy grants, anchor tenancy, sandboxes, and procurement signals that catalyse supply-chain readiness, accelerate demonstration missions, and foster data-sharing frameworks (e.g., SSA/SDA integration) essential for trustworthy, fault-tolerant ISAM capability.

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 we assess how capabilities will shift.

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

**Insight**: The capabilities identified in this Autonomous Robotics cycle demonstrate a very unequal distribution across the five functional domains, with a 70% focus on capabilities that could be defined as ‘design’ activities.

This reflects the pioneering nature of this potential in-orbit economy, as in contrast with other technologies areas, there is no heritage infrastructure to adapt and build upon, and many of the job roles in this emerging technology area will be required to design and build systems that have no real parallel to those that have existed before.

It is likely that as this area develops, the scale of activities grows, and successes breed confidence in the capability in this sector to create a profitable in-orbit economy, this focus will shift to the later stages of the capabilities identified above.

For some of the other Autonomous Robotics applications that we discussed in the introduction, where we recognise that there are other applications for space-enabled autonomy outside of in-orbit systems, this focus may be different; this study however was limited by the focus that we defined for the scope and time-scale available, and further assessment would be required to assess other industry applications.

**Links:** Link to visualisation tool for **61 capabilities** [[17]]

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[17] https://hvmcatapultforesighting.retool.com/embedded/public/f56f84e9-8ab8-414f-aa1a-0b42ab5c71df?token=2a668f2e63faf1dddcc400328f65e0d4

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

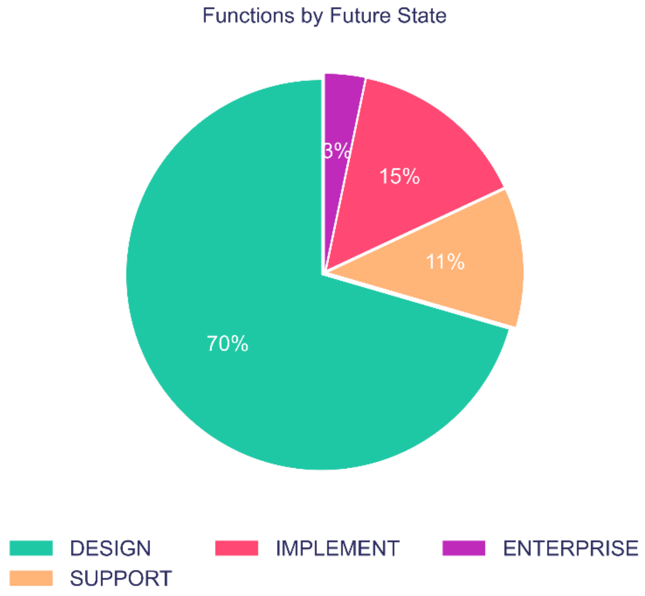

*Figure 3: Future Supply Chain Capability Function Distribution %*

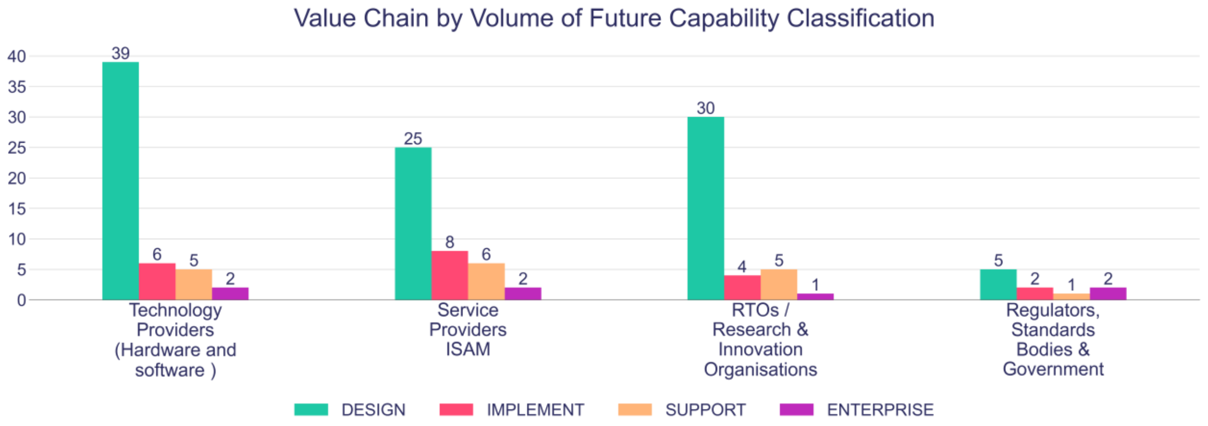

*Figure 4: Distribution of Functions across each Supply Chain partner*

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.

**Insight**: The graphs above demonstrate that while the distribution of the capabilities predicted by this cycle focus predominantly on design, this is not the case for all areas of the supply chain.

Technology providers and the Service providers feature a similar pattern of focus, with a steeply descending order of the capabilities featured across the functional domains. RTOs / Research & Innovation Organisations feature a slightly different distribution, as it is recognised that while due to the cutting-edge nature of this emerging technology area, much of the design work will fall to researchers working within these organisations, they are less likely to lead the projects that enable to technology. Many of the capabilities assigned to this supply chain then, including some of those under design are done in a supportive capacity, as a technical partner or advisor to the commercial ventures being explored.

The supply chain partner role whose distribution is most distinct from the others is that of the Regulators, Standards Bodies & Government. There are far fewer capabilities assigned here, but not because these stakeholders will have little to do with autonomous robotics development, in fact it is very likely that funding lead from government initiatives will continue to be a strong driver for in-orbit robotics, and regulatory compliance will define how these activities are undertaken. However, the skills required there do not in as many cases represent a skills progression from the existing knowledge, skills and behaviours required currently. Where there are new skills requirements, these are more evenly spread across the functional domains.

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 **4 supply chain partners** [[18]]

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[18] https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=2a668f2e63faf1dddcc400328f65e0d4

### 2.3.3 Functional Cycle Capabilities Currently Not Served

Out of the 61 future capabilities identified for this cycle to adopt this technology across the supply chain, 15 are not currently well matched with any duty statements found in existing apprenticeship standards or the selected HE provision that was surveyed to provide a sample assessment of Higher education training coverage, due to the known reliance on this training from the sector.

For this cycle, the threshold used to determine whether the provision was a suitable match was 55%. The vast majority of the capabilities that were above that threshold were not high matches, with only one capability reaching above the 75% match – the average match was only 59%, suggesting that while they are counted as acceptable, these training routes still represent an imperfect provision for this particular use case. Also available in the visualisation tool's FOP vs Provision tab, is an assessment of how much of the applicable course or apprenticeships' learning capability statements sit outside of the necessary information needed to undertake these roles.

The 15 unmatched capabilities are listed below:

| Capability Statement | Provision mapping % |
|---|---|
| Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning. | 55% |
| Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. | 54% |
| Develop control algorithms to support close proximity operations under the computational and propulsion system constraints. | 54% |
| Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | 53% |
| Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | 53% |
| Design thermal controls to maintain robotic system stability across expected space temperature changes and pointing conditions. | 53% |
| Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations. | 53% |
| Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | 52% |
| Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | 52% |
| Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | 52% |
| Track and manage records of robotics and autonomous systems fleet asset operations and maintenance. | 51% |
| Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | 51% |
| Improve satellite perception accuracy during close-proximity inspection and manipulation tasks in orbit. | 51% |
| Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. | 51% |
| Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | 50% |

*Table 3: unmatched capabilities to existing provision*

**Insight**: The future capabilities explored by this cycle demonstrate that while very few capabilities are perfectly matched, the majority (around ¾) are at least partially addressed by existing provision. However, as expected, this is heavily weighted to rely on University degree programmes for which there are only a few appropriate courses across the UK, putting strain on any targets that might be made for the accessibility and diversity of the future workforce, as this relies upon access, both geographically and economically, to a handful of higher education institutions.

Even more acute, many of the most appropriate degree courses are those that are either integrated masters, or postgraduate master's programmes, requiring longer years of study and potentially multiple applications to specific courses and their accompanying costs. One commonly highlighted university course in this analysis is the Cranfield Robotics MSc, which requires a first or second-class degree in a specific collection of undergraduate degree to be eligible, a competitive application rate, and represents an intensive and rigorous year of study once successful.

This critical dependency on a handful of postgraduate level studies places pressure on an already beleaguered higher education system, with universities reducing their offering of courses, or merging institutions entirely. Cranfield University announced its future merger with King's College London on the 14th of May 2026, in which press statement the universities explicitly listed aerospace, advanced manufacturing, AI and robotics as one of the key areas that they hoped the merger would bolster. However, this does also represent a consequence of the tumultuous few years for Higher Education in the UK, which makes this critical dependency on HE provisions more acute.

The development of more appropriate apprenticeships could help this, as few existing apprenticeships offer sufficient matches for this cycle's future occupational profiles (explore more below). However, where we do see the best matches from apprenticeship standards, these are typically from courses from level 6 or 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.

### 2.3.4 Prioritised Capability Themes

In total across the various supply chain partner 61 capabilities were identified. (See Appendix **B Functional Cycle** Capabilities for the full detail).

Within our cycle workshops, we underwent a few activities to establish which themes were most key, or most urgent to the success of the deployment of this emerging technology area. This included surveying the cohort to rank the criticality of each capability, and then a full workshop with our contributing experts to discuss the capabilities that occupied that tension point of least served by provision, and most critical to the future.

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

### 2.3.5 Top 4 Priority Themes (Ranked by Frequency in FOPs)

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; with examples of the priority future occupational roles whose capabilities might fall within these categories:

- **Software, Communications & Security**
  e.g. Autonomy & Perception Engineer, Autonomous Operations Lead
- **Simulation & Validation**
  e.g. Simulation & Modelling Engineer, Robotics Development Engineer, Autonomy & Perception Engineer.
- **Systems Integration**
  e.g. Systems Integration Engineer, Mission Design Architect, Autonomous Systems Engineer, Robotics Development Engineer
- **Regulatory, Compliance & Safety**
  e.g. AI Governance Lead, Robotics Standards & Governance Specialist, Autonomous Operations Lead

These themes, broken down below, are also represented by the 9 priority Future Occupational Profiles, which can be found at Appendix 4.4. Later in this report, in section 2.3.3 **(Discussion of Noteworthy Observations),** 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 our horizon.

**Insight**:

**Software, Communications & Security**
This category of poorly served capabilities represents a new critical collection of skills, core to the utilisation of the technology. These include the development of computer vision algorithms to establish and verify autonomous manipulation tasks in orbit, advanced displays and sensing for real-time co-ordination of robotic support systems, either with the stable communication capacity to interface with ground support, or with machine learning for autonomous problem-solving. This would also include anomaly detection and response systems for cyber security, to ensure the resilient provision of this capability. This collection requires a comparatively small cohort of specialists, but demands an extreme level of expertise, and has a lot of cross-over to other remote-controlled autonomous robotics systems operating in hostile environments. This means it is a good area for skills development, but also one that will likely suffer from competition.

**Simulation & Validation**
This category also represents a new field of ground-up development and will represent a much larger workforce demand. Capabilities represented in this category include the design and implementation of both functional and operational tests of autonomous robotics systems, to both improve the design of the components or overall system, or to undertake verification & validation testing (including qualification) that would demonstrate that robotics systems meet mission requirements and regulatory standards. These activities, critical to mission release, will require multiple specialists, especially as commercial IP will reduce the number of workforces that could work on projects in parallel.

**Systems Integration**
This category is a development or specialisation of roles that already exist – like a spacecraft Thermal Engineering position. These capabilities however are more specific to this robotics challenge, by fusing and integrating multiple systems to meet operational targets. This could include the interface between human and AI agents, or between the system of systems that will make up progressively more complex in-orbit activities.

**Regulatory, Compliance & Safety**
This category includes the development of common standards that improve compatibility, interoperability and safety, as well as establishing assurance frameworks and the regulatory requirements for activities in this field. It holds the largest number of transferable skills and therefore may represent a different skills challenge. However, insufficient knowledge or skills at a regulatory or safety-standards level could represent a significant blocker to progress, and while in some cases this expertise is not required to be deep, the breadth of understanding across the ecosystem is difficult to train. There is also a significant pressure within these capabilities for an understanding of the international and geopolitical policy ramifications of this work, which make this, while a very small workforce requirement, a critical role area that could either represent a blocker or a beneficial enabler to the potential of this emerging technology.

## 2.4 Workforce Insight

### 2.4.1 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 required in the future to allow technology adoption.

**Links:** Link to **FOP Matrix** [19]

### 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 uses the same role levels 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:

- **Professional & Delivery**
  Diagnose, adapt, and collaborate within known systems.
- **Strategic & Operational Management**
  Design systems, manage resources and drive innovation.
- **Enterprise Leadership**
  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 Autonomous Robotics specialists this emergent technology requires.

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[19] HVMhttps://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=2a668f2e63faf1dddcc400328f65e0d4C Foresighting

## Future Occupational Profiles results

To enable the development of autonomous robotics systems for the implementation of in-orbit operations, **21 FOPs** were identified. These FOPs can be seen below listed by Role Level and across the supply chain partners identified.

**Table key:** supply chain partners

1. RTOs Research & Innovation Organisations
2. Regulators, Standards Bodies & Government
3. Service Providers ISAM
4. Technology Providers (Hardware and software)

| RL | FOP | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **1** | Simulation & Modelling Engineer | | | ✓ | ✓ |
| | Systems Integration Engineer | | | ✓ | |
| | Space Manufacturing Engineer | ✓ | | | |
| | Robotics Development Engineer | ✓ | | | |
| | Robotics Testing Technician | | | | ✓ |
| | GNC Engineer | | | | ✓ |
| | Autonomy & Perception Engineer | | | | ✓ |
| | Autonomous Systems Engineer | ✓ | | | |
| | Mechanical & Hardware Development Engineer | | | | ✓ |
| | Autonomous Operations Lead | | | ✓ | |
| | Mission Design Architect | | | ✓ | |
| | Mission Operations Architect | | | ✓ | |
| **2** | Intellectual Property Analyst | | ✓ | | |
| | Product Assurance Manager | | | ✓ | ✓ |
| | Technical Architect | | | ✓ | |
| | AI Governance Lead | | ✓ | | |
| | Robotics Systems Architect | | | | ✓ |
| **3** | Robotics Development Lead | ✓ | | | |
| | Space Policy Lead | | ✓ | | |
| | Legal & Compliance Regulatory Affairs Officer | | ✓ | | |
| | Robotics Standards & Governance Specialist | | ✓ | | |

*Table 4: Future occupational profiles assigned to supply chain partner*

## Priority FOPs

The FOPs were reviewed by our 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 the adoption of autonomous robotics systems for space enabled technologies. There are **9 profiles** highlighted in this analysis below, and though the future workforce will require all of them in order to function, these were identified as those which represent a limiting factor; without these roles, the growth of this area will be held at a workforce shortage bottleneck.

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

These roles are prioritised because they:

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

**Insight**:

Cycle selected Priority Future Occupational Profiles (FOPs) and why there were selected:

### 1. Simulation & Modelling Engineer

A Simulation & Modelling Engineer evolves from today's modelling roles to build physics-based and digital-twin environments that validate autonomous, fault-tolerant robotic behaviours. They develop navigation, anomaly-detection and verification tools that ensure safe and robust robotic performance in uncertain orbital conditions while reducing the sim-to-real gap. With the increase in digital twin technologies, there would be requirements to increase skills needed to validate the simulations and models

This role was identified as a top priority profile, because it represents the capacity to verify and clear mission critical stage-gates within technology development and mission success.

### 2. Systems Integration Engineer

A Systems Integration Engineer designs coordinated autonomous robotic operations by selecting suitable technologies, configuring communication pathways, and integrating multi-agent behaviours into mission plans. They develop real-time control and autonomy algorithms for constrained processors, implement operational sequences, and maintain systems ensuring stable, safe robotic execution in orbit.

Systems Integration engineers appear often in the most critical roles for space-enabled technologies, as typically new capabilities represent a layering of multiple systems which are interdependent and reliant on seamless interoperability in order to ensure the smooth and reliable operation of the technology use-case.

### 3. Autonomous Operations Lead

An Autonomous Operations Lead directs how AI-driven robotics are deployed in space missions. They oversee autonomy design and verification on constrained hardware, align software libraries and ML models with safety and policy requirements, manage cyber-secure anomaly detection, and help shape common standards for safe, transparent autonomous operations in orbit.

Both from a security and sovereign resiliency perspective, the responsibility of managing the autonomous elements of the robotics systems underpins many of the other roles in this emerging technology area.

### 4. Mission Design Architect

A Mission Design Architect defines how autonomous robotics enable future space missions. They translate objectives into system requirements, oversee the selection of radiation-tolerant technologies and materials, and shape robotic mechanisms and sensing architectures, ensuring mission concepts exploit advanced technologies and autonomy while remaining feasible, robust and aligned with operational performance needs.

As discussed earlier in the report, design capabilities make up the majority of the skills development requirement, and this role holder would be responsible for design decisions that enable mission feasibility.

### 5. Robotics Development Engineer

A Robotics Development Engineer advances from current robot design work to create multiagent, fault tolerant systems for in-orbit servicing. They develop new simulation environments, engineer mechanisms, end-effectors, control electronics and autonomy-ready hardware, validating performance under launch and environmental space conditions, limited computing to ensure safe, coordinated robotic operations in space infrastructure.

This role has one of the longest lists of capability requirements, as their skills portfolio is required to be both deep and broad. As the problem-solver for many of the frontier areas of this technology development, robotics development engineers will be required to walk into new projects equipped with the ability to work towards solutions at pace.

### Autonomy & Perception Engineer

An Autonomy & Perception Engineer will advance space-based robotics by fusing multi-agent coordination, AI-driven perception and fault-tolerant autonomy. Evolving from today's robotic controls work, the role will design radiation-robust systems, verify learning-based behaviours, and integrate autonomous operations into mission plans to enable resilient, precise ISAM activities in orbit.

As the autonomous robotics systems in-orbit are functioning in an environment that it is almost impossible for a human engineer to validate or fix an issue on-site, autonomous sensing and fault tolerance is very important to the long-term success of any in-space (or hostile environment) robotics system.

### Autonomous Systems Engineer

An Autonomous Systems Engineer designs and implements systems which observe, perceive, decide and act autonomously operating on constrained, radiation tolerant processors. They design multiagent robotics coordination, real-time control and formal verification methods to ensure safe, compliant mission behaviour, strengthening robotic performance during servicing, assembly and hazard sensitive operations across future space infrastructure. This role would also ensure compliant product delivery against regulatory standards. They advance fault tolerant robotic autonomy through digital twin simulation, hardware-in-the-loop validation and communication modelling.

Similar to the Robotics Development Engineer, this role will undertake a role of significant responsibility, developing autonomous systems that are secure, agile and meet regulatory challenges. Autonomous systems are also often expected to deliver increased reliability and productivity, requiring a vast knowledge base to both understand the requirement and create the system able to deliver.

**AI Governance Lead**
An AI Governance Lead develops assurance frameworks and verification methods that ensure machine-learning-driven autonomy in space robotics is transparent, reliable and compliant to given frameworks. They safeguard critical decision-making by embedding rigorous safety controls and regulatory alignment into robotic AI systems operating in complex orbital environments.

Artificial intelligence is a very fast-paced and dynamic area of technological development, and meeting the requirement for responsible and safe utilisation of AI and machine learning in autonomous systems while also enabling new capabilities is a unique combination of skillsets that are so new to the workforce that a very small pool are available for an explosion of applications for AI technologies across all areas of industry. Space-based AI applications will need to compete with other highly paid sectors and their parallel workforce requirements.

**Robotics Standards & Governance Specialist**
A Robotics Standards & Governance Specialist defines technical and regulatory standards that ensure safe, compatible autonomous robotics in orbit. They shape interoperability protocols; apply space safety frameworks and coordinate multi-vendor alignment so future robotic systems can collaborate reliably across shared infrastructure and mission architectures.

As discussed in 2.1.4, a well-informed regulatory specialist is required to have a functional understanding of a vast number of considerations, and therefore a skills gap within this area could represent a significant blocker to this future economy's growth.

**Links:** See Appendix C(**List of full FOPs**)for full details on FOPs versus provision. Link to visualisation tool for **21 FOPs** [[20]]

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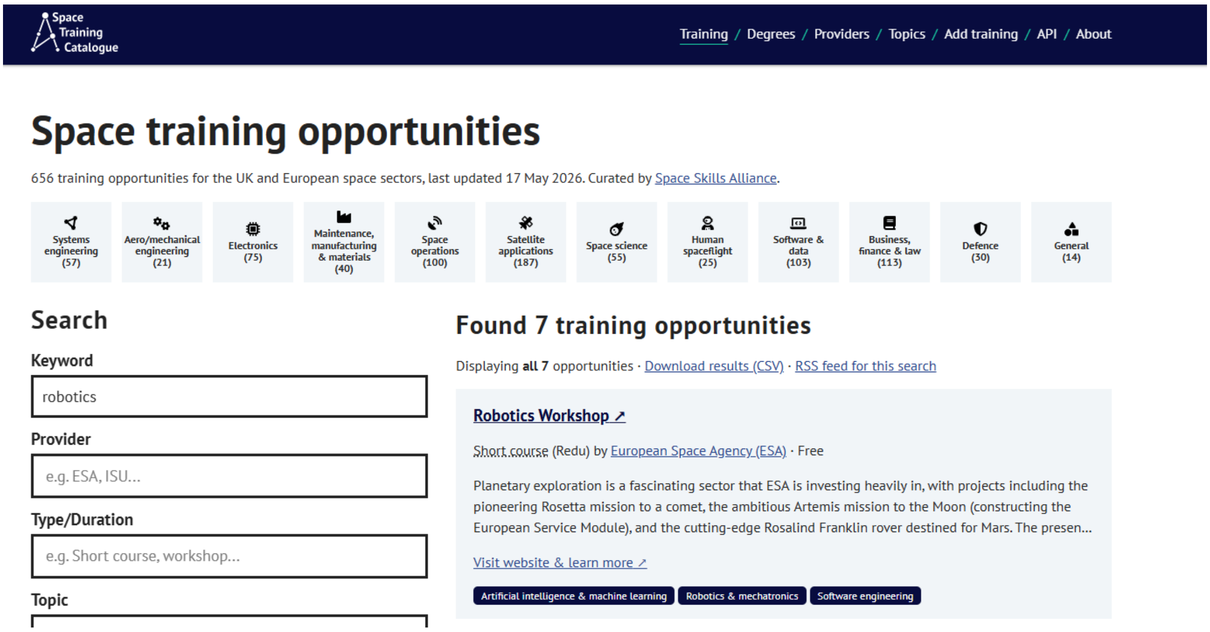
[20] Future occupational profiles hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=2a668f2e63faf1dddcc400328f65e0d4

## 2.5 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 by our 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.[21] As such, for the purposes of this cycle, we have custom input capabilities 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 those available for Autonomous Robotics, we 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.[22] This does not, however, present a particularly rosy view of provision for robotics as an area of development; only seven training opportunities are listed as contributing upskilling for robotics, and while other categories have tangentially applicable subject matter, these will likely represent a significant amount of superfluous training from the specific needs required to adapt a robotics engineer into one specialised for space-enabled robotics systems.



Space training opportunities

656 training opportunities for the UK and European space sectors, last updated 17 May 2026. Curated by Space Skills Alliance.

Search

Keyword: robotics

Provider: e.g. ESA, ISU...

Type/Duration: e.g. Short course, workshop...

Topic

Found 7 training opportunities

Displaying **all 7** opportunities · Download results (CSV) · RSS feed for this search

Robotics Workshop ↗

Short course (Redu) by European Space Agency (ESA) · Free

Planetary exploration is a fascinating sector that ESA is investing heavily in, with projects including the pioneering Rosetta mission to a comet, the ambitious Artemis mission to the Moon (constructing the European Service Module), and the cutting-edge Rosalind Franklin rover destined for Mars. The presen...

Visit website & learn more ↗

*Figure 5 Space Skills Alliances' Space Training Catalogue, filtered to review current courses and short courses tagged with robotics training provision.*

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[21] *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.

[22] *Space Skills Training Catalogue*, Space Skills Alliance. Available: https://training.spaceskills.org/

### 2.5.1 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.

### FOP Simulation & Modelling Engineer

**Key Tasks:** A Simulation & Modelling Engineer evolves from today's modelling roles to build physics-based and digital-twin environments that validate autonomous, fault-tolerant robotic behaviours. They develop navigation, anomaly-detection and verification tools that ensure safe and robust robotic performance in uncertain orbital conditions while reducing the sim-to-real gap. With the increase in digital twin technologies, there would be requirements to increase skills needed to validate the simulations and models.

**Aligned to supply chain partners:** Technology Providers (Hardware and software), Service Providers ISAM

In FOP vs Provision there was an 50% Fit with Skills England Advanced robotics engineer [[23]]. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| DESIGN | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning |
| DESIGN | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space |
| DESIGN | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. |
| DESIGN | Create physics-based simulation environments to validate robotic manoeuvres under orbital dynamics and uncertain space conditions. |
| DESIGN | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. |
| DESIGN | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. |

*Table 5: Simulation & Modelling Engineer capabilities not served by selected provision*

The above capabilities list those within the FOP Simulation & Modelling Engineer not met by any existing education programmes. This means these are areas where new training provision should be developed to support the future workforce needs. In this case, the best existing training provision is from an apprenticeship, as higher education provision was not specific enough to this new emergent area of skills requirement. Either this apprenticeship standard could be improved, or module design recommended to increase the number of skills development pathways that support this role.

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[23] https://skillsengland.education.gov.uk/apprenticeship-standards/st1381?view=standard

## FOP Systems Integration Engineer

**Key Tasks:** A Systems Integration Engineer designs coordinated autonomous robotic operations by selecting suitable technologies, configuring communication pathways, and integrating multiagent behaviours into mission plans. They develop real-time control and autonomy algorithms for constrained processors, implement operational sequences, and maintain systems ensuring stable, safe robotic execution in orbit.

**Aligned to supply chain partners:** Service Providers ISAM

In FOP vs Provision there was an 53% Fit with Cranfield - Robotics MSc (All Modules). The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| **DESIGN** | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space |
| **DESIGN** | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. |
| **DESIGN** | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. |
| **DESIGN** | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. |
| **DESIGN** | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. |
| **DESIGN** | Configure computing systems to operate reliably in radiation exposed environments while meeting autonomy performance needs. |
| **DESIGN** | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. |
| **SUPPORT** | Operate and maintain ground support systems for autonomous robotics systems operations. |

*Table 6: Systems Integration Engineer capabilities not served by cycle's selected provision*

Systems Engineers are both pivotal and in short supply across multiple applications of space-enabled technologies, as well as in adjacent sectors. However, systems engineering courses are not as competitively applied for, perhaps due to a lack of understanding of the career opportunities they represent. While the training provision is not specialist enough for an ideal coverage of the skills needs for the space sector, this problem is therefore two-fold; we need to uplift a systems engineer to this specific technology area, and we need more systems engineers being developed on these courses.

## FOP Autonomous Operations Lead

**Key Tasks:** An Autonomous Operations Lead directs how AI-driven robotics are deployed in space missions. They oversee autonomy design and verification on constrained hardware, align software libraries and ML models with safety and policy requirements, manage cyber-secure anomaly detection, and help shape common standards for safe, transparent autonomous operations in orbit.

**Aligned to supply chain partners:** Service Providers ISAM

In FOP vs Provision there was an 50% Fit with Cranfield - Robotics MSc (All Modules). The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| DESIGN | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning |
| DESIGN | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints |
| DESIGN | Configure computing systems to operate reliably in radiation exposed environments while meeting autonomy performance needs. |
| DESIGN | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. |
| DESIGN | Create top level specifications & operational plans for robotics systems infrastructure which set out the requirements for verification & validation procedures |
| ENTERPRISE | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls |
| IMPLEMENT | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. |

*Table 7: Autonomous Operations Lead capabilities not served by selected provision*

This matching analysis highlights that while half of the required capabilities are developed if an individual were to take every module available on this course (functionally impossible), this would also mean that over 78% of the course teaching would be extraneous to the needs of this future role. Combined with the common matching of roles to this postgraduate degree course, this suggests that this role could be a good candidate for an overhaul of future course design for new training provision focused on autonomy.

## FOP Mission Design Architect

**Key Tasks**: A Mission Design Architect defines how autonomous robotics enable future space missions. They translate objectives into system requirements, oversee the selection of radiation-tolerant technologies and materials, and shape robotic mechanisms and sensing architectures, ensuring mission concepts exploit advanced technologies and autonomy while remaining feasible, robust and aligned with operational performance needs.

**Aligned to supply chain partners:** Service Providers - ISAM

In FOP vs Provision there was an 40% Fit with Robotics engineer – degree. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| DESIGN | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. |
| DESIGN | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. |
| IMPLEMENT | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. |

*Table 8: Mission Design Architect capabilities not served by selected provision*

This role profile only features five evolving skills requirements, but only one of these is served well by existing training, making this a critically under-served workforce need. While above we have listed the Robotics engineer degree apprenticeship, four other training routes also supplied the same pattern of coverage, at 40% and with the same one capability (around writing system requirements) being covered by a number of master's degree courses.

## FOP Robotics Development Engineer

**Key Tasks:** A Robotics Development Engineer advances from current robot design work to create multi-agent, fault-tolerant systems for in-orbit servicing. They develop new simulation environments, engineer mechanisms, end-effectors, control electronics and autonomy-ready hardware, validating performance under launch and environmental space conditions, limited computing to ensure safe, coordinated robotic operations in space infrastructure.

**Aligned to supply chain partner:** RTOs Research & Innovation Organisations

In FOP vs Provision there was an 54% Fit with Robotics engineer – degree. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| DESIGN | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space |
| DESIGN | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. |
| DESIGN | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. |
| DESIGN | Design thermal controls to maintain robotic system stability across expected space temperature changes and pointing conditions. |
| DESIGN | Design robotic structures that survive launch vibration and release shocks to ensure reliable deployment in orbit. |
| DESIGN | Configure computing systems to operate reliably in radiation exposed environments while meeting autonomy performance needs. |
| DESIGN | Develop motor control electronics that provide reliable actuation for robotic mechanisms in space. |
| DESIGN | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. |
| DESIGN | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. |
| DESIGN | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. |
| IMPLEMENT | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. |
| IMPLEMENT | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. |
| SUPPORT | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. |

*Table 9: Robotics Development Engineer not served by cycle's provision*

13 of the core capabilities for the Robotics Development Engineer role do not meet the 55% match threshold from any training provision available, reflective of the deep knowledge specialism required for this role. Due to the demanding nature of this role, on-the-job experience, and the practical application of the knowledge to real-life challenges is of huge benefit to this role profile, which makes the degree apprenticeship (level 6) a good route for training. It is worth noting that this degree apprenticeship is only available for delivery at once training provider – Cranfield University.

This cycle would recommend either an update to the standards of this apprenticeship, or a ‘bolt-on’ industrial placement training opportunity, where recent graduates could be supported to channel their expertise into a space-enabled robotics application.

## FOP Autonomy & Perception Engineer

**Key Tasks**: An Autonomy & Perception Engineer will advance space-based robotics by fusing multi-agent coordination, AI-driven perception and fault-tolerant autonomy. Evolving from today's robotic controls work, the role will design radiation-robust systems, verify learning-based behaviours, and integrate autonomous operations into mission plans to enable resilient, precise ISAM activities in orbit.

**Aligned to supply chain partners:** Technology Providers (Hardware and software).

In FOP vs Provision there was an 48.3% Fit with Skills England Advanced robotics engineer[24]. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| **SUPPORT** | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. |
| **DESIGN** | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. |
| **DESIGN** | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. |
| **DESIGN** | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space |
| **DESIGN** | Develop computer vision algorithms and state estimation of the client satellite to support robotic manipulation tasks in orbit |
| **DESIGN** | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. |
| **DESIGN** | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. |
| **DESIGN** | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. |
| **DESIGN** | Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. |
| **DESIGN** | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. |
| **DESIGN** | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. |
| **IMPLEMENT** | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. |
| **IMPLEMENT** | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. |
| **IMPLEMENT** | Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations |
| **SUPPORT** | Operate robotic systems remotely to conduct inspection, servicing and assembly tasks in orbit. |

*Table 10: Autonomy & Perception Engineer capabilities not served by selected provision*

The Advanced Robotics Engineer apprenticeship represents the best match to provision, at 60% of the role capability requirements and with many of the apprenticeship's other duty statements holding at least a partial match. However, this apprenticeship is a Level 7 role

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[24] https://skillsengland.education.gov.uk/apprenticeship-standards/st1381?view=standard

and has no current training providers. Alternative matches available are the Robotics Engineer degree apprenticeship at a 41% match, and the Cranfield Robotics MSc, with the same matching score. In order for the better match to be feasible for the Level 7 apprenticeship, a stimulant to incentivise industry to support the cost of this training would need to be devised.

## FOP Autonomous Systems Engineer

**Key Tasks:** An Autonomous Systems Engineer designs and implements systems which observe, perceive, decide and act autonomously operating on constrained, radiation-tolerant processors. They design multi-agent robotics coordination, real-time control and formal verification methods to ensure safe, compliant mission behaviour, strengthening robotic performance during servicing, assembly and hazard-sensitive operations across future space infrastructure. This role would also ensure compliant product delivery against regulatory standards. They advance fault-tolerant robotic autonomy through digital-twin simulation, hardware-in-the-loop validation and communication modelling.

**Aligned to supply chain partners:** RTO Research & Innovation Organisations

In FOP vs Provision there was an 48% Fit with Robotics engineer – degree. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| DESIGN | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints |
| DESIGN | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. |
| DESIGN | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. |
| DESIGN | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. |
| DESIGN | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space |
| DESIGN | Develop algorithms for autonomous navigation in robotics using computer vision. |
| DESIGN | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning |
| DESIGN | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. |
| ENTERPRISE | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls |
| IMPLEMENT | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. |

*Table 11: Autonomous Systems Engineer FOP capabilities not served by selected provision*

These unserved capabilities list the most efficient intervention to improve training provision for this set of capabilities. Similar to the Systems Integration engineer, the best strategy for addressing this skills gap could either be adaptation of the existing provision to provide the specialisation required, or an upskilling intervention designed to specialise the workforce required. This could be achieved either through a CPD training course, or through industrial placements that facilitate hands-on experience gain for new graduates.

## FOP AI Governance Lead

**Key Tasks:** An AI Governance Lead develops assurance frameworks and verification methods that ensure machine-learning-driven autonomy in space robotics is transparent, reliable and compliant to given frameworks. They safeguard critical decision-making by embedding rigorous safety controls and regulatory alignment into robotic AI systems operating in complex orbital environments.

**Aligned to supply chain partners**: Regulators, Standards Bodies & Government.

In FOP vs Provision there was an 75% Fit with Cranfield - Robotics MSc (All Modules. The unmatched FOP capabilities are shown in the table below:

| Function Area | Capability Statement |
|---|---|
| **DESIGN** | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. |

*Table 12: AI Governance Lead capabilities not served by selected provision*

The AI Governance Lead is one of the roles best served by existing provision, with only one capability statement entirely under served. As this in a fast-evolving field, it is likely that this list of required capabilities will continue to grow, but as a priority area for both government-funded activities and commercially profitable projects, it is likely that CPD course provision will fill this provision gap.

Past CPD courses that would be appropriate to revive and adapt include those run by the SatNEx School at the Bradford-Renduchintala Centre for Space AI, and the Space Applications Learning Hub course provided by the Royal Institute of Navigation.

## FOP Robotics Standards & Governance Specialist

**Key Tasks:** A Robotics Systems Architect coordinates design & development teams against the specifications for the delivery of robotics systems. This role provides direction for coordinated autonomous robotic operations by selecting suitable technologies, configuring communication pathways, and integrating multi-agent behaviours into mission plans. They employ appropriate autonomy algorithms for constrained processors, create modular assembly sequences for large orbital structures, and ensuring efficient ground.

**Aligned to supply chain partners:** Regulators, Standards Bodies & Government.

In FOP vs Provision there was an 75% Fit with Cranfield - Robotics MSc (All Modules).

| Function Area | Capability Statement |
|---|---|
| DESIGN | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. |

*Table 13:Robotics Standards & Governance Specialist capabilities not served by selected provision*

Here the training provision existing is a reasonable fit for the skills that this cycle identifies as needed for the development of this role. However, it is noteworthy that the next best role has only a 25% match, highlighting the extreme reliance on only a handful of courses. It is also likely, as we discussed around the capability theme of **Regulatory, Compliance and Safety**, that these roles would ideally be held by someone with a very broad understanding of the entire ecosystem, and therefore this likely represents a role-holder in the mid to late stages of their career. This makes this role difficult to design for, but reliant upon steady experience gain.

**Links:** Link **to FOP vs Provision [**[25]] to see full list of capabilities for cycle FOP against provision.

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[25] FOP vs Provision https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=2a668f2e63faf1dddcc400328f65e0d4

## FOPs with the biggest Education provision gaps

The table below lists the total FOPs defined for this foresighting cycle. It highlights provision gaps by showing the best fit current apprenticeship standard, based on Maximum Fit Factor. The Maximum Fit Factor is combined with the Surplus Factor to determine the Apprenticeship Suitability score of Low, Medium or High.

A detailed comparison of current apprenticeship provision against the capability requirements of the identified FOPs is available in the data visualisation tool: *FOP vs Provision.*[26]

**Table Key**: Supply chain partners (SCP)

1. RTOs Research & Innovation Organisations
2. Regulators, Standards Bodies & Government
3. Service Providers ISAM
4. Technology Providers (Hardware and software)

| Role Level | FOP Title | Required for SCP | Best Fit Cycle selected provision | Suitability [27] |
|---|---|---|---|---|
| Strategic & Operational Management | Technical Architect | 3 | Cranfield - Robotics MSc (All Modules) | **LOW** |
| Enterprise Leadership | Legal & Compliance Regulatory Affairs Officer | 1 | Cranfield - Robotics MSc (All Modules) | **LOW** |
| Professional & Delivery | Mechanical & Hardware Development Engineer (Robotics) | 4 | Advanced robotics engineer | **LOW** |
| Professional & Delivery | GNC Engineer | 4 | Advanced robotics engineer | **LOW** |
| Strategic & Operational Management | Mission Design Architect | 3 | Robotics engineer - degree | **LOW** |
| Professional & Delivery | Robotics Testing Technician | 4 | Advanced robotics engineer | **LOW** |
| Professional & Delivery | Autonomous Systems Engineer | 1 | Robotics engineer - degree | **LOW** |
| Professional & Delivery | Autonomy & Perception Engineer | 4 | Advanced robotics engineer | **LOW** |
| Strategic & Operational Management | Product Assurance Manager | 3, 4 | Advanced robotics engineer | **LOW** |
| Professional & Delivery | Simulation & Modelling Engineer | 3, 4 | Advanced robotics engineer | **LOW** |
| Strategic & Operational Management | Autonomous Operations Lead | 3 | Cranfield - Robotics MSc (All Modules) | **LOW** |

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[26] FOP vs Provision https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=eaa250b5f67ebebd98d49fef6a03bcdf

[27] Fit Factor is determined based on semantic matching between the capability statements within a profile and the duty statements within a learning provision. 100% would indicate a match above the threshold for linguistic matching, for all capabilities within a FOP.

| Role Level | FOP Title | Required for SCP | Best Fit Cycle selected provision | Suitability [27] |
|---|---|---|---|---|
| Professional & Delivery | Systems Integration Engineer | 3 | Cranfield - Robotics MSc (All Modules) | **MEDIUM** |
| Professional & Delivery | Robotics Development Engineer | 1 | Robotics engineer - degree | **MEDIUM** |
| Professional & Delivery | Space Manufacturing Engineer | 1 | Robotics engineer - degree | **MEDIUM** |
| Strategic & Operational Management | Robotics Systems Architect | 4 | Cranfield - Robotics MSc (All Modules) | **MEDIUM** |
| Enterprise Leadership | Robotics Development Lead | 1 | Robotics engineer - degree | **MEDIUM** |
| Strategic & Operational Management | Mission Operations Engineer | 3 | Advanced robotics engineer | **MEDIUM** |
| Strategic & Operational Management | Intellectual Property Analyst | 2 | Cranfield - Robotics MSc (All Modules) | **MEDIUM** |
| Strategic & Operational Management | AI Governance Lead | 2 | Cranfield - Robotics MSc (All Modules) | **HIGH** |
| Enterprise Leadership | Robotics Standards & Governance Specialist | 2 | Cranfield - Robotics MSc (All Modules) | **HIGH** |
| Enterprise Leadership | Space Policy Lead | 2 | Astronautics and Space Engineering BEng (Hons) or MEng-1 (combination of modules) | **HIGH** |

*Table 14: FOPs vs Closest in cycle selected provision*

**FOP Distribution link**[28]

**Insight**:

**Seven** of the available FOPs are best served by the Level 7 Advanced Robotics Apprenticeship, which currently has no training providers available. With the funding cut to support level seven apprenticeships, and a low uptake of apprenticeships historically in the space sector, this option is only feasible for large primes in this sector.

**Thirteen** of the remaining FOPs are best served by training provision out of Cranfield University, either via their Robotics MSc or degree apprenticeship. This study was only able to utilise a sample of university degree courses that shared their course capabilities publicly, so it is possible that there are other options to dilute this heavy reliance, but it highlights a point of critical failure and acute reliance on higher education provision.

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[28] FOP Distribution link https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=2a668f2e63faf1dddcc400328f65e0d4

### 2.5.2 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:

- **Informing / Guiding understanding of the alignment between future-state capability requirements and current educational provision.**
- **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:

- **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.
- **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.

## 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 |
|---|---|
| Life Cycle Assessment | 15 |
| Sustainability | 14 |
| Process Optimization | 12 |
| Waste Reduction | 12 |
| Manufacturing Processes | 10 |
| Process development | 10 |
| Regulatory Compliance | 10 |
| Sustainable Design | 10 |
| Chemical Process Engineering | 9 |
| Process Control | 9 |
| Continuous Manufacturing | 8 |
| Corporate Sustainability | 8 |
| Equipment Design | 8 |
| Process Engineering | 8 |
| Quality Control | 8 |
| Sustainable Product Development | 8 |
| Environmental Compliance | 7 |
| Resource Recovery | 7 |
| Waste Management | 7 |
| Analytical Chemistry | 6 |
| Analytical Techniques | 6 |
| Automation Technologies | 6 |
| Process Analytical Technology (PAT) | 6 |
| Process Design | 6 |
| Regulations | 6 |
| Solvent Recovery Techniques | 6 |
| Sustainable Business | 6 |

*Table 15: Most frequent Knowledge Tags*

### *Most frequent Skills Tags*

| Tag | Tag Frequency |
|---|---|
| Perform Data Analysis | 20 |
| Improve Chemical Processes | 11 |
| Analyse Production Processes for Improvement | 9 |
| Promote Sustainability | 9 |
| Use modelling & simulation for process development | 9 |
| Assess Environmental Impact | 7 |
| Optimise Production Processes Parameters | 7 |
| Identify Process Improvements | 6 |
| Implement Sustainable Procurement | 6 |
| Select Sustainable Technologies In Design | 6 |

*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.

### 2.5.3 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 of Noteworthy Observations

Earlier, in 2.1.4, we introduced four key themes of capability areas that were underserved by the existing training provision. These were:

- Software, Communications & Security
- Simulation & Validation
- Systems Integration
- Regulatory, Compliance & Safety

These themes highlight a shift in workforce capability needs toward strategic design, management, and governance of autonomous systems. 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**:

Cycle selected Priority Future Occupational Profiles (FOPs) and why there were selected:

**1. Simulation & Validation**

As the theme where most of the capabilities represent pioneering new skills requirements, the recommendation to approach this area of priority capabilities is varied. While this cycle identifies this as a key area, it is likely that this set of skills requirements may feature across multiple advanced manufacturing sectors, and one initial recommendation would be a Catapult Network activity to cross-reference these capability needs against those identified in other sectors, to consolidate needs across the use-cases of this skillset. As such, the results of that activity may highlight the need for the development of whole new courses, if adaptation or module overhaul would not represent a significant change to the course provision.

This cycle has also raised the key value of opportunities to gain hands on experience, and this can be achieved in a number of ways – not least by the apprenticeships and degree apprenticeships that matched highly for these roles. Within HE, for example at the University of Hertfordshire, robotics is studied in a practical, hands-on way through virtual reality robotics labs and other practical elements that develop both hardware and software validation skills. Where training providers cannot include this in their curricula, graduate industrial placements may be a solution.

**2. Systems Integration**

Systems integration roles are in demand across multiple sectors, and awareness that the space sector is a viable career path for graduates is not strong. Building career pathways in systems engineering would help stimulate more students in these courses, and support their conversion into space. That conversion however, is likely needed, as very few systems engineering training courses are specific enough to be an immediate fit to the needs of the space sector.

A long-format CPD course could be employed to upskill individuals into the systems specialists needed for these roles, for which training providers can utilise unused apprenticeship levy funds. Alternatively, as above, a year-long industrial placement would be perfect to develop young professionals with the experience needed by the industry.

### 3. Software, Communications & Security

This theme highlights something of a gap in the educational provision already in place, as typically training focuses on either software or on mechanical robotics, rarely attacking the interface of the two through secure software interfacing and the potential for autonomous control through machine learning models. Here, one of the challenges is understanding when to utilise AI and when to maintain human authorship for security reasons, but while existing training around cyber security and AI considerations is growing, the gap is the specialisation for space.

This could be achieved either through course design adaptation with space-application modules, or through CPD courses that upskill individual upon hire from the broad training received through their degree, to the specialist requirements needed for Autonomous Robotics systems in orbit.

### 4. Regulatory, Compliance & Safety

This area represents the highest number of transferable skills from other sectors, and for some cases this may mean that CPD training courses are enough to upskill workforce that are switching their careers for the space sector. For some areas of this theme, sovereign security concerns and mission safety add urgency to ensuring that the right workforce is available to take these roles, but the ideal candidates for these roles are those with a longer history of experience in the sector; to stimulate this, we must support the growth of a specialist autonomous robotics workforce across the board

## 2.6 Summary of key recommendations

Educators identified several capability gaps where curriculum provision does not currently meet forecasted workforce demand. Our 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 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. There also may be other HE courses that deliver appropriate training that have not been included in this survey; at present over half of the future occupational roles are best served by a degree or degree apprenticeship supplied by one academic institution.

One consistent theme between the recommendations for training is around the importance of hands-on experience – often highlighted by the demand for mid-career workforce that do not require any training to begin delivery. Where this emerging technology area is an entirely new frontier, career switching is less realistic an option, and parallels between utilisation of autonomous robotics systems are at a similar deployment stage, meaning that workforce transfer between difference sectors is more likely to represent competition for the skills required, than a solution to the skills need. Future consolidation with other Workforce Foresighting cycles, such as the Autonomous Robotics for Welding, Joining and Inspection carried out by HVM Catapult (NMIS), would be valuable to assess this consolidated skills demand. Other ways to support hands-on experience pathways include the support of apprenticeships programmes, which have typically been difficult to introduce to the space sector.

To address the key capability gaps identified, and reacting to the individual recommendation from the priority future occupational profile, the following headline recommendations can be made:

**Apprenticeship solutions for space** – how to incentivise apprenticeships
This study demonstrates that should enough apprenticeships be available, they would represent a solution to many of these skills needs, and with the standards already in place making a reasonable match, this could be a relatively quick intervention if a solution was found to incentivise industry to support the costs required to invest in a higher-level apprentice.

**Industrial placements** – converting education and theory into practical experience
Where apprenticeships are not feasible, one solution to upskill from the abstracted theory provided by educational channels, or the need for critical thinking and problem solving within the workforce to be developed through a little experience is industrial placements. These could be convened by a central body but used to stimulate and facilitate the sector’s resilience to workforce bottlenecks but developing a pipeline of young professionals with appropriate skills experience.

**Consolidated advocacy & policy development** – cross-sector demand
This includes connecting the skills needs of this cycle to those pressures felt in adjacent sectors, to identify development gaps which span multiple sectors, and could result in a stronger call for university course design or new 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 few courses are not enough to supply the number of roles projected in Autonomous Robotics across the space sector and those other adjacent industries. This means more career pathway development is required to encourage more students into Robotics courses, be that either through university or through apprenticeships. We would also suggest that in those cases where job roles represent a sovereign risk, or at least one of interest to national security, courses are protected against the pressures Universities are currently under which tends to encourage the generalisation of course design, rather than protecting key specialisms.

**CPD for specialisation** – proactive upskilling
If we must accept that not all prospective applicants for these roles will have received the specialist training necessary for the in-orbit applications of autonomous robotics, we must prepare to upskill individuals from courses that supply a more generalised skillset. These courses might utilise unspent apprenticeship levies and could also be designed to accommodate mid-career switchers, or veterans seeking to transition from military service.

# 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 our 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).

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 Autonomous Robotics Systems for Operations in Space Workforce Foresighting Cycle, the following data points were identified and focus areas were developed.

### 3.1.1 Key Findings

***Future Capabilities & Roles:***

**61 future capabilities** were identified, leading to **21 Future Occupational Profiles** (FOPs) across four supply chain partners. Those FOPs included three role levels with varying levels of responsibility and were mapped against supply chain partners within functional domains, highlighting that the majority of this cycle occupied the **design** domain of skills requirements. **186 KSBs** (knowledge skills and behaviours tags) were assigned to this cycle.

***Priority Capabilities Themes:***

These capability themes have been prioritised because they directly address the most pressing challenges and opportunities in the process of analysing Autonomous Robotics skills needs.

- Software, Communications & Security
- Simulation & Validation
- Systems Integration
- Regulatory, Compliance & Safety

***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:

- Simulation & Modelling Engineer
- Systems Integration Engineer
- Autonomous Operations Lead
- Mission Design Architect
- Robotics Development Engineer
- Autonomy & Perception Engineer
- Autonomous Systems Engineer
- AI Governance Lead Robotics Standards & Governance Specialist

***Education provision gaps:***

As discussed in more detail in Section 2.3.3 and 2.4 there is no one-size fits all solution to the gaps in educational provision for Autonomous Robotics, as both the scale of the need and the appropriate intervention differs across different parts of the future workforce. However, we identified some individual solutions for the different thematic areas of underserved capabilities and then grouped those solutions together into a summary of the levers that would be effective to address those gaps.

- **Apprenticeship solutions for space** – Apprenticeships could quickly address many skills gaps using existing standards, but uptake depends on incentivising employers to cover the higher costs of advanced apprenticeships.
- **Industrial placements** – Industrial placements provide practical experience to complement academic learning and build problem-solving skills, helping create a more resilient workforce pipeline.
- **Consolidated advocacy & policy development** – Aligning skills needs across sectors can highlight shared gaps and strengthen the case for new university courses and apprenticeship pathways.
- **Higher Education course provision** – Current courses broadly meet technical needs but lack sufficient student numbers, requiring stronger promotion, clearer pathways, and protection of strategically important specialisms.
- **CPD for specialisation** – Targeted CPD can upskill individuals from generalist backgrounds into specialised roles, with flexible routes supporting career switchers and better use of existing funding like apprenticeship levy.

For the full summary details, please review section 2.4 (**2.6 Summary of key recommendations**), and to view each recommended response tailored to the Priority Capability Themes, please see section 2.3.3 (**2.3.3 Functional Cycle Capabilities Currently Not Served**)

### 3.1.2 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.

This report outlines the consequences for industry and for educators, but a few key themes are pervasive:

- Skills shortages should be understood as a key blocker to economic growth. A healthy workforce pipeline both fuels the realisation of the ambitions of innovative growth but also stimulates the economy on a national and a regional level, with clusters of activities focusing on local talent pipelines, and strengthening the UK economy in the process.
- In order to be effective, both in terms of impact and from cost-effective and streamlined effort, the need to act in a targeted development of the pipeline to give the UK the right to succeed in these challenging areas.
- In-person experience gain is key, and can be achieved through multiple routes, be that apprenticeships, more hands-on course design from higher education providers, or through industrial placements.
- The interface between government, industry and academic institutions is crucial to support this emerging technology area; regulation and most funding resources are controlled by government, and with pressures on academic systems already, effective and clear demand signals need to be sent by industry so that efficient interventions can be designed. Where these require industry investment or collaboration, it should be recognised that these activities are designed to release pressures on industry workforce.

The bottom line is that this emerging technology could enable a £1 billion UK economy, and to create an environment fit to nurture that ambition, skills capabilities need to transform at speed.

## 3.2 What this means for Industry

The UK space robotics opportunity is large and sits squarely within the horizon considered for this cycle, but success depends on rapidly building a highly specialised, sovereign, and **cross-disciplinary workforce**. Without this, growth will stall despite strong market and technological readiness. This the challenge at the core of skills development work; that our technology and our innovation capital will reach a bottleneck from the workforce available and both the productivity and market share that could be enjoyed by the UK space sector will not be realised.

Industrial capability for this cycle is not at the lower levels of basic engineering, and while one role was identified that would be appropriate for a level 4 educational level, the majority of the requirements for this technology area require undergraduate or postgraduate equivalent level of study. This signals a move towards complex, system-level engineering and assurance roles, for which extensive training and specialisation is required.

The skills demand for Autonomous Robotics for space-enabled technologies – and specifically in-orbit applications – do not exist in a vacuum, and other adjacent sectors face a similar set of needs. The intersection between an advanced specialism in robotics, and the utilisation of AI and machine learning solutions mean that this skillset is highly transferable to other applications in defence, nuclear, maritime and other advanced manufacturing applications. This means that skills gaps are going to form in narrow, highly specialised fissures, where a high-value talent pool is undersupplied and the need for expertise acute.

## 3.3 What this means for Educators

The challenge in this emerging technology area is not just to produce more graduates, but to produce d**ifferently skilled graduates** who hold deep specialisations, system-level thinking, and practical experience. This requires a fundamental shift in curriculum design, delivery models, and industry collaboration. The skills gap is also not small, with the misalignment between the skills requirements averaging at 59%.

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 and curricula. Where possible then, our recommendations for change seek not to disrupt, but to build upon existing provision, with respect for the specialists already delivering training in these fields. Underlining this approach is the protection of systems of training or course delivery that is demonstrably working already to ease this skills gap and support those levers to be more effective.

Continued collaboration with stakeholders and the consolidation of skills reviews and data available from other Foresighting cycles will be crucial to ensure that the demands on the UK's educational system are fair and consistent, with clear messaging that engages at a top level. In order to enact change, a consortium of educators could be formed from amongst those who contributed to this report and beyond, to continue work with Satellite Applications 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).
This report also recommends as proactive and foresight driven approach, in anticipation of the skills needs across multiple high-tech sectors, and to plan which tactical, shorter-term

interventions can be enacted by educators 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 our horizon window, while already planning for the longer-term ambitions that will make the biggest waves if invested in early.

### 3.3.1 Summary of suggested next steps:

There are, across the breadth of this report, many possible avenues to addressing the challenge of skills provision for Autonomous Robotics. These ideas are thanks to the input and effort of many stakeholders that have engaged with the cycle, and the efforts of both the Satellite Applications Catapult and the Workforce Foresighting Hub to draw those conclusions together. Just as this report highlights the human capital at the heart of this emerging technology opportunity, it will be the human connections, forged across communities in a connected ecosystem across the UK, that will enact the changes required to create a healthy talent pipeline to enable the potential of businesses in this country.

Below is a suggested plan for some next steps, and this report would welcome its audience to engage with us to shape its implementation and continue to work with us on making real progress towards catalysing the growth of this sector.

### 3-Stage  Plan for Delivering a UK Autonomous Robotics Workforce

**Purpose:** This action plan sets out a suggested coordinated roadmap to develop the skilled workforce required to enable the UK's leadership in autonomous robotics for space and other hostile environments. It aligns stakeholders across government, industry, and education to address critical capability gaps, strengthen talent pipelines, and embed a continuous foresighting approach to respond to rapid technological change.

#### *Stage 1: Establish National Coordination and Governance (0–6 months)*

*Objectives*

- Create a unified national strategy for autonomous robotics workforce development for the space sector, supporting either the Space Skills Taskforce in this thematic area, or the Robotics Advisory Group within DSIT.
- Align policy, funding, and industrial priorities to address critical capability gaps and sovereignty risks across multiple sectors, so that the needs of the space sector interface with demand signals from other sectors using autonomous robotics systems.

*Key Actions*

1. Inform the existing networks for ISAM, facilitated by the ISAM committee organised by UKspace, about the outcomes of this report, and engage with other skills steering groups from non-space specific sectors, like the UK-RAS SERAS strategic taskforce for skills and education in robotics to create a cohesive skills activity map.
2. Define workforce priorities using the four priority capability themes (Software & Security; Simulation & Validation; Systems Integration; Regulatory & Safety) and nine Priority Future Occupational Profiles (FOPs).
3. Embed workforce planning into major programmes & address sovereign capability risks
4. Identify roles requiring UK-based or security-cleared talent
5. Encourage workforce resilience planning in funded programmes, in a similar manner to Social Value propositions, so that technology roadmaps are accompanied by the workforce needs required.

*Key Stakeholders*

DSIT (and within that UKSA), UKspace trade association, Innovate UK, Satellite Applications Catapult, Catapult network, EPSRC UK-RAS Network, Industry leaders, SPAN & SUN networks, Space Skills Advisory Panel (Space Skills Taskforce).

### *Stage 2: Strengthen Education Pathways and Target Capability Gaps (6–18 months)*

*Objectives*

- Address critical misalignment between current provision and future workforce needs.
- Scale and specialise education pathways to meet emerging demand.

*Key Actions*

1. Protect and expand critical Higher Education provision by ring-fence support for robotics, systems engineering, and space engineering courses.
2. Scale and modernise apprenticeships to expand the utilisation of Level 6–7 robotics and systems engineering apprenticeships in the space sector, by exploring ways to incentivise employer uptake. Adapt standards to include space/hostile-environment applications, to reduce the gap between the current training provision and the skills this report identifies we will need to succeed.
3. Design structured industrial placement programmes for this emerging technology area that co-ordinates opportunities to convert academic learning into applied capability, and targets priority roles (e.g. systems integration, simulation engineering)
4. Develop targeted CPD pathways for specialisation, focus short-course provision on:
    a. Space-specific autonomy and robotics
    b. Simulation, validation, and digital twinning
    c. AI safety, assurance, and regulation
    d. Radiation-tolerant systems and extreme environment engineering
5. Embed robotics capabilities into adjacent disciplines
    a. Integrate modules into: Data science, AI/ML, Cybersecurity, Mechanical and electrical engineering

*Key Stakeholders*

DfE & DSIT, Skills England, universities, FE providers, Cranfield university and other specialist institutions, industry training providers.

### *Stage 3: Build Talent Pipelines and Embed Hands-on Experience (1–3 years)*

*Objectives*

- Create a sustainable, scalable talent pipeline aligned with industry demand.
- Ensure continuous alignment between education, innovation, and industrial deployment.

*Key Actions*

1. Embed experiential learning across all pathways by integrating hands-on experience into university courses, offering industrial placements and support for more a more diverse workforce by maintaining multiple routes into the sector.
2. Create targeted pipelines for priority roles with a focus on scaling talent in:
3. Systems Integration Engineers
4. Simulation & Modelling Engineers
5. Autonomous Systems Engineers
6. AI Governance and Standards roles
7. Encourage Educator–Industry Compacts to increase knowledge exchange and drive practical applications into study through co-developed curricula, guest lectures from industry experts and real-world case studies that share access to tools, data and facilities.
8. Drive cross-sector talent strategies to align robotics workforce development across areas like Defence, Nuclear, Offshore and subsea industries, and mitigate talent competition through coordinated planning.
9. Strengthen outreach and talent attraction by promote robotics careers as high-impact and future-facing with highlights on real-world applications to address under-subscription in key fields like systems engineering.

*Key Stakeholders*

UKspace, ISAM committee, SPAN, SUN, other skills taskforces like the Nuclear Skills Taskforce and the UK-RAS Skills strategic task group.

## 3.4 Summary: Top Priorities for the Next 12 Months

What are the key actions:

- **Communicate findings widely across the robotics and space ecosystem**
  Engage industry, academia, and government through formal coordination forums and sector bodies.
- **Align workforce strategy with national space and robotics policy**
  Work with DSIT (including UKSA), and other stakeholders to embed skills into major programmes.
- **Accelerate development of targeted CPD provision**
  Deliver short, high-impact upskilling courses focused on autonomy, simulation, and systems integration.
- **Protect and scale critical university courses**
  Support specialist robotics and systems engineering provision through funding and policy intervention.
- **Expand and incentivise apprenticeship pathways**
  Particularly higher-level apprenticeships aligned to priority roles.
- **Develop structured industrial placements at scale**
  Create a coordinated pipeline for practical experience aligned to industry demand.
- **Promote robotics careers and address talent shortages in key disciplines**
  With special focus on systems engineering and simulation-focused roles, recognising that there is a need for such roles across space, and likely also in adjacent sectors.

The UK has a time-limited opportunity to lead in autonomous robotics and carve its place in both the orbital economy, and the multiple other areas of application for autonomous robotics, be that through space-enabled technologies or other industries in our economy. Success in this area depends on rapidly building a workforce that is equipped with the right skills at the right time, and is specialised, systems-focused and is comfortable with practical, hands-on problem-solving.

If addressed strategically, the skills gap can be transformed from a constraint into a competitive advantage for national growth, resilience, and global leadership.

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# Appendix

# Appendix

## 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.<br>Full URL: Data Capturehttps://hvmcatapultforesighting.retool.com/embedded/public/e869283b-4b8a-437c-973e-64ab292e5b87?token=2a668f2e63faf1dddcc400328f65e0d4 Overview |
| Supply Chain Capabilities | Provides an overview of the identified capabilities at a Supply Chain / Workflow Partner level.<br>By selecting/deselecting each Supply Chain / Workflow Partner you can review the capabilities identified as required in that area of the Supply Chain / Workflow.<br>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.<br>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.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/3573002a-ab48-4fad-9765-bee00876a42e?token=2a668f2e63faf1dddcc400328f65e0d4 |
| 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.<br>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.<br>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.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/81d272f0-ad80-421c-8926-86655913acdf?token=2a668f2e63faf1dddcc400328f65e0d4 |

| 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.<br>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.<br>The populated table allows you review and compare different FOPs within or across role families. You can view the capabilities in each FOP and the assigned proficiency levels.<br>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.<br>Full URK: https://hvmcatapultforesighting.retool.com/embedded/public/f99a913f-8827-4730-8893-d618d489bc84?token=2a668f2e63faf1dddcc400328f65e0d4 |
| Future KSBs Summary | Not yet completed in this cycle.<br>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.<br>This is used to:<br>• To review the identified Knowledge, Skill and Behaviour tags for a given capability, to support development of future education and learning material.<br>• To review the requirements from a capability level, rather than a role family/occupational profile grouping.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/8634650f-9700-4627-8431-068b4b764222?token=2a668f2e63faf1dddcc400328f65e0d4 |

| 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.<br>Clicking the "View FOPs" button alongside each capability will provide a list of the proficiencies (EPA) with the FOPs that fall into them.<br>The exported version of this data will include a full breakdown of the FOP IDs which contain the capability within a specific proficiency.<br>This is used to:<br>• understand the levels/volumes of common/crossover Capabilities, to support prioritisation of Capability Development<br>• identify which Occupational Profiles contain these common/crossover capabilities, and so which may be prioritised for development activity<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/ce67cca1-5beb-4557-8482-8a0b6e174933?token=2a668f2e63faf1dddcc400328f65e0d4 |
| Capabilities Matched to Current Provision | This page allows you to review and compare individual capabilities against 'Duty' statements in an Apprenticeship / Occupational Standard.<br>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.<br>You can filter in several ways to focus your review:<br>• By the Capability Classification Framework (left-hand panel).<br>• By capabilities that **are** served by the reference mapping framework – the default is Institute for Apprenticeships and Technical Education (Skills England Occupational Standards) provision.<br>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.<br>The data also allows you to identify where provision may already exist to support specific capabilities.<br>Full URL: hvmcatapultforesighting.retool.com/embedded/public/219ff6af-36ea-4b5e-bda1-b0b989c0e3f0?token=2a668f2e63faf1dddcc400328f65e0d4 |

| 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).<br>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.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/c699e504-3f64-45a0-b52e-ad44a95f9aa4?token=2a668f2e63faf1dddcc400328f65e0d4 |
| 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).<br>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.<br>It will help you focus in on which provision to focus your attention for analysis.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/1c4e204b-3927-4226-9f8e-2f62ce0643c5?token=2a668f2e63faf1dddcc400328f65e0d4 |
| 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.<br>Each capability also includes Knowledge, Skill and Behaviour Tags, to support with scaffolding future education provision.<br>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<br>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.<br>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<br>URL: https://hvmcatapultforesighting.retool.com/embedded/public/6a205e7e-8f33-4765-b39b-82f1f549217a?token=2a668f2e63faf1dddcc400328f65e0d4 |

| **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.<br>The information here allows you to prioritise effort or action over the short, medium or long-term.<br>This is displayed as a Matched/Not Matched Capability, comparing the Capability in a FOP to the Duties in a Standard.<br>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.<br>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.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/d9f485a2-6d23-45dd-ab48-4c4c87ced0c7?token=2a668f2e63faf1dddcc400328f65e0d4 |
| FOP Priorities | Provides a list of all the FOPs within the selected cycle with details of their fit and surplus factors.<br>The information here allows you to prioritise effort or action over the short, medium or long-term.<br>Full URL: https://hvmcatapultforesighting.retool.com/embedded/public/ad0f6dcb-9535-4239-96a7-c8d0e005477a?token=2a668f2e63faf1dddcc400328f65e0d4 |

*Table 17: Online Data visualisation Tool*

## B Functional Cycle Capabilities

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:**

1. RTOs Research & Innovation Organisations
2. Regulators, Standards Bodies & Government
3. Service Providers ISAM
4. Technology Providers (Hardware and software)

| Function | Capability statement | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| DESIGN | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | ✓ |  | ✓ | ✓ |
| DESIGN | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | ✓ |  | ✓ | ✓ |
| DESIGN | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | ✓ | ✓ | ✓ | ✓ |
| DESIGN | Create top level specifications & operational plans for robotics systems infrastructure which set out the requirements for verification & validation procedures |  |  | ✓ |  |
| DESIGN | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. |  |  | ✓ | ✓ |
| DESIGN | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | ✓ |  | ✓ | ✓ |
| DESIGN | Design thermal controls to maintain robotic system stability across expected space temperature changes and pointing conditions. | ✓ |  |  | ✓ |
| DESIGN | Design robotic structures that survive launch vibration and release shocks to ensure reliable deployment in orbit. | ✓ |  |  | ✓ |
| DESIGN | Design mechanical components that support reliable robotic performance during in-orbit servicing and assembly activities. | ✓ |  |  | ✓ |
| DESIGN | Manufacture precision components that meet material and tolerance requirements for robotic operations in space. | ✓ |  |  | ✓ |
| DESIGN | Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. |  |  | ✓ | ✓ |
| DESIGN | Develop algorithms for autonomous navigation in robotics using computer vision. | ✓ |  | ✓ | ✓ |
| DESIGN | Build, integrate and test functional robot systems to meet operational requirements. | ✓ |  | ✓ | ✓ |
| DESIGN | Design advanced displays, sensing, and computer vision systems for robotic platforms. | ✓ |  | ✓ |  |
| DESIGN | Create physics-based simulation environments to validate robotic manoeuvres under orbital dynamics and uncertain space conditions. | ✓ |  | ✓ | ✓ |
| DESIGN | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | ✓ | ✓ | ✓ |  |
| DESIGN | Create assurance frameworks for machine learning models in robotics to enhance transparency and reliability in critical decisions. |  | ✓ | ✓ |  |

| Function | Capability statement | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **DESIGN** | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints | ✓ | ✓ | ✓ | ✓ |
| **DESIGN** | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Develop motor control electronics that provide reliable actuation for robotic mechanisms in space. | ✓ |  |  | ✓ |
| **DESIGN** | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. |  | ✓ | ✓ | ✓ |
| **DESIGN** | Design and implement dynamic collision avoidance tools for satellite navigation systems using software models. |  |  |  | ✓ |
| **DESIGN** | Develop novel satellite navigation systems for close proximity operations |  |  |  | ✓ |
| **DESIGN** | Design and implement dynamic collision avoidance tools for robotics systems using software models. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Improve satellite perception accuracy during close-proximity inspection and manipulation tasks in orbit. |  |  |  | ✓ |
| **DESIGN** | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. | ✓ |  | ✓ | ✓ |
| **DESIGN** | Conduct structured verification & validation tests (including qualification) to demonstrate that robotic systems perform reliably across expected orbital and environmental conditions. | ✓ |  |  | ✓ |
| **DESIGN** | Enhance robotic and autonomous equipment functionality by iterative or simulated performance testing under various environmental and operational use cases | ✓ |  |  | ✓ |
| **DESIGN** | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning | ✓ |  | ✓ | ✓ |
| **DESIGN** | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | ✓ |  |  | ✓ |
| **DESIGN** | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. |  |  | ✓ | ✓ |
| **DESIGN** | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. | ✓ |  | ✓ | ✓ |

| Function | Capability statement | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **DESIGN** | Develop computer vision methods and satellite state estimates to support precise robotic manipulation tasks during orbital operations. | | | | ✓ |
| **DESIGN** | Develop control algorithms to support close proximity operations under the computational and propulsion system constraints | | | | ✓ |
| **DESIGN** | Coordinate hyper redundant systems including satellites and robots involving combined control and novel learning-based approaches | | | | ✓ |
| **DESIGN** | Develop computer vision algorithms and state estimation of the client satellite to support robotic manipulation tasks in orbit | | | | ✓ |
| **DESIGN** | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | ✓ | | ✓ | ✓ |
| **ENTERPRISE** | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | ✓ | ✓ | ✓ | ✓ |
| **ENTERPRISE** | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | ✓ | ✓ | ✓ | ✓ |
| **IMPLEMENT** | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | ✓ | | ✓ | ✓ |
| **IMPLEMENT** | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. | ✓ | | ✓ | ✓ |
| **IMPLEMENT** | Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations | ✓ | | ✓ | ✓ |
| **IMPLEMENT** | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | ✓ | | ✓ | ✓ |
| **IMPLEMENT** | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | ✓ | ✓ | ✓ | ✓ |
| **IMPLEMENT** | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | ✓ | | ✓ | |
| **IMPLEMENT** | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. | | ✓ | ✓ | |
| **IMPLEMENT** | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | ✓ | | ✓ | ✓ |
| **IMPLEMENT** | Track and manage records of robotics and autonomous systems fleet asset operations and maintenance. | | | ✓ | |
| **SUPPORT** | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | ✓ | | ✓ | ✓ |
| **SUPPORT** | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | ✓ | ✓ | ✓ | |
| **SUPPORT** | Assess autonomous space robotics mission hazards to meet safety, debris mitigation, security and planetary protection controls | ✓ | | | |
| **SUPPORT** | Operate and maintain ground support systems for autonomous robotics systems operations. | ✓ | | ✓ | ✓ |
| **SUPPORT** | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | ✓ | | ✓ | ✓ |

| Function | Capability statement | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **SUPPORT** | Troubleshoot robotic and autonomous support systems for optimal functionality. | ✓ |  | ✓ | ✓ |
| **SUPPORT** | Operate robotic systems remotely to conduct inspection, servicing and assembly tasks in orbit. |  |  | ✓ | ✓ |

## C List of full FOPs

***FOP title Autonomy & Perception Engineer***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: RTOs Research & Innovation Organisations

| ID | **Capability Statement** - Autonomy & Perception Engineer | RL1 Proficiency |
|---|---|---|
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 323233 | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | **Awareness** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Awareness** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Awareness** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Awareness** |
| 343765 | Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. | **Awareness** |
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 323233 | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | **Awareness** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Awareness** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Awareness** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Awareness** |
| 343765 | Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. | **Awareness** |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Practitioner** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Practitioner** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Practitioner** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Practitioner** |
| 323239 | Operate robotic systems remotely to conduct inspection, servicing and assembly tasks in orbit. | **Practitioner** |
| 323244 | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | **Practitioner** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Practitioner** |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | **Practitioner** |

| **ID** | **Capability Statement** - Autonomy & Perception Engineer | **RL1 Proficiency** |
|---|---|---|
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Practitioner** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Practitioner** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Practitioner** |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Expert** |
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | **Expert** |
| 323135 | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | **Expert** |
| 323219 | Enhance robotic and autonomous equipment functionality by iterative or simulated performance testing under various environmental and operational use cases | **Expert** |
| 323227 | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | **Expert** |
| 323229 | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. | **Expert** |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | **Expert** |
| 343766 | Develop computer vision methods and satellite state estimates to support precise robotic manipulation tasks during orbital operations. | **Expert** |
| 343769 | Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations | **Expert** |
| 343772 | Coordinate hyper redundant systems including satellites and robots involving combined control and novel learning-based approaches | **Expert** |
| 343773 | Develop computer vision algorithms and state estimation of the client satellite to support robotic manipulation tasks in orbit | **Expert** |

*Table 18: Autonomy & Perception Engineer  FOP*

***FOP title Autonomy & Perception Engineer***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: RTOs Research & Innovation Organisations

| ID | **Capability Statement** - Autonomy & Perception Engineer | RL1 Proficiency |
|---|---|---|
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 323233 | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | **Awareness** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Awareness** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Awareness** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Awareness** |
| 343765 | Identify systems specific to hardware needs to support AI-enhanced functionalities and to incorporate advanced sensor technologies. | **Awareness** |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Practitioner** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Practitioner** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Practitioner** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Practitioner** |
| 323239 | Operate robotic systems remotely to conduct inspection, servicing and assembly tasks in orbit. | **Practitioner** |
| 323244 | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | **Practitioner** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Practitioner** |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | **Practitioner** |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Expert** |
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | **Expert** |
| 323135 | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | **Expert** |
| 323219 | Enhance robotic and autonomous equipment functionality by iterative or simulated performance testing under various environmental and operational use cases | **Expert** |

| ID | **Capability Statement** - Autonomy & Perception Engineer | **RL1 Proficiency** |
|---|---|---|
| 323227 | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | **Expert** |
| 323229 | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. | **Expert** |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | **Expert** |
| 343766 | Develop computer vision methods and satellite state estimates to support precise robotic manipulation tasks during orbital operations. | **Expert** |
| 343769 | Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations | **Expert** |
| 343772 | Coordinate hyper redundant systems including satellites and robots involving combined control and novel learning-based approaches | **Expert** |
| 343773 | Develop computer vision algorithms and state estimation of the client satellite to support robotic manipulation tasks in orbit | **Expert** |

*Table 19: Autonomy & Perception Engineer FOP*

***FOP title Autonomous Systems Engineer***

**Role Level 1** Professional & Delivery

**Required for supply chain partners**: RTOs Research & Innovation Organisations

| ID | **Capability Statement** - Autonomous Systems Engineer | RL1 Proficiency |
|---|---|---|
| 323240 | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 209227 | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning | **Practitioner** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Practitioner** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Practitioner** |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | **Practitioner** |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | **Practitioner** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Practitioner** |
| 323222 | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. | **Expert** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Expert** |
| 323226 | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints | **Expert** |
| 323223 | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | **Expert** |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | **Expert** |
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Expert** |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | **Expert** |
| 323229 | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. | **Expert** |
| 323219 | Enhance robotic and autonomous equipment functionality by iterative or simulated performance testing under various environmental and operational use cases | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |
| 329304 | Assess autonomous space robotics mission hazards to meet safety, debris mitigation, security and planetary protection controls | **Expert** |

*Table 20: Autonomous Systems Engineer FOP*

*FOP title GNC Engineer*

**Role Level 1** Professional & Delivery

**Required for supply chain partners**: Technology Providers (Hardware and Software)

| ID | **Capability Statement** - GNC Engineer | **RL1 Proficiency** |
|---|---|---|
| 343767 | Design  and implement dynamic collision avoidance tools for satellite navigation systems using software models. | Awareness |
| 343771 | Develop control algorithms to support close proximity operations under the computational and propulsion system constraints | **Expert** |
| 343772 | Coordinate hyper redundant systems including satellites and robots involving combined control and novel learning-based approaches | **Expert** |
| 343773 | Develop computer vision algorithms and state estimation of the client satellite to support robotic manipulation tasks in orbit | **Expert** |
| 323223 | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | **Expert** |
| 323240 | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | **Expert** |
| 343770 | Develop  novel satellite navigation systems for close proximity operations | **Expert** |
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Expert** |
| 343768 | Improve satellite perception accuracy during close-proximity inspection and manipulation tasks in orbit. | **Expert** |
| 322867 | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. | **Expert** |
| 323135 | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | **Expert** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Expert** |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | Practitioner |
| 343769 | Maintain an understanding of both types of sensors and sensor-fusion techniques for close proximity operations | Practitioner |

*Table 21: GNC Engineer FOP*

***FOP title Mechanical & Hardware Development Engineer (Robotics)***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: Technology Providers (Hardware and Software)

| ID | **Capability Statement** - Mechanical & Hardware Development Engineer (Robotics) | RL1 Proficiency |
|---|---|---|
| 323220 | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. | **Awareness** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Awareness** |
| 323221 | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. | **Practitioner** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Practitioner** |
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | **Practitioner** |
| 322867 | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. | **Practitioner** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Practitioner** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Practitioner** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Awareness** |
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | **Expert** |
| 323232 | Design thermal controls to maintain robotic system stability across expected space temperature changes and pointing conditions. | **Expert** |
| 323235 | Design robotic structures that survive launch vibration and release shocks to ensure reliable deployment in orbit. | **Expert** |
| 323236 | Design mechanical components that support reliable robotic performance during in-orbit servicing and assembly activities. | **Expert** |
| 323237 | Manufacture precision components that meet material and tolerance requirements for robotic operations in space. | **Expert** |
| 302254 | Build, integrate and test functional robot systems to meet operational requirements. | **Expert** |
| 323233 | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | **Expert** |
| 323243 | Develop motor control electronics that provide reliable actuation for robotic mechanisms in space. | **Expert** |

*Table 22: Mechanical & Hardware Development Engineer (Robotics) FOP*

***FOP title Robotics Development Engineer***

**Role Level 1** Professional & Delivery

**Required for supply chain partners**: RTOs Research & Innovation Organisations

| ID | **Capability Statement** - Robotics Development Engineer | **RL1 Proficiency** |
|---|---|---|
| 323232 | Design thermal controls to maintain robotic system stability across expected space temperature changes and pointing conditions. | Awareness |
| 323235 | Design robotic structures that survive launch vibration and release shocks to ensure reliable deployment in orbit. | Awareness |
| 323243 | Develop motor control electronics that provide reliable actuation for robotic mechanisms in space. | Awareness |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | Awareness |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | Awareness |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | Practitioner |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | Practitioner |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | Practitioner |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | Practitioner |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | Practitioner |
| 329304 | Assess autonomous space robotics mission hazards to meet safety, debris mitigation, security and planetary protection controls | Practitioner |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | Practitioner |
| 323220 | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. | Expert |
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | Expert |
| 323236 | Design mechanical components that support reliable robotic performance during in-orbit servicing and assembly activities. | Expert |
| 302254 | Build, integrate and test functional robot systems to meet operational requirements. | Expert |
| 305464 | Design advanced displays, sensing, and computer vision systems for robotic platforms. | Expert |
| 323233 | Develop robotic end-effectors that safely manage contact forces during manipulation and servicing tasks in orbit. | Expert |
| 323105 | Create physics-based simulation environments to validate robotic manoeuvres under orbital dynamics and uncertain space conditions. | Expert |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | Expert |
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | Expert |
| 323221 | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. | Expert |

| **ID** | **Capability Statement** - Robotics Development Engineer | **RL1 Proficiency** |
|---|---|---|
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | Expert |
| 322867 | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. | Expert |
| 323135 | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | Expert |
| 323227 | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | Expert |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | Expert |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | Expert |

*Table 23: Robotics Development Engineer FOP*

***FOP title Robotics Testing Technician***

**Role Level 1** Professional & Delivery

**Required for supply chain partners**: Technology Providers (Hardware and Software)

| **ID** | **Capability Statement -** Robotics Testing Technician | **RL1 Proficiency** |
|---|---|---|
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | Awareness |
| 323228 | Operate and maintain ground support systems for autonomous robotics systems operations. | Awareness |
| 323222 | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. | Practitioner |
| 323227 | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | Practitioner |
| 210239 | Track and manage records of robotics and autonomous systems fleet asset operations and maintenance. | Practitioner |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | Practitioner |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | Practitioner |
| 323237 | Manufacture precision components that meet material and tolerance requirements for robotic operations in space. | Expert |
| 302254 | Build, integrate and test functional robot systems to meet operational requirements. | Expert |

*Table 24: Robotics Testing Technician FOP*

***FOP title Simulation & Modelling Engineer***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: Technology Providers (hardware and software), Service Providers ISAM

| **ID** | **Capability Statement** - Simulation & Modelling Engineer | **RL1 Proficiency** |
|---|---|---|
| 343766 | Develop computer vision methods and satellite state estimates to support precise robotic manipulation tasks during orbital operations. | **Awareness** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Practitioner** |
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | **Practitioner** |
| 323222 | Validate fault-tolerant autonomous robotic behaviours using digital-twins and hardware-in-the-loop simulation to address the sim-to-real gap and ensure safe operations in uncertain space conditions. | **Expert** |
| 209227 | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning | **Expert** |
| 323240 | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | **Expert** |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | **Expert** |
| 323105 | Create physics-based simulation environments to validate robotic manoeuvres under orbital dynamics and uncertain space conditions. | **Expert** |
| 323244 | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | **Expert** |
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Expert** |
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | **Expert** |
| 323219 | Enhance robotic and autonomous equipment functionality by iterative or simulated performance testing under various environmental and operational use cases | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Expert** |

*Table 25: Simulation & Modelling Engineer FOP*

***FOP title Space Manufacturing Engineer***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: RTOs Research & Innovation Organisations

| **ID** | **Capability Statement** – Space Manufacturing Engineer | **RL1 Proficiency** |
|---|---|---|
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | **Awareness** |
| 323225 | Conduct structured verification & validation tests (including qualification) to demonstrate that robotic systems perform reliably across expected orbital and environmental conditions. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 323224 | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | **Practitioner** |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | **Practitioner** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Practitioner** |
| 323237 | Manufacture precision components that meet material and tolerance requirements for robotic operations in space. | **Expert** |

*Table 26: Space Manufacturing Engineer FOP*

***FOP title Systems Integration Engineer***

**Role Level 1** Professional & Delivery
**Required for supply chain partners**: Service Providers ISAM

| ID | **Capability Statement** - Systems Integration Engineer | **RL1 Proficiency** |
|---|---|---|
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Practitioner** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Practitioner** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Practitioner** |
| 323224 | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | **Practitioner** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Practitioner** |
| 323228 | Operate and maintain ground support systems for autonomous robotics systems operations. | **Practitioner** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Practitioner** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Expert** |
| 323220 | Integrate radiation-tolerant computing platforms with autonomy stacks to maintain reliable robotic performance in space environments. | **Expert** |
| 323223 | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | **Expert** |
| 305464 | Design advanced displays, sensing, and computer vision systems for robotic platforms. | **Expert** |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |
| 323135 | Fuse multi-sensor data streams to improve robotic perception accuracy during close-proximity inspection and manipulation tasks in orbit. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |

*Table 27: Systems Integration Engineer FOP*

**_FOP title AI Governance Lead_**

**Role Level 2** Strategic & Operational Management

**Required for supply chain partners**: Regulators, Standards Bodies & Government

| **ID** | **Capability Statement** - AI Governance Lead | **RL2 Proficiency** |
|---|---|---|
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Awareness** |
| 323113 | Create assurance frameworks for machine learning models in robotics to enhance transparency and reliability in critical decisions. | **Expert** |
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Expert** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Expert** |

*Table 28: AI Governance Lead FOP*

***FOP title Autonomous Operations Lead***

**Role Level 2** Strategic & Operational Management

**Required for supply chain partners**: Service Providers ISAM

| **ID** | **Capability Statement -** Autonomous Operations Lead | **RL2 Proficiency** |
|---|---|---|
| 329303 | Create top level specifications & operational plans for robotics systems infrastructure which set out the requirements for verification & validation procedures | **Awareness** |
| 209227 | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning | **Awareness** |
| 305464 | Design advanced displays, sensing, and computer vision systems for robotic platforms. | **Awareness** |
| 323244 | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | **Awareness** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Awareness** |
| 323229 | Utilise latest AI training systems and modelling technologies before deployment into missions to improve robotic performance in-orbit. | **Awareness** |
| 323136 | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. | **Awareness** |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | **Awareness** |
| 323226 | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints | Expert |
| 323113 | Create assurance frameworks for machine learning models in robotics to enhance transparency and reliability in critical decisions. | Expert |
| 195491 | Develop algorithms for autonomous navigation in robotics using computer vision. | Expert |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | Expert |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | Expert |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | Expert |

*Table 29: Autonomous Operations Lead FOP*

## *FOP title Intellectual Property Analyst*

**Role Level 2** Strategic & Operational Management
**Required for supply chain partners**: Regulators, Standards Bodies & Government

| ID | **Capability Statement** - Intellectual Property Analyst | RL2 Proficiency |
|---|---|---|
| 323244 | Develop software libraries that meet regulatory expectations and reduce verification effort for autonomous robotic applications. | **Awareness** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Awareness** |
| 323245 | Contribute  in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Practitioner** |

*Table 30: Intellectual Property Analyst FOP*

## *FOP title Mission Design Architect*

**Role Level 2** Strategic & Operational Management
**Required for supply chain partners**: Service Providers ISAM

| ID | **Capability Statement** - Mission Design Architect | RL2 Proficiency |
|---|---|---|
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | **Expert** |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Expert** |
| 323221 | Ensure that all materials are radiation hardened to provide reliable robotic performance in space environments. | **Expert** |
| 323227 | Deploy novel sensor technologies or adapt existing ones to the space environment to enhance the versatility of robotic and autonomous systems. | **Expert** |
| 323247 | Write  system requirements that reflect mission objectives, operational needs and robotic performance expectations. | **Expert** |

*Table 31: Mission Design Architect FOP*

*FOP title Mission Operations Engineer*

**Role Level 2** Strategic & Operational Management
**Required for supply chain partners**: Service Providers ISAM

| ID | **Capability Statement** - Mission Operations Engineer | RL2 Proficiency |
|---|---|---|
| 329303 | Create top level specifications & operational plans for robotics systems infrastructure which set out the requirements for verification & validation procedures | **Expert** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Expert** |
| 210239 | Track and manage records of robotics and autonomous systems fleet asset operations and maintenance. | **Expert** |
| 323228 | Operate and maintain ground support systems for autonomous robotics systems operations. | **Expert** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |
| 323239 | Operate robotic systems remotely to conduct inspection, servicing and assembly tasks in orbit. | **Expert** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Expert** |

*Table 32: Service Providers ISAM FOP*

***FOP title Product Assurance Manager***

**Role Level 2** Strategic & Operational Management

**Required for supply chain partners**: Technology Providers (Hardware and software), Service Providers ISAM

| ID | **Capability Statement** - Product Assurance Manager | RL2 Proficiency |
|---|---|---|
| 209227 | Implementing real-time anomaly detection and response systems for cyber security of autonomous robotic systems using artificial intelligence and machine learning | **Awareness** |
| 302254 | Build, integrate and test functional robot systems to meet operational requirements. | **Expert** |
| 323226 | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints | **Expert** |
| 323109 | Develop predictive fault-detection and recovery systems for robotic platforms to minimise downtime during proximity operations. | **Expert** |
| 323225 | Conduct structured verification & validation tests (including qualification) to demonstrate that robotic systems perform reliably across expected orbital and environmental conditions. | **Expert** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Expert** |
| 322867 | Validate autonomous navigation and control software on space-rated hardware to ensure safe, reliable robot motion under limited computing and communication. | **Expert** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Expert** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Expert** |
| 322868 | Validate learned guidance and control software against safety limits using simulation and hardware testing before deploying autonomous robots on satellites. | **Expert** |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | **Expert** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Expert** |

*Table 33: Product Assurance Manager FOP*

***FOP title Robotics Systems Architect***

**Role Level 2** Strategic & Operational Management
**Required for supply chain partners**: Technology Providers (Hardware and software)

| **ID** | **Capability Statement -** Robotics Systems Architect | **RL2 Proficiency** |
|---|---|---|
| 323224 | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | **Awareness** |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | **Practitioner** |
| 323228 | Operate and maintain ground support systems for autonomous robotics systems operations. | **Practitioner** |
| 210250 | Troubleshoot robotic and autonomous support systems for optimal functionality. | **Practitioner** |
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Expert** |
| 323223 | Configure communication architecture to provide stable command pathways and telemetry for autonomous robotic systems in orbit. | **Expert** |
| 323238 | Develop autonomy algorithms that operate effectively on memory-limited processors used in space robotic systems. | **Expert** |
| 323234 | Integrate robotic system behaviours with mission operations plans to ensure consistent tasks and safe execution. | **Expert** |
| 323246 | Integrate autonomous robotic tasks into mission concepts to ensure consistent planning and operational alignment. | **Expert** |
| 213484 | Develop advanced control algorithms for real-time coordination of robotic support systems, potentially incorporating machine learning. | **Expert** |

*Table 34: Robotics Systems Architect FOP*

***FOP title Technical Architect***

**Role Level 2** Strategic & Operational Management
**Required for supply chain partners**: Service Providers ISAM

| **ID** | **Capability Statement** - Technical Architect | **RL2 Proficiency** |
|---|---|---|
| 323113 | Create assurance frameworks for machine learning models in robotics to enhance transparency and reliability in critical decisions. | Practitioner |
| 323240 | Design communication links that maintain stable commands and telemetry for autonomous robots operating in orbit. | Practitioner |
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | Practitioner |
| 323224 | Develop modular & adaptable assembly sequences for large orbital structures to support safe robotic construction and dynamically stable configuration under variable orbital conditions. | Expert |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | Expert |
| 323136 | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. | Expert |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | Expert |

*Table 35: Technical Architect FOP*

***FOP title Legal & Compliance Regulatory Affairs Officer***

**Role Level 3** Enterprise Leadership

**Required for supply chain partners**: Regulators, Standards Bodies & Government

| ID | **Capability Statement** - Legal & Compliance Regulatory Affairs Officer | RL3 Proficiency |
|---|---|---|
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Awareness** |
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Awareness** |
| 323136 | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. | **Expert** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Expert** |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | **Expert** |
| 323226 | Apply formal methods to confirm that autonomy software complies with defined safety rules and mission performance constraints | **Expert** |

*Table 36: Legal & Compliance Regulatory Affairs Officer FOP*

***FOP title Robotics Development Lead***

**R1ole Level 3** Enterprise Leadership

**Required for supply chain partners**: RTOs Research & Innovation Organisations

| **ID** | **Capability Statement** - Robotics Development Lead | **RL3 Proficiency** |
|---|---|---|
| 323102 | Design multi-agent coordination frameworks to allow collaborative robotic behaviours during complex assembly and repair operations in space | **Awareness** |
| 323236 | Design mechanical components that support reliable robotic performance during in-orbit servicing and assembly activities. | **Awareness** |
| 302254 | Build, integrate and test functional robot systems to meet operational requirements. | **Awareness** |
| 305464 | Design advanced displays, sensing, and computer vision systems for robotic platforms. | **Awareness** |
| 323105 | Create physics-based simulation environments to validate robotic manoeuvres under orbital dynamics and uncertain space conditions. | **Awareness** |
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Awareness** |
| 323242 | Configure computing systems to operate reliably in radiation-exposed environments while meeting autonomy performance needs. | **Awareness** |
| 201345 | Design and implement dynamic collision avoidance tools for robotics systems using software models. | **Awareness** |
| 323230 | Design & oversee functional and operational tests on autonomous robotics systems to validate functionality. | **Awareness** |
| 323218 | Assess specific hazards in autonomous space robotics missions to provide precise recommendations for licensing and operational policies. | **Awareness** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | Practitioner |
| 210179 | Research the feasibility, design, operation, or performance of robotic mechanisms, components, or systems for space applications. | Expert |
| 213454 | Select appropriate technology for autonomous or collaborative robotic systems to enhance operational efficiency. | Expert |
| 323247 | Write system requirements that reflect mission objectives, operational needs and robotic performance expectations. | Expert |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | Expert |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | Expert |

*Table 37: Robotics Development Lead FOP*

### *FOP title Robotics Standards & Governance Specialist*

**Role Level 3** Enterprise Leadership
**Required for supply chain partners**: Regulators, Standards Bodies & Government

| ID | **Capability Statement** - Mi Robotics Standards & Governance Specialist | RL3 Proficiency |
|---|---|---|
| 323104 | Implement formal verification methods for AI-driven autonomy to ensure compliance with safety-critical mission requirements and regulatory standards. | **Practitioner** |
| 323241 | Adopt recognised standards and regulations to align robotic system development with space safety and servicing expectations. | **Expert** |
| 323111 | Define interoperability standards for robotic interfaces and autonomy protocols to support multi-vendor collaboration in space infrastructure assembly. | **Expert** |
| 323245 | Contribute in developing common standards that improve safety and compatibility for autonomous robotics in space. | **Expert** |

*Table 38: Robotics Standards & Governance Specialist FOP*

### *FOP title Space Policy Lead*

**Role Level 3** Enterprise Leadership
**Required for supply chain partners**: Regulators, Standards Bodies & Government

| ID | **Capability Statement** - Space Policy Lead | RL3 Proficiency |
|---|---|---|
| 323136 | Interpret policy frameworks to guide compliance planning for autonomous space missions and support secure licensing submissions. | **Expert** |
| 323231 | Assess autonomous space robotics mission hazards to set safety, debris mitigation, security and planetary protection controls | **Expert** |

*Table 39: Space Policy Lead 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.

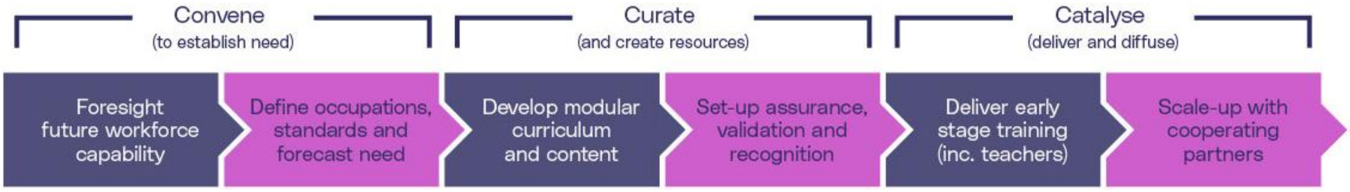
Whilst we are well placed to take advantage in the UK, the Government and industry have identified that we need a workforce able to adapt to new capabilities that require different and often higher skill sets. The ‘Manufacturing the Future Workforce’ report, published in 2020, states: “Failure to address 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.



*The Skills Value Chain*

### *Workforce foresighting*

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

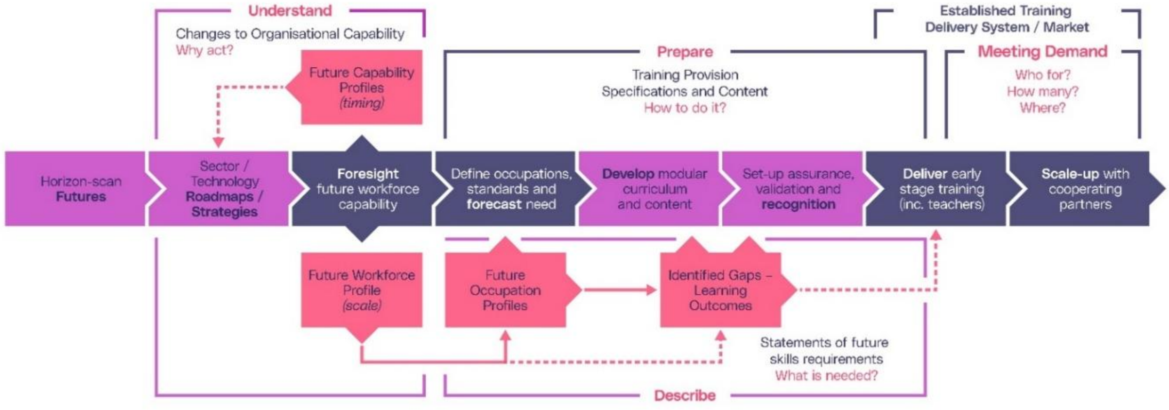


*Figure 6: Workforce Foresighting & Skills Value Chain*

***Approach** used - principles and implementation*

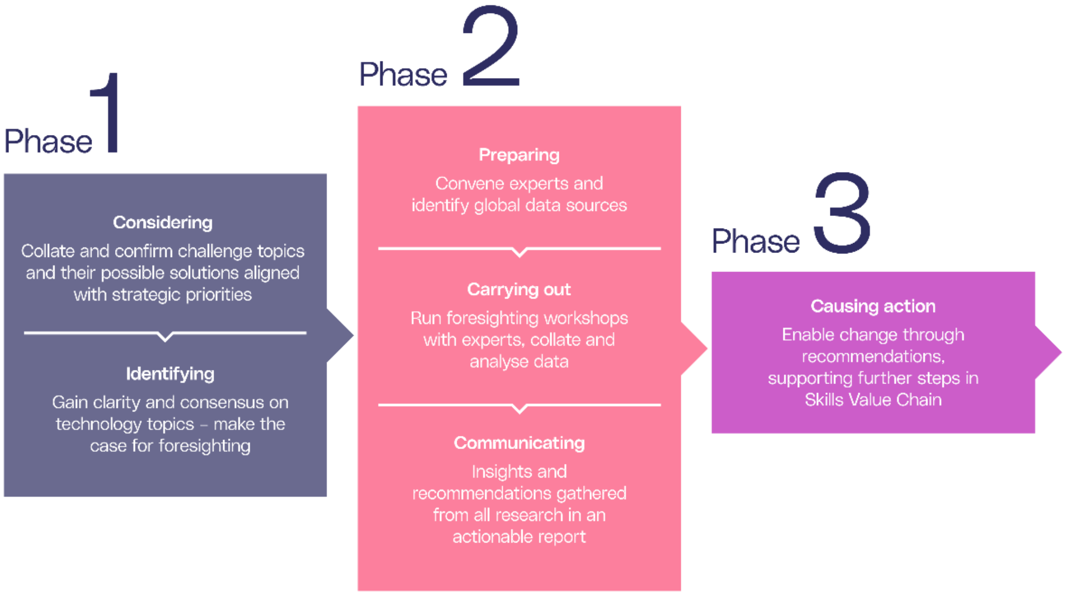
The core of workforce Foresighting is convening three groups of relevant specialists to conduct structured, Delphi-style, facilitated workshops to capture and discuss the set of organisational capabilities that will be required to respond to and exploit technology innovation.

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



*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 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.