



ARTIFICIAL INTELLIGENCE ROADMAP FOR SPACE

Strategic Priorities for the UK Sector 2026 - 2036



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Foreword

Artificial Intelligence (AI) is rapidly becoming a defining capability for the future of space. From resilient satellite communications and Earth observation analytics to autonomous spacecraft operations, in-orbit servicing, and deep-space exploration, AI is reshaping how space systems are designed, operated, and scaled. For the United Kingdom (UK), this presents both a significant opportunity and a strategic imperative.

This Artificial Intelligence Roadmap for Space sets out a ten-year vision for how the UK can harness AI to strengthen its position in the global space economy. It recognises that the UK is unlikely to compete on scale alone in hyperscale computing or constellation ownership. Instead, our competitive advantage lies in trusted, certifiable, and resource-efficient AI systems that can deliver high-value services across both upstream and downstream space markets.

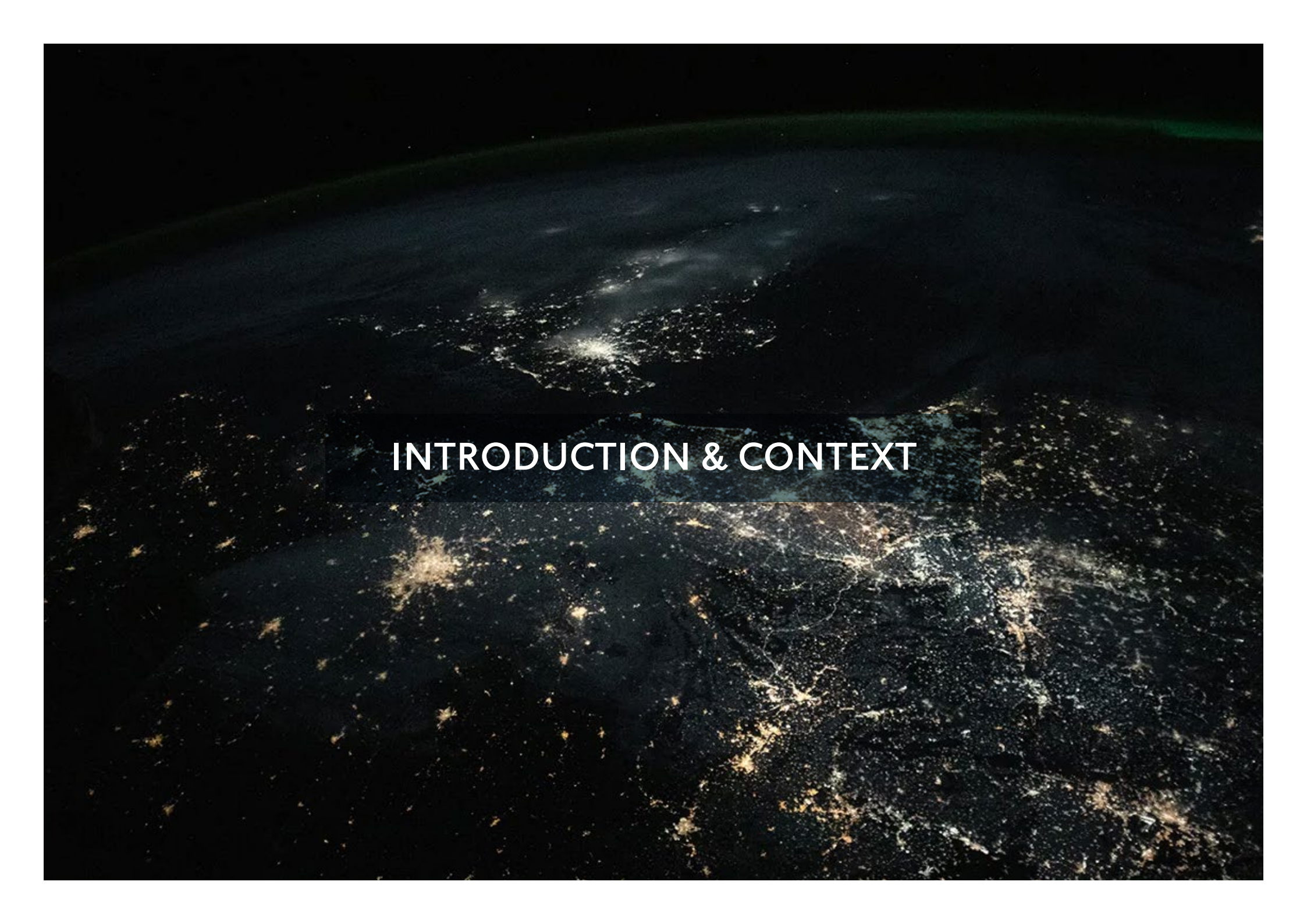
Developed through consultation with more than 100 stakeholders across industry, academia, government, and the wider innovation ecosystem, this roadmap reflects a broad and evidence-based view of the UK space sector. It identifies the technologies, capabilities, and investments needed to translate the UK's strengths in AI, data science, and systems engineering into global leadership in AI-enabled space services.

The report highlights eight priority AI technologies, seven strategic investment themes, and a set of actionable recommendations to accelerate adoption, strengthen resilience, and unlock economic growth. It also emphasises the importance of governance, assurance, skills, infrastructure, and collaboration in ensuring that innovation translates into operational capability.

The choices made over the next decade will determine whether the UK remains a contributor to global programmes or becomes a leader in shaping the future of intelligent space systems. This roadmap provides a clear pathway to achieve our national ambition.



Dame Dr Margaret Aderin
(Chancellor, University of Leicester)



INTRODUCTION & CONTEXT

Executive Summary

The Artificial Intelligence Roadmap for Space (AIRS) sets out a ten-year strategic framework to guide the development and adoption of artificial intelligence across the UK space sector. Commissioned by the UK Space Agency, the roadmap identifies priority AI technologies, mission-aligned use cases, ecosystem enablers, and investment pathways required to drive UK leadership in AI-enabled space systems by 2036.

AI is beginning to evolve as a foundational technology across both downstream and upstream domains. In downstream services – including Earth Observation (EO), Satellite Communications (SatCom), Positioning, Navigation & Timing (PNT), and Space Domain Awareness (SDA) – AI enables scalable analytics, integrity monitoring, anomaly detection, and dynamic network optimisation. These capabilities shift value creation from asset ownership to decision-intelligence, strengthening sovereign control and exportable digital services.

Upstream, AI can enhance autonomous satellite operations, predictive maintenance, digital twins, in-orbit servicing, assembly and manufacturing (ISAM), and advanced space exploration missions. In launch and spaceport operations, AI-driven trajectory optimisation, range safety analytics, and predictive maintenance are likely to improve reliability and reduce turnaround time – critical to improving the economics and competitiveness of UK launch capabilities. In exploration contexts, AI supports long-duration autonomy, crew assistance, robotics, and resilient operations in communication-constrained environments.

The AIRS roadmap introduces eight shortlisted AI technologies and functionalities – derived from a broader framework of 12 AI functionalities – to ensure comprehensive coverage of emerging AI capabilities, including hybrid physics-informed AI, agentic systems, simulation and testing, and resource-efficient edge AI. These AI technologies and functionalities have been shortlisted based on a mapping against Space applications spanning upstream, downstream and midstream use cases as well as cross-cutting themes.

The shortlisted AI technologies and functionalities are the following:

- AI 1. Computer vision/image analytics (especially image segmentation and classification and object detection)**
- AI 2. AI for simulation and testing (especially simulation-to-real and digital twins)**
- AI 3. AI for analytics, forecasting and discovery (including anomaly detection, causal inference and predictive analytics)**
- AI 4. Machine Learning (including one-shot or few-shot ML)**
- AI 5. AI for planning, optimisation and scheduling**
- AI 6. Agentic/autonomous AI for behaviour and control**
- AI 7. Human-AI interaction**
- AI 8. Edge computing**

The roadmap also emphasises meta-level enablers – governance, validation and certification, national data infrastructure, skills development, and cross-sector ecosystem coordination – as critical to scaling adoption.

The UK's competitive advantage lies not in hyperscale compute, but in trusted, certifiable, resource-efficient AI integrated into safety-critical systems. Strategic differentiation should focus on AI assurance leadership, frugal and edge AI, downstream EO analytics, ISAM autonomy, and sovereign decision layers for SDA and PNT.

The report identifies seven strategic investment themes to direct the proposed investment roadmap over the timeline. These investment themes are:

- 1. Space Domain Awareness and Orbital Security**
- 2. Resilient Positioning, Navigation and Timing**
- 3. Secure and Intelligent Satellite Communications Infrastructure**
- 4. Earth Observation and Intelligent Climate Services**
- 5. Space Infrastructure and Autonomous Operations**
- 6. Secure Space Access and Launch Support Services**
- 7. Cross-Cutting: National Space Data and AI Infrastructure**

The main outcome of this study is eight key recommendations presented, which stem from a mapping between the eight shortlisted AI technologies and functionalities and the seven major investment themes for the UK. These key recommendations are:

- R1. Establish a high-assurance AI-enabled national space surveillance, satellite tracking and awareness capability.**
- R2. Employ AI to improve sovereign position, navigation and timing resilience.**
- R3. Embed AI across satellite communications, supporting security, control and quality.**
- R4. Build and support a national AI-for-earth observation ecosystem for decision support across commercial and government applications.**
- R5. Accelerate AI-enabled autonomy and hybrid Physics-AI systems.**
- R6. Integrate AI into launch economics and spaceport operations.**
- R7. Develop a trusted national space data and AI infrastructure layer.**
- R8. Create a specialised national AI central hub to coordinate AI-led activities.**

The AIRS roadmap's top recommendations centre on coordinated ecosystem development and capability-led investment. The immediate priorities include establishing the UK as a global leader in AI assurance, validation and certification for safety-critical space systems; embedding AI requirements into UK Space Agency funding and procurement frameworks; accelerating downstream EO analytics and decision-intelligence platforms through partnership; strengthening sovereign capabilities in space domain awareness and PNT resilience through AI-enabled integrity and data fusion; and integrating AI across autonomous operations, ISAM, and UK launch services to improve reliability and cost competitiveness.

Cross-cutting investment in resource-efficient and edge AI, federated data infrastructure, and national testbeds will underpin adoption at scale. Together, these measures position the UK to differentiate through trusted, certifiable, and mission-aligned AI while driving sustainable sector growth to 2035 and beyond.

Finally, the evidence highlights a strategic reality: the UK may not out-scale global AI or constellation leaders, but it can out-integrate and out-govern them. UK Space Agency can act strategically to ensure the UK space sector is well-equipped to meet challenges and lead the wider AI community toward meaningful solutions and economic growth.

By 2036, success will be measured not only by AI-enabled missions deployed but also by the UK's ability to embed AI across national and international space services, strengthen launch and exploration capability, scale commercial platforms, and shape international standards for responsible AI in space.



Picture courtesy of ESA

Purpose of the Roadmap

The ten-year Artificial Intelligence Roadmap for Space (AIRS) sets out how the United Kingdom can maximise the impact of AI across future space missions and services.

Developed for the UK Space Agency and the Department for Science, Innovation and Technology by Space Professionals Partnership Ltd, the roadmap identifies the AI technologies and capabilities most likely to shape the next generation of space systems. These include applications across EO, Satcom, PNT and SDA/SST, as well as satellite operations, launch services, in-orbit infrastructure and services, cross-sector applications, and scientific exploration of the Moon, Mars and beyond.

The roadmap also looks beyond 2036, when many AI technologies are expected to mature from research prototypes to operational capabilities in space missions. It highlights where AI and space technologies intersect most strongly and where targeted investment can unlock scientific, economic and national-security benefits for the UK space sector.

The analysis identifies technologies that can enhance national resilience, strengthen the UK's competitive position, and support the development of new commercial services. It also highlights how the UK's existing research and industrial strengths can be leveraged, while strengthening the national AI supply chain and ecosystem by fostering a resilient commercial and industrial base, developing a skilled workforce, and recognising critical capabilities as strategic assets. In addition, it identifies where targeted support will be

required to scale promising technologies toward flight readiness. More broadly, the AIRS roadmap provides evidence-based guidance for policymakers, industry, and academia to align investment, skills development, and collaborative research. By embedding AI more systematically into future mission architectures, it aims to move beyond isolated demonstrations and enable sustained growth, innovation, and international leadership for the UK space sector.

Setting the UK Context

The UK space sector is uniquely positioned to lead the ambition set out in the National Artificial Intelligence Strategy and sustain the UK's status as a science and AI superpower. The UK's AI sector in 2026 blends a longstanding research pedigree, a dynamic start-up community, and a growing role in legislative leadership. The UK currently ranks 4th in The Observer's Global AI Index, reflecting strengths in research and talent. This UK has attracted significant recent investment announcements from Microsoft, Nvidia, Google, and OpenAI. Collectively, the AI sector comprises more than 5,800 companies, employs over 86,000 people, and contributes £11.8bn Gross Value Added to the economy¹. The UK also ranks third globally in AI publications per capita, highlighting its research strength.

It is well recognised that a broad range of space missions would benefit from AI investment, spanning upstream and downstream activities and encompassing both national and European programmes. While public attention has focused on generative AI

¹ <https://www.gov.uk/government/publications/artificial-intelligence-sector-study-2024/artificial-intelligence-sector-study-2024>

and large language models, space missions will rely on a broader set of AI capabilities. With the UK ecosystem combining world-class universities, a dynamic start-up community, and strong capabilities in data science, signal processing, and advanced software engineering, the UK has a strong foundation for international competitiveness.

AI is already being demonstrated in orbit within Europe. ESA's PhiSat-1 CubeSat used an onboard AI chip to filter cloud-covered images, reducing bandwidth and energy use, while PhiSat-2 expands this by hosting AI "apps" in space. ESA's OPS-SAT programme has served as a testbed for machine learning experiments, and ESA's Discovery Programme has explored autonomous "Smarter Satellites." Yet most efforts remain small-scale and experimental, highlighting the need to scale AI into operational missions.

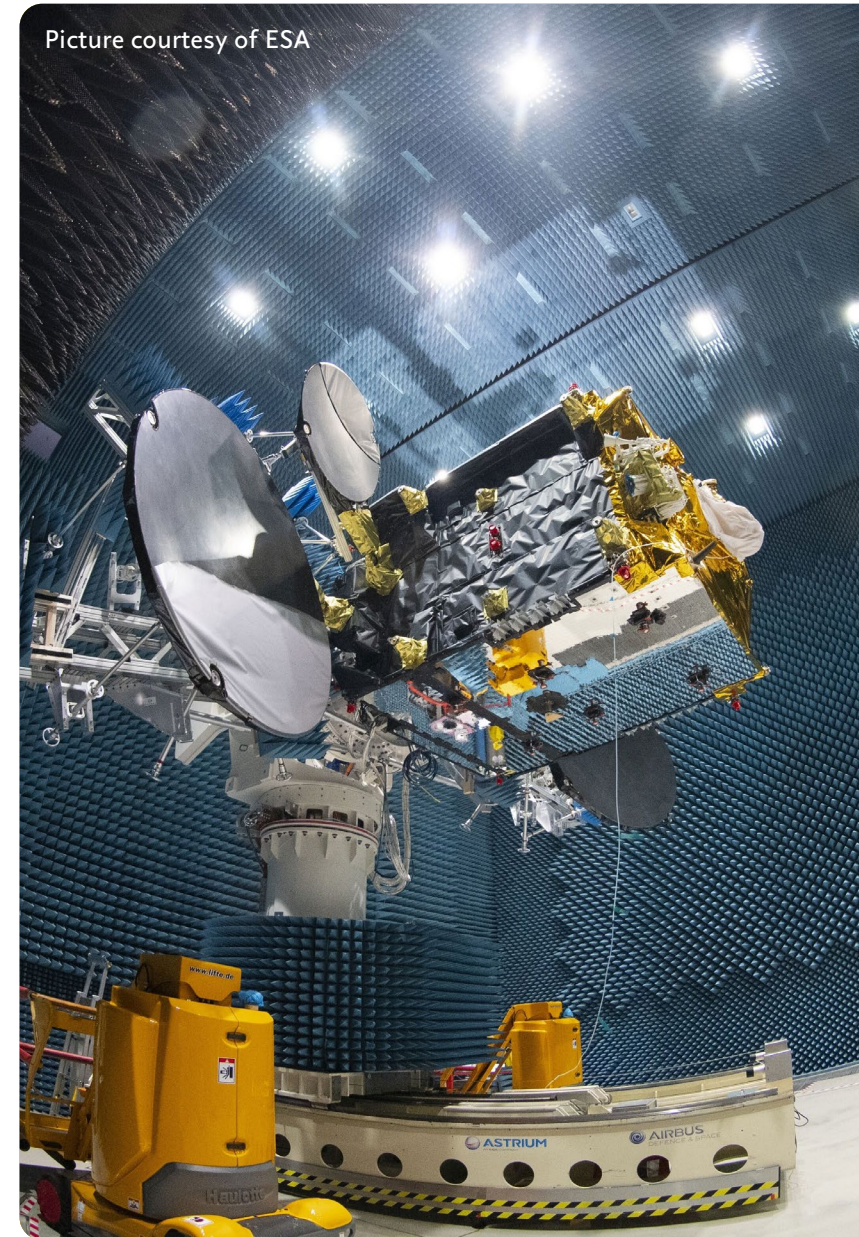
Although the UK is ranked among the world's AI leaders, it lags in investment in hyperscale infrastructure. It also lacks control over critical space assets in PNT, SatCom, and space access. The UK's competitive edge must therefore come from playing to our strengths:

- developing solutions that generate measurable societal and economic value
- attracting global partnerships and revenue
- being nimble and resourceful with the capital available.

To secure a leading global position in AI-enabled Space innovation, the UK must commit to two strategic priorities:

- an AI-powered collaboration between government, industry, and academia
- targeted investment in both platforms and skills that will allow UK space companies to scale.

Picture courtesy of ESA



Methodology used to create the roadmap

The roadmapping methodology used here is underpinned by a comprehensive review of state-of-the-art, domain-agnostic AI technologies and functionalities. The resulting longlist was systematically mapped against longlists of downstream and upstream space use cases. Stakeholder input played a pivotal role in refining the prioritisation, shaping the scope, and informing the resulting roadmap and recommendations.

The roadmap presented is evidence-based and co-developed through consultation with more than 100 stakeholders across the UK space ecosystem, including primes, SMEs, start-ups, scale-ups, consultancies, funding bodies, academia, and RTOs. Stakeholder engagement was facilitated by multiple channels: (i) On-line survey, (ii) On-line Workshop, (iii) One-on-one stakeholder interviews, (iv) In-Person Downstream Workshop and (v) In-Person Upstream Workshop.

This involved identifying priority AI technologies, functionalities and strategic capabilities that directly support UK mission needs. In parallel, the building blocks of a resilient AI-for-space ecosystem were identified to accelerate innovation and growth. This draws on established best practice in strategic roadmap development, tailored for AI technologies and space domains. Taken together, this approach demonstrates both a deep understanding of AI technologies and a clear view of how they intersect with UK and ESA mission priorities.

The roadmap was developed through a structured, three-phase process encompassing:

- data capture and assessment framework development
- filtering, analysis and prioritisation
- multi-stage roadmap validation with industry and senior stakeholders.

The roadmap was developed through a capability-led methodology, beginning with identifying UK mission requirements and then mapping the AI technologies, functionalities, enablers, and infrastructure most relevant to those requirements. This analysis is structured as a set of “swim lanes” spanning capabilities in hardware platforms, data, algorithms, collaboration frameworks, and international positioning, each assessed against UK economic goals, skills needs, and dual-use opportunities.

Cross-cutting themes such as governance, procurement, and adoption ensure the roadmap is both practical and aspirational. This approach is designed to ensure traceable, evidence-based decision-making, provide multiple structured opportunities for stakeholder input, ensure that commercial and strategic space-sector drivers guide goals, and align the roadmap with growth.

To identify the areas most likely to impact the UK space sector and to minimise the risk of missing critical AI developments not already considered by the sector, a new AI framework was required. For this roadmap project, a new taxonomy or long-list of AI functionalities has been developed to provide the necessary framework and to cross-reference against upstream and downstream space needs and across the value chain.

A satellite image of the North Atlantic Ocean, showing the eastern coast of North America on the left and the western coast of Europe on the right. The ocean is a deep blue, with white clouds scattered across the surface. A semi-transparent dark blue horizontal band is centered across the image, containing the text "AN OPPORTUNITY FOR THE UK" in white, bold, sans-serif capital letters.

AN OPPORTUNITY FOR THE UK

Why AI-for-Space and Why Now

AI is a broad domain covering a range of functionalities, technologies and applications. Global investment in AI is at an unprecedented level, particularly in generative AI technologies, including large language models and other forms of general-purpose foundation models, and the compute infrastructure needed to power them. Despite the current focus, generative AI does not constitute the totality of AI.

AI is rapidly becoming a foundational technology for the space sector, enabling new capabilities across both upstream and downstream missions. Advances in machine learning, data analytics, autonomous systems, and edge computing now make it possible to process large volumes of space-derived data, automate spacecraft operations, and optimise mission performance in ways that were previously impractical. These capabilities are particularly relevant as the space environment becomes more complex, data-rich, and operationally demanding.

Several factors make this an especially important moment to accelerate AI adoption in space. First, the volume of space data is growing exponentially due to expanding constellations of satellites, new sensors, and continuous earth observation. AI provides the tools needed to extract actionable insights from these data streams in near real time. Second, space missions increasingly require greater autonomy. Communication delays, bandwidth constraints, and the need for rapid decision-making mean that satellites and other space systems must be able to sense, analyse, and act independently.

Recent demonstrations show that AI can already operate successfully in space environments. ESA Missions (PhiSat, OPS-SAT) have demonstrated onboard machine learning for image filtering, anomaly detection, and operational experimentation. However, these efforts remain largely experimental and have not yet been scaled into mainstream operational missions.

At the same time, global investment in AI is accelerating across multiple sectors. This presents both an opportunity and a strategic imperative for the space sector to integrate AI more systematically into mission architectures. By embedding AI capabilities into spacecraft, ground systems, and data services, space agencies and industry can enhance mission efficiency, reduce operational costs, and unlock new commercial and scientific applications.

In this context, the AIRS roadmap highlights the AI technologies and functionalities, investments, and ecosystem developments required to transition AI in space from isolated demonstrations to a core enabling capability for future missions and services.



The Space Sector Market Needs

The global space sector is undergoing rapid transformation, driven by increasing satellite deployments, growing demand for data-driven services, and the emergence of new space infrastructure, including mega-constellations, in-orbit services, and commercial exploration missions. These developments are generating significant market demand for technologies that can enhance efficiency, manage operational complexity, and extract greater value from space assets.

Across downstream applications, market demand is centred on the ability to process and interpret vast datasets generated by earth observation, communications networks, and navigation systems. AI-enabled analytics can transform raw satellite data into actionable insights for sectors such as climate monitoring, agriculture, insurance, defence, logistics, and financial services. As the volume and diversity of space-derived data increase, automated analytics, anomaly detection, and predictive modelling become essential for delivering scalable, commercially viable services.

Upstream applications present a different but equally significant set of needs. Satellite constellations, launch systems, and emerging in-orbit infrastructure require greater autonomy and operational efficiency to remain economically viable. AI can support predictive maintenance, optimise constellation operations, enable autonomous rendezvous and servicing missions, and improve launch planning and turnaround efficiency. These capabilities are

particularly relevant for future activities such as In-Orbit Servicing, Assembly and Manufacturing (ISAM) and long-duration exploration missions.

In addition to technical capability, the market also requires trusted and certifiable AI systems. Space missions operate in safety-critical environments where reliability, explainability, and validation are vital. Developing AI systems that meet these requirements represents both a challenge and a commercial opportunity.

The UK AI sector is well-placed to meet the Space sector's needs. In 2024, it comprised 5862 companies, between them generating £23.9bn in revenue, £11.8bn in GVA and attracting £4.7bn in VC funding². However, most of these are not looking at Space currently – investment is primarily going into life sciences and biotech, automotive and transportation, financial services, and healthcare and wellness. There is an opportunity to attract attention and innovation from the UK AI Sector to the UK Space Sector.

The AIRS roadmap, therefore, emphasises the importance of aligning AI technology development with clear mission and market needs. By focusing on applications that deliver measurable operational and economic benefits, the UK space sector can accelerate adoption and support sustainable growth across upstream and downstream markets.

²Artificial Intelligent Sector Study 2024. Department for Science, Innovation and Technology. Sept 2025.

<https://www.gov.uk/government/publications/artificial-intelligence-sector-study-2024/artificial-intelligence-sector-study-2024>



UK Advantage & International Context

The UK enters the AI-for-space landscape with several significant advantages. It has a strong global position in AI, ranking among the top countries in international indices for AI research, talent, and innovation. Its ecosystem combines world-class universities, a dynamic start-up community, and strong capabilities in data science, signal processing, and advanced software engineering. These strengths provide a strong foundation for applying AI technologies to space systems and services.

The UK benefits from a strong regulatory and governance environment. Leadership in AI governance, safety assurance, and standards development creates opportunities for the UK to influence international frameworks for the responsible deployment of AI in space. This capability is particularly important as space systems become more autonomous and safety-critical.

The UK is unlikely to match these investments in scale in terms of public investment. Data gathered by the Organisation for Economic Co-operation and Development (OECD), as shown in Figure 1, suggests there is an opportunity to leverage more private investment from public investment in the UK, given comparisons with other geographies³.

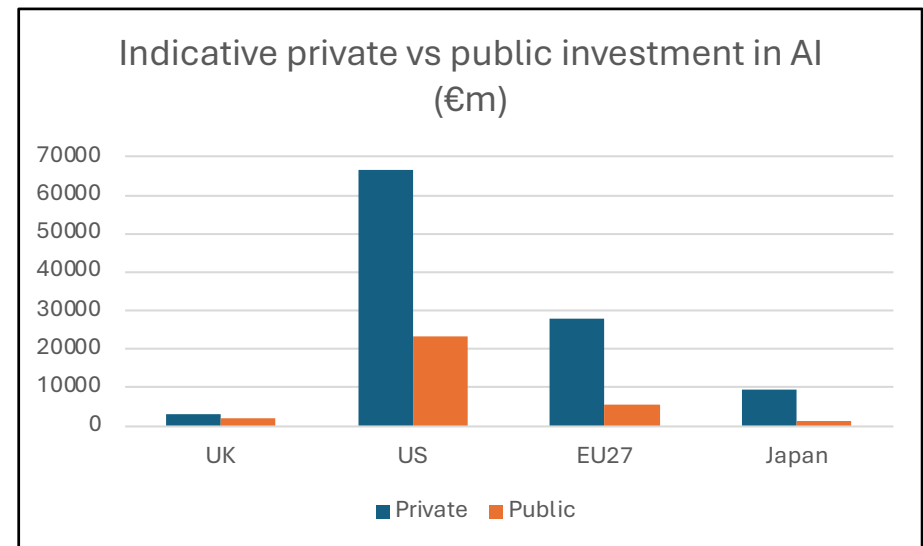


Figure 1. Indicative private vs public investment in AI (€m)

The global competition is fierce for both the space and AI sectors. Figure 2 shows how the UK ranks alongside other nations in AI-related activity across four separate indices.

³Standardised data on private and public investment is not available but an experimental methodology is described in <https://oecd.ai/en/ai-investment>. This is an adaptation of an original work by the OECD. The opinions expressed and arguments employed in this adaptation should not be reported as representing the official views of the OECD or of its member countries.

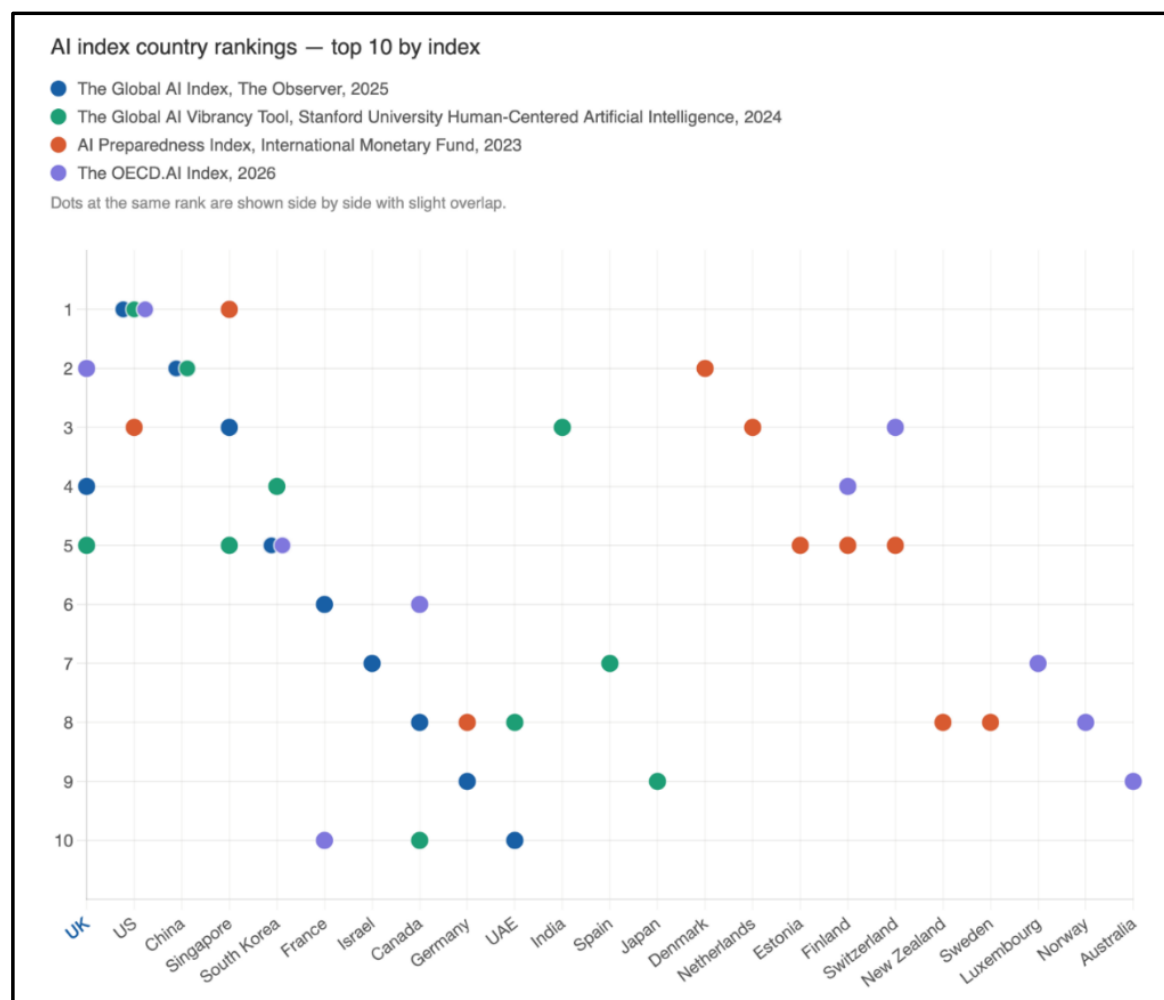


Figure 2. International Benchmarking of AI

The four indicators in Figure 2 are as follows:

- **The Global AI Index⁴** covers 83 countries across implementation, innovation, and investment, with heavy weighting on private sector AI activity, R&D output, and commercial deployment. It rewards countries with large, well-funded tech ecosystems.
- **The Global AI Vibrancy Tool⁵** measures AI research output, private investment, frontier model development, and workforce talent across 36 countries.
- **The AI Preparedness Index⁶** assesses how ready a country's economy and institutions are to adopt and benefit from AI, looking at digital infrastructure, regulatory environment, human capital, and innovation capacity. It measures structural readiness rather than current AI activity.
- **The OECD.AI Index⁷** tracks AI policy, research, and adoption across OECD member states, with an emphasis on governance frameworks, responsible AI, and national AI strategy maturity.

⁴ The Global AI Index, The Observer, 2025, <https://observer.co.uk/data/global-ai>

⁵ The Global AI Vibrancy Tool, Stanford University Human-Centred Artificial Intelligence, 2024, <https://hai.stanford.edu/ai-index/global-vibrancy-tool>

⁶ AI Preparedness Index, International Monetary Fund, 2023, https://www.imf.org/external/datamapper/AI_PI@AIPI/ADVEC/EME/LIC

⁷ The OECD.AI Index, 2026, https://www.oecd.org/content/dam/oecd/en/publications/reports/2026/02/oecd-ai-observatory-index_8f5fa0f2/32c01014-en.pdf

The UK is ranked highly in three of these indices. In the AI Preparedness Index, it was ranked joint 12th alongside Japan, Australia, South Korea, and Israel, reflecting its economy-wide digital readiness.

Countries such as the United States and China are investing heavily in large-scale AI infrastructure, including hyperscale computing and vertically integrated space systems. Other nations are also investing in AI development and exploitation. These assessments show that many countries are in the global AI race and suggest opportunities to collaborate with others with complementary strengths.

Participation in European Space Agency programmes and partnerships with global technology companies allows the UK to leverage international capabilities while contributing specialised expertise in AI-enabled systems. The UK's competitive advantage lies in its ability to accelerate the pull-through of its research strengths, integrate AI effectively into mission architectures, and lead in trusted, certifiable AI systems.

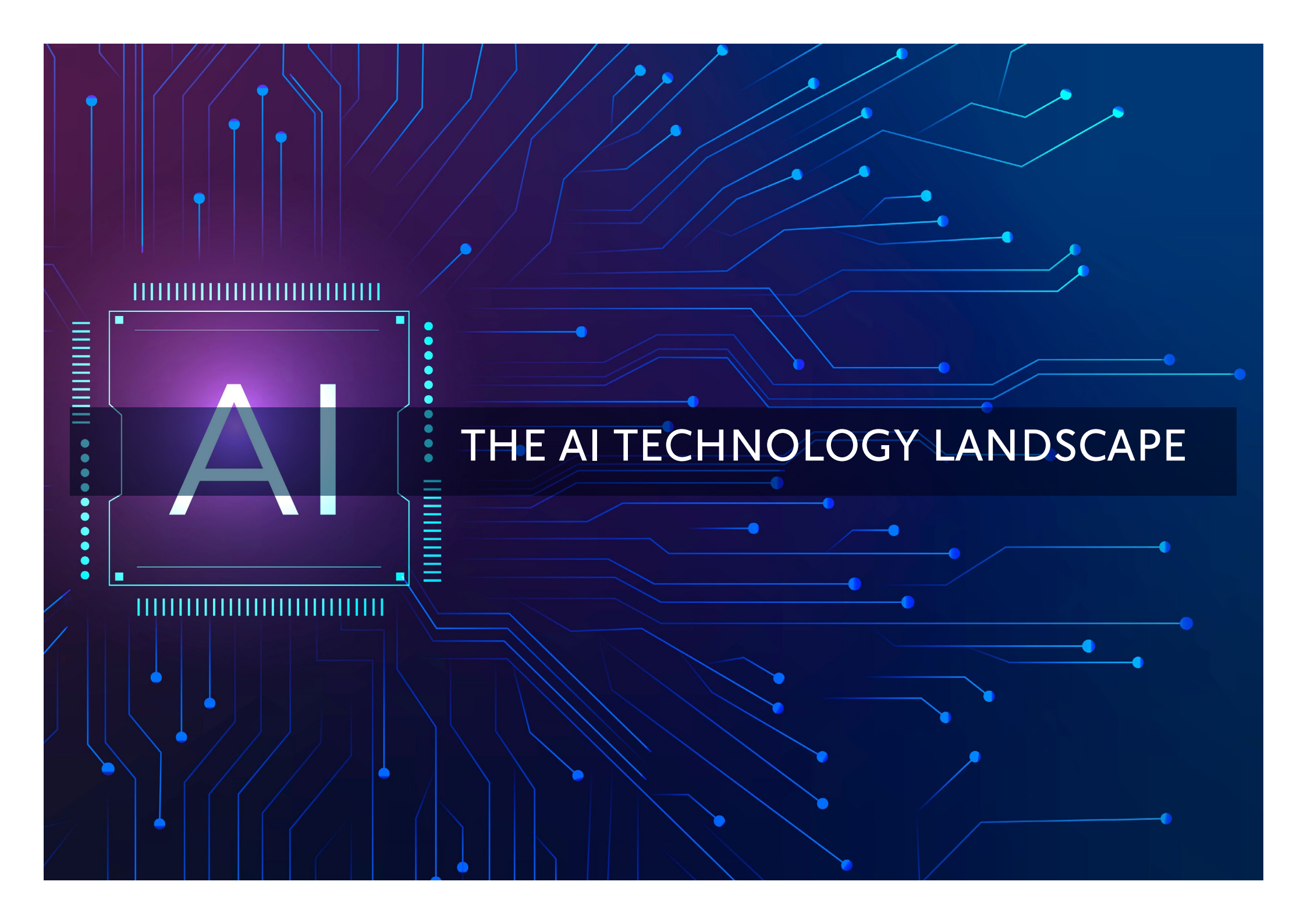
The AIRS roadmap highlights how the UK can build on its strengths by focusing on areas where it can deliver distinctive value. These include AI assurance and certification, resource-efficient and edge AI-for-space environments, hybrid physics-informed AI, and advanced data analytics for earth observation and climate services. By pursuing these priorities, the UK can position itself not only as

a user of AI technologies but also as a global leader in developing trusted, mission-aligned AI systems for the future space economy.

The UK Space Agency's innovation funding, while catalytic, operates mainly at project-level not programme-level, and lacks strategic prioritisation. A clear national programme driving capability from the Technology Readiness Level⁸ (TRL) 3-4 towards market deployment could provide sustained, programme-level investment to close functionality gaps beyond those addressed by competitive grant calls alone. Otherwise, the risk is that the UK remains a strong contributor to others' programmes rather than providing leadership, deliberate prioritisation and active UK advocacy for AI-intensive mission elements.



⁸ https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Shaping_the_Future/Technology_Readiness_Levels_TRL

The background of the entire image is a dark blue to purple gradient, overlaid with a complex network of glowing blue and white circuit lines. These lines represent a digital or neural network structure, with many small blue dots at the intersections and endpoints. On the left side, there is a stylized representation of a computer chip or processor. It is a dark purple rectangle with a white border. Inside this rectangle, the letters 'AI' are prominently displayed in a large, white, sans-serif font. Above and below the 'AI' text, there are horizontal rows of small white vertical bars, resembling a barcode or data interface. To the left of the chip, there are vertical columns of small white dots and lines, further enhancing the technological aesthetic.

AI

THE AI TECHNOLOGY LANDSCAPE

AI Technologies Shortlist

The broad field of AI will continue to develop, and all areas will have applications in Space. Figure 3 shows a range of AI functionalities relevant to the UK Space Sector and where developments are expected to emerge in the next decade and beyond.

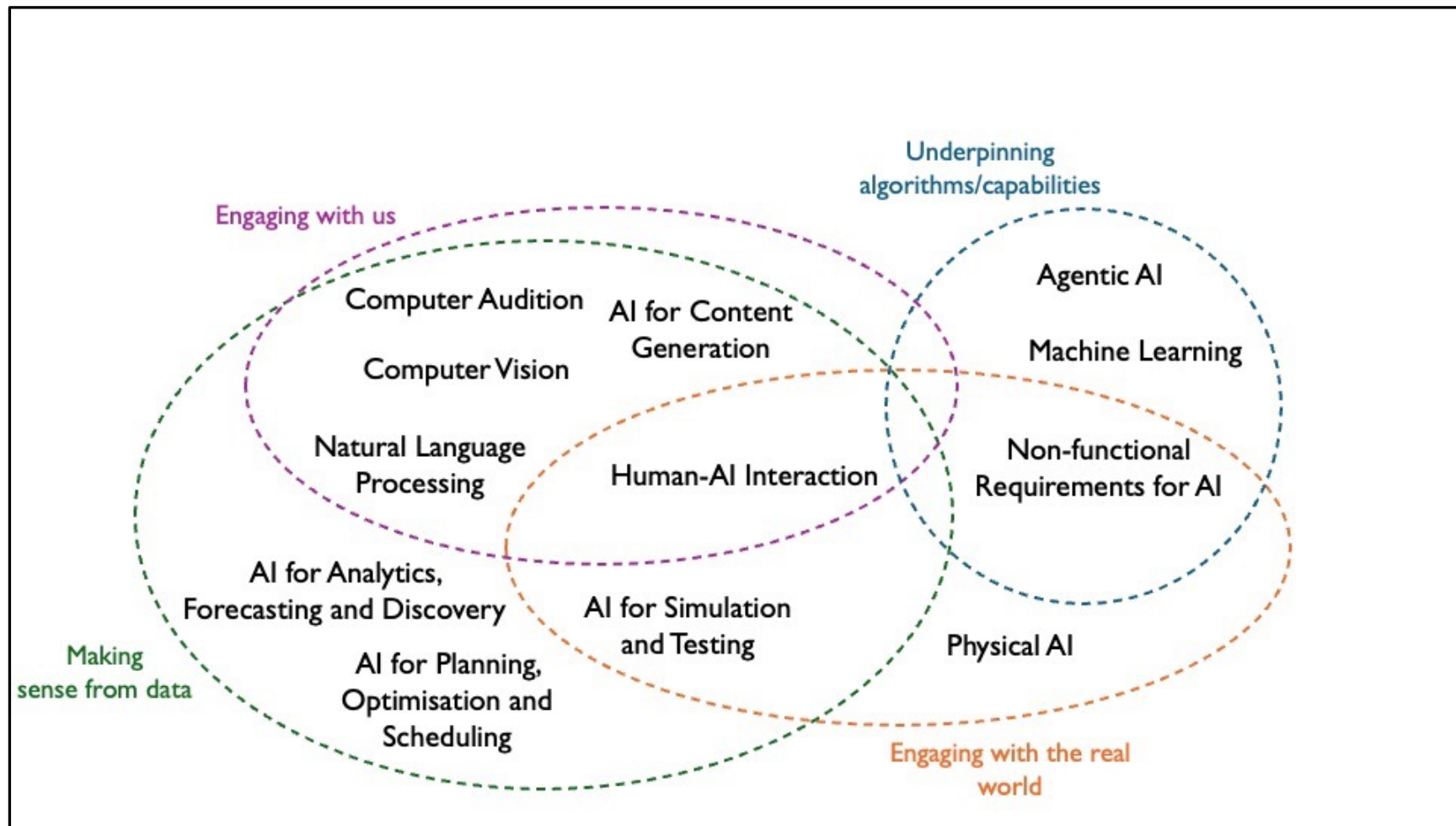


Figure 3. Broader AI functionalities relevant to the UK Space Sector

When emerging AI technologies and functionalities are mapped against Space applications, including Upstream, Downstream, midstream uses-cases and cross-cutting themes, a shortlist emerges of those with the broadest potential impact:

- AI 1.** Computer vision/image analytics (especially image segmentation, classification and object detection)
- AI 2.** AI for simulation and testing (especially simulation-to-real and digital twins)
- AI 3.** AI for analytics, forecasting and discovery (including anomaly detection, causal inference and predictive analytics)
- AI 4.** Machine Learning (including one-shot or few-shot ML)
- AI 5.** AI for planning, optimisation and scheduling
- AI 6.** Agentic/autonomous AI for behaviour and control
- AI 7.** Human-AI interaction
- AI 8.** Edge computing

This is not meant to limit investment and exploration but to provide some focus for where innovations would benefit the whole sector. Other AI functionalities, such as computational linguistics, tactile sensing, physical AI and collaborative robotics, are highly important for specific application areas and warrant specific attention and support.

Across the breadth of AI, some specific themes emerged, corresponding to emerging AI developments likely to drive innovation and performance in various Space applications:

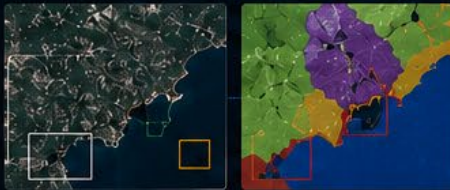
- AI that can fuse and model multiple data types (sensor, text, imagery) and modes of interaction (vision, speech, action) to derive a more complete picture of an environment, state or event, providing greater robustness in the face of incomplete or noisy data
- AI that can combine low-level, data-driven pattern matching with higher-level knowledge representation and reasoning to provide insights that can be rationalised and described to us
- AI that can model and understand the physical world to enable operations that align with reality and power truly realistic simulated environments for testing and training
- AI that can operate for long periods of time, with continuous learning to adapt performance to a new reality, and with low demands for resources, including energy
- Processes and systems for providing explainability (or defensibility) plus ways to verify and certify AI-powered systems.

Unless otherwise specified, the indicative TRL assessments offered in this section are based on UK capability and for Space applications.

AI-for-Space Applications

AI is transforming how we observe, understand and operate in space—enabling smarter missions, faster decisions and a sustainable space future.

- 1 AI 1. COMPUTER VISION / IMAGE ANALYTICS**
(especially image segmentation, classification and object detection)



DETECT CLASSIFY SEGMENT

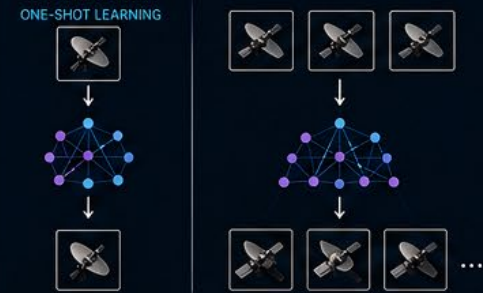
- 2 AI 2. AI FOR SIMULATION AND TESTING**
(especially simulation-to-real and digital twins)



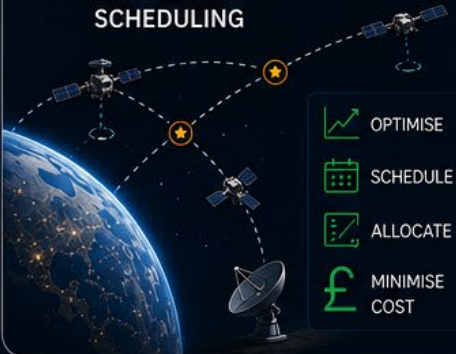
- 3 AI 3. AI FOR ANALYTICS, FORECASTING AND DISCOVERY**
(including anomaly detection, causal inference and predictive analytics)



- 4 AI 4. MACHINE LEARNING**
(including one-shot or few-shot ML)



- 5 AI 5. AI FOR PLANNING, OPTIMISATION AND SCHEDULING**



- 6 AI 6. AGENTIC / AUTONOMOUS AI FOR BEHAVIOUR AND CONTROL**



- 7 AI 7. HUMAN-AI INTERACTION**



- 8 AI 8. EDGE COMPUTING**



ENHANCES MISSION EFFICIENCY



REDUCES COSTS AND OPERATIONAL RISK



ACCELERATES DISCOVERY AND INNOVATION



SUPPORTS SUSTAINABLE USE OF SPACE



EMPOWERS HUMANS TO GO FURTHER

AI 1. Computer Vision

Computer vision enables machines to interpret and extract insights from visual data, such as photographs, video, and satellite imagery. Image segmentation divides a scene into meaningful regions – separating, for example, water from land or buildings from roads. Object detection locates and identifies specific items within an image, such as vehicles, ships, or infrastructure, while tracking follows those objects across a sequence of images over time. Images can be classified based on distinguishing features that may or may not be visible to the naked eye. These capabilities turn raw imagery into structured, searchable information at speeds and scales no human team could match and can identify subtle changes over time that might warrant a closer look.

Space Relevance

In Space, computer vision is already reshaping how we observe and understand the earth. Satellites equipped with on-board image analysis can filter out cloudy or unusable images before transmitting data, saving precious communication bandwidth. Downstream, the technology enables continuous monitoring of deforestation, urban growth, agricultural health, disaster damage, and ice sheet retreat by comparing images taken days, weeks, or months apart.

Vessel movements and changes to infrastructure can be detected. As satellite constellations grow, automated image analytics will become essential for extracting value from the flood of data they produce.

Computer vision functionality can help in upstream applications, for example, in detecting defects in manufactured components for launchers, satellites and vehicles.

Emerging developments include vision-based foundation models – large pre-trained AI systems that can classify scenes they have never been explicitly trained on – enabling flexible, general-purpose image understanding without the need for extensive task-specific datasets. Also, lightweight models designed to run on low-power hardware are enabling spacecraft to make intelligent decisions about what to photograph and transmit, turning passive imaging platforms into responsive, autonomous observers.

Other promising directions include models that run continuously over long periods to detect subtle, slow-moving changes, and physics-informed vision models that incorporate physical laws relevant to the observed environment.

UK Capability

Computer vision is well-established with commercial deployments across autonomous vehicles, retail, medical imaging and agriculture and the UK has established strengths in earth observation analytics. Lightweight image classification on satellites has been demonstrated (e.g. SSTL's FIPC programme, ESA's Φ-Sat missions) but deployment of adapted foundation-scale, more general-purpose computer vision models is less mature (TRLs 3-5 globally including in the UK).

Critical enablers include sustained access to high-quality training datasets and affordable compute for model development.

Outcome

Within the next five years, real-time on-board image triage should become routine for new satellite missions; within ten, constellations could operate as coordinated, self-tasking sensor networks; and within fifteen, persistent global change detection – combining vision, physics and multi-sensor fusion – could deliver near-continuous situational awareness.



AI 2. AI for Simulation and Testing

AI for simulation and testing includes the use of virtual environments to design, validate, and optimise physical systems before they are built or while they are in operation. A digital twin is a dynamic virtual replica of a real-world object or process which can be continuously updated with real sensor data and used to model

and predict how a system will behave under different conditions. Simulation-to-real transfer addresses the challenge of training AI in virtual worlds and then deploying it reliably in the messier, less predictable physical world.

Space Relevance

Digital twins of spacecraft, test facilities, and mission environments enable engineers to rehearse operations virtually, predict equipment wear, optimise maintenance schedules, and train operators without risking real and expensive hardware. When combined with AI, these twins can process vast amounts of operational data and adapt their predictions in real time, identifying potential failures before they occur.

Simulation-to-real transfer is becoming central to autonomous space robotics: AI systems are trained in simulated environments to perform tasks such as docking, inspection, and repair, then deployed on real spacecraft.

A key emerging development is hybrid modelling, which combines AI's ability to spot patterns in data with physics-based rules that prevent physically impossible predictions – a critical safety requirement for space systems. As missions grow more complex and travel further from earth, the ability to build, test, and continuously refine systems in simulation before committing to reality will become indispensable for reducing cost, risk, and development time.

Looking further ahead, data from sensors, imagery, and other sources can enrich world models, helping ensure simulations more

accurately reflect physical realities and possibilities in both well-known and novel environments.

UK Capability

The UK has notable strengths in simulation and gaming, and an active research base in physics-informed machine learning. There are ongoing digital twin initiatives – notably the National Digital Twin Programme and UK Digital Twin Centre – with the strongest deployment focus on aerospace, defence, transport, and utilities. UK-led sim-to-real transfer demonstration, particularly for autonomous orbital behaviours, is limited (lack of evidence beyond TRLs 3-4), and physics-AI hybrid models for space system safety assurance remain at an early research stage (TRL 3).

Critical enablers are interoperability standards for digital twin data and access to high-fidelity simulation environments that accurately represent space conditions.

Outcome

Within the next five years, AI-augmented digital twins could be standard for spacecraft subsystem testing; within ten years, full-mission digital twins could support real-time operational decision-making from launch through end-of-life; and within fifteen years, federated networks of digital twins may enable system-of-systems simulation across entire constellations and ground infrastructure.



AI 3. AI for Analytics, Forecasting and Discovery

This area encompasses a range of AI techniques that identify patterns in data, predict future events, and uncover relationships among elements of complex systems. Anomaly detection identifies when something deviates from normal – an unexpected change in an orbit or an unusual pattern in communication data. Causal inference goes a step further than spotting correlations: it seeks to establish which events actually cause others, enabling root-cause diagnosis. Predictive analytics uses historical and real-time data to forecast future events, from equipment failures to environmental events.

Space Relevance

For Space, these capabilities address some of the most pressing operational challenges. Satellite health monitoring increasingly relies on AI to detect subtle anomalies in telemetry data without waiting for ground-based analysis.

Causal methods are evolving to treat anomalies not as simple statistical outliers but as changes in the underlying relationships between interconnected subsystems, enabling faster and more accurate diagnosis. Predictive maintenance across satellite fleets can anticipate component degradation and schedule interventions before failures occur.

World modelling represents a particularly exciting frontier: AI systems that can internally simulate how a spacecraft or environment will respond to different decisions could enable genuinely adaptive mission planning, where autonomous systems reason about consequences rather than simply following pre-programmed rules. As space systems become more complex and operate further from real-time human oversight, these analytical and forecasting capabilities will be fundamental to safe, efficient operations.

Further research and development are needed to ensure useful insights can be found when it counts, as the volume and complexity of data increase, and to serve these insights in ways that support high-quality and defensible decision-making, surfacing and quantifying uncertainties and risks, and operating continuously over longer periods.

UK Capability

Predictive analytics and anomaly detection are mature in the UK, with national-scale deployments across financial services, healthcare, weather forecasting and energy. Causal inference and world modelling are still in their early stages (up to TRL 3), with few UK-led programmes or demonstrators. The UK has internationally recognised expertise in AI safety, probabilistic modelling, and causal inference research, anchored in strong university groups.

Access to benchmark telemetry and operational datasets is needed to train and validate analytics, forecasting and discovery systems—current data-sharing constraints slow progress.

Outcome

Within the next five years, AI-driven anomaly detection should be deployable on-board for real-time satellite health monitoring; within ten, causal reasoning systems could autonomously diagnose and resolve routine faults without ground intervention; and within fifteen, world models may enable spacecraft to anticipate and adapt to novel situations they have never encountered.

AI 4. Machine Learning

Machine learning concerns the development of AI that can improve its performance over time as it processes more data, gaining experience and refining models with the latest information. Supervised learning trains models on large collections of labelled examples: showing the system thousands of images of forests and cities, for instance, until it can reliably distinguish between them. This works well when plentiful labelled data is available. Few-shot, one-shot, and zero-shot learning are useful for situations where labelled data is scarce or expensive to obtain. These methods enable AI to generalise from just a handful of examples, a single instance, or even none at all – by leveraging transferable patterns and similarities.

Space Relevance

In space applications, one-shot and few-shot learning approaches could allow models to adapt quickly to new tasks with minimal new data, making them ideal for on-board satellite AI that must handle novel situations far from ground support.

Large pre-trained vision-language models are increasingly enabling flexible classification without extensive retraining, combining textual descriptions with visual understanding to identify objects and scenes in ways that generalise across different contexts. Emerging research is also focusing on making these methods explainable – not just producing a classification but showing why the AI reached its conclusion. This is particularly important in space, where autonomous decisions may be safety-critical and need to be auditable. The ability to learn effectively from limited data will be a key enabler as space operations scale up and diversify into new domains and environments.

Currently, however, more advanced forms of machine learning and the extraction of potential explanations tend to demand high levels of compute capacity, limiting their development and application in some areas. Ongoing developments into more memory-efficient architectures could allow machine learning to be exploited more widely.

In addition, developments in neuro-symbolic computing – combining the power and flexibility of data-intensive, perceptive deep learning-based ML with more logical and inherently explainable approaches – could enable more transparent and reliable forms of intelligence.

UK Capability

Supervised learning is widely deployed across financial services, healthcare and retail. In space applications specifically, few-shot and meta-learning approaches remain largely at the research and pilot stage (TRL 3-4), though UK universities – including Oxford, Edinburgh, and UCL – are globally cited contributors to the field. Broader commercial deployment beyond NLP is maturing rapidly, driven by foundation models, making early investment in space-specific applications a timely opportunity.

Key enablers include curated, domain-specific benchmark datasets for space applications and frameworks that support on-device model adaptation.

Outcome

Within the next five years, few-shot methods should allow rapid retraining of satellite classifiers in orbit as new targets of interest emerge; within ten, foundation models fine-tuned with minimal labelled space data could handle a wide range of observation and operational tasks; and within fifteen, continuously self-improving learning systems may operate across satellite fleets, sharing knowledge without sharing raw data.



AI 5. AI for Planning, Optimisation and Scheduling

AI for planning encompasses techniques for determining the optimal sequence of actions to achieve a goal under real-world constraints such as limited time, energy, communication windows, and competing priorities. Optimisation finds the best – or near-best – solution from a vast number of possibilities, while scheduling allocates specific tasks to specific time slots and resources. These problems are computationally challenging because the number of

possible combinations grows explosively with the number of variables involved. AI approaches range from classical rule-based planners to modern methods that use learning to improve their estimates of how long tasks will take, how resources will be consumed, and how to adapt when conditions change unexpectedly.

Space Relevance

Space operations exhibit levels of complexity and adaptability requirements that necessitate the use of AI in planning. A single satellite must balance observation requests, data downlink windows, battery charging, orbit maintenance, and thermal management – and a constellation of hundreds or thousands of satellites multiplies this complexity enormously. AI schedulers can increase an imaging constellation’s productivity by ensuring satellites are not duplicating coverage and are dynamically re-tasked to urgent targets within minutes.

On planetary missions, AI planners enable rovers to decide autonomously which science targets to investigate based on available time and energy each day, adapting as new discoveries are made. The trend toward mega-constellations and multi-element missions is making AI planning not just useful but essential: human operators cannot manage the volume and speed of decisions required.

Emerging developments include distributed planning methods in which satellites coordinate without centralised ground control, and the integration of reinforcement learning to improve planning performance through experience. As missions extend further from earth and real-time human intervention becomes impossible,

autonomous planning will be a foundational capability for all space operations.

UK Capability

The UK has strong AI planning capabilities in energy grid management, logistics, and transport, with DeepMind's data centre optimisation reflecting the depth of its research. The UK has research strength in combinatorial optimisation and constraint reasoning, with growing applications to space through academic-industry collaborations. Distributed optimisation for constellation-scale scheduling remains at TRL 4-6 with limited UK operational demonstration, and Reinforcement Learning-integrated planning is at a demonstrator stage globally (TRLs 5-6) with a few UK-led examples.

Critical enablers include validated simulation environments for testing planning algorithms before deployment and regulatory frameworks that permit increasing levels of autonomous decision-making in orbit.

Outcome

Within the next five years, AI-assisted scheduling should be standard for UK-operated constellations; within ten, satellites may routinely coordinate observations and downlinks autonomously using distributed planning; and within fifteen, fully autonomous multi-mission planning (spanning observation, communication, servicing, and deorbiting) could operate with only supervisory human oversight.



AI 6. Agentic/Autonomous AI for Behaviour and Control

Agentic AI describes systems that can perceive their surroundings, set goals, make plans, take actions, and adapt their behaviour based on results – all with minimal human direction. Unlike simpler automation that follows rigid rules, agentic systems reason about what to do, adjust when things go wrong, and pursue objectives through flexible, multi-step strategies. When multiple such agents work together – coordinating, sharing information, or dividing tasks – they form multi-agent systems capable of tackling problems too complex for any single system. The underlying technologies include and combine sensor interpretation, decision-making algorithms, and machine learning.

Space Relevance

In space, autonomous AI will be vital when real-time remote control is impractical or impossible. Mars missions already face communication delays of up to 24 minutes each way, and future deep-space missions will face even longer gaps. AI-controlled robots operating autonomously aboard the International Space Station have already been demonstrated.

The emerging vision is of spacecraft that function as cognitive systems: capable of autonomous docking, in-orbit servicing and repair, adaptive scientific exploration, and collaborative operations across multi-vehicle missions. Multi-agent coordination is also relevant for future asteroid mining, distributed sensing, and orbital debris management.

Key research challenges remain in safety assurance (ensuring autonomous systems behave predictably in critical situations), graceful degradation (maintaining useful function when components fail), and appropriate human oversight (keeping humans meaningfully in the loop even as autonomy increases).

UK Capability

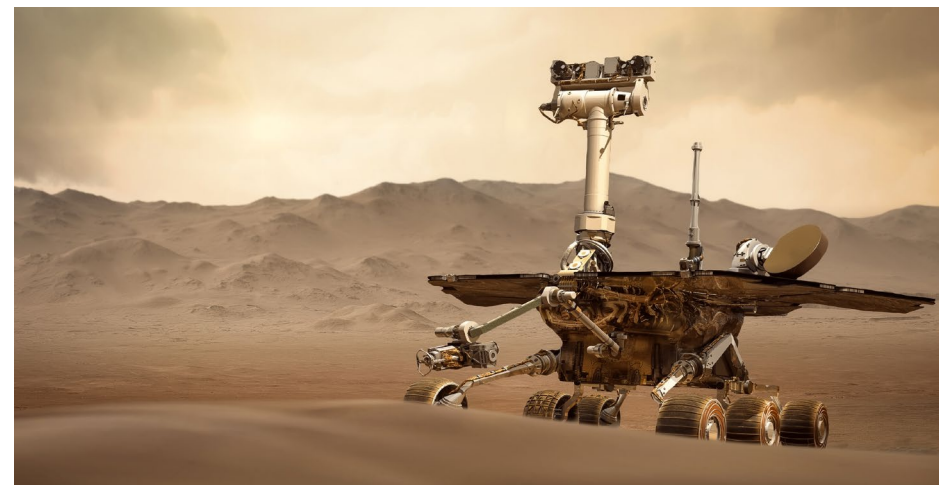
The highest-TRL agentic AI activity is perhaps represented by Wayve's autonomous driving and applications in industrial robotics and financial trading. The UK has academic strength in multi-agent systems (e.g., Southampton, Edinburgh and Oxford) and emerging capability in autonomous systems and space robotics, with active programmes in in-orbit servicing and autonomous rendezvous (e.g. UK Space Agency-funded ARGUS project moving to TRL 7 for

flight-ready rendezvous, proximity, and operations), though it is behind the US in flight-demonstrated autonomy. This is not matched by demonstrators in areas, such as swarm intelligence or self-repair, where activity is primarily at TRLs 1-3.

The critical enablers are verification and validation frameworks for safety-assured autonomy and in-orbit testbeds where agentic systems can be demonstrated incrementally.

Outcome

Within the next five years, supervised autonomous operations such as routine inspection and station-keeping should be achievable; within ten, AI agents could conduct complex multi-step servicing missions with minimal human intervention; and within fifteen, collaborative multi-agent systems may autonomously manage debris removal, resource extraction, or construction tasks in orbit and on planetary surface.



AI 7. Human-AI Interaction

Human-AI interaction is concerned with how people and AI systems work together effectively. This goes beyond designing user interfaces: it encompasses ensuring AI reasoning is transparent and explainable, building appropriate levels of trust (so humans neither over-rely on nor needlessly override AI), designing systems where control can shift smoothly between human and machine depending on the situation, and supporting communication through multiple channels including voice, gesture, and visual displays. The goal is AI that genuinely augments human capability – handling routine, dangerous, or computationally intensive tasks while leaving creativity, judgment, and high-level decision-making to people.

Space Relevance

In space, effective human-AI teaming is not a nice-to-have but a mission-critical requirement. Astronaut time is focused and limited, so AI systems that can take over routine monitoring, maintenance checks, and procedural tasks free crew members to focus on complex and high-priority activities. Free-flying AI assistants have been tested aboard the International Space Station, providing voice-controlled support for experiments, maintenance guidance, and even basic emotional awareness to support crew wellbeing during long-duration missions.

Extended and virtual reality training environments enhanced by AI create realistic simulations of space conditions for astronaut preparation on the ground. A central and growing challenge to human situational awareness is adaptive autonomy: as AI undertakes tasks in greater numbers and of higher complexity, the partnership between human and AI will need to evolve. Whenever

a human needs to re-engage or take back control, the efficiency and effectiveness of these transitions will be safety- and mission-critical. This is an active area of research and will determine whether future deep-space crews experience AI as a trusted partner or a source of frustration and risk.

Other active areas of research in this domain include adaptive trust calibration, to develop ways to dynamically adjust AI transparency and explanation depth based on user expertise, task context, and AI confidence levels, as well as multimodal interaction which integrates language, vision, and physical action for robotics applications able to convert text instructions directly into control predictions for human-robot teaming.

UK Capability

The UK has established strengths in human factors research and AI ethics, with institutions contributing to the development of relevant international standards. There are applied deployments across surgical robotics, assistive technology and defence, with UKRI's Trustworthy Autonomous Systems programme producing several demonstrator-stage projects. Most activity focuses on co-located human-machine teaming; supervisory control where AI executes autonomously over extended periods remains at an earlier (not beyond TRLs 3-4, including for terrestrial applications), with no UK equivalent of ESA's AI Lab at the European Astronaut Centre. Critical enablers include representative environments for testing human-AI collaboration under realistic operational stress.

Outcome

Within the next five years, AI assistants with adaptive explanation capabilities should support ground-based mission operations; within ten, human-AI teams could manage routine in-orbit tasks with the AI handling execution and the human providing oversight; and within fifteen, deeply integrated human-AI partnerships may sustain long-duration deep-space missions where crew and AI share decision authority across a wide range of operational and scientific tasks.



AI 8. Edge Computing

Edge computing means processing data where it is collected – on the device, vehicle, or satellite itself – rather than sending it to a distant data centre or ground station for analysis. This reduces delay, cuts communication bandwidth, improves privacy, and enables systems to act on information in real time. For AI applications, edge computing demands hardware that delivers high performance while consuming very little power and surviving harsh

conditions. Enabling technologies include techniques for shrinking AI models to fit on small processors, photonic (or optical) chips, and an emerging class of brain-inspired processors called neuromorphic chips that mimic how biological neurons work – activating only when needed and consuming a fraction of the energy of conventional processors.

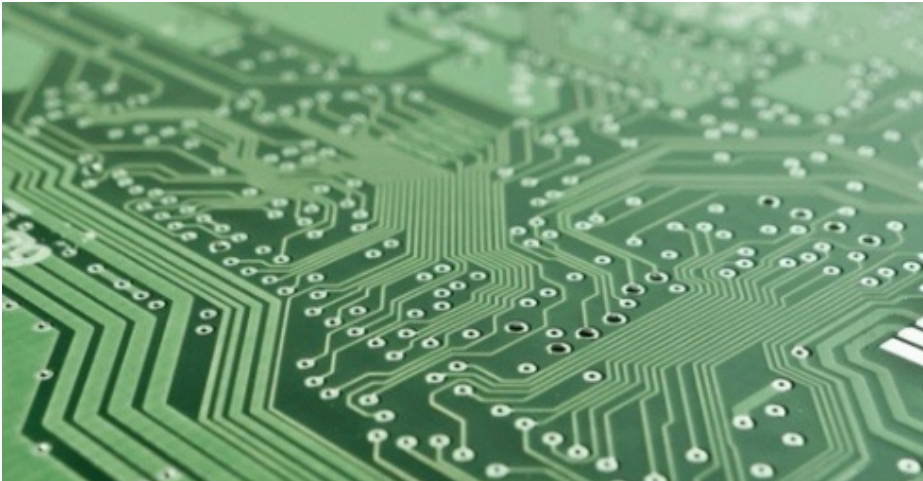
Space Relevance

In space, edge computing may be essential rather than optional for many applications. Satellites generate enormous volumes of data – often terabytes of imagery per day – but have very limited ability to transmit it all to earth. On-board AI processing allows spacecraft to analyse images, detect interesting events, and transmit only the most valuable data, dramatically improving the efficiency of every communication window.

Planetary rovers use edge AI to analyse terrain and navigate autonomously, making them intelligent explorers rather than remotely steered vehicles. The challenges are formidable: space hardware must withstand radiation, extreme temperatures, and operate within tiny power budgets. Neuromorphic processors are emerging as particularly promising for space because they can deliver AI inference at milliwatt power levels – orders of magnitude more efficient than conventional chips.

Research is advancing in radiation-tolerant processor designs specifically for orbital and deep-space environments. For robotics, edge AI enables in-orbit servicing robots, free-flying station assistants, and autonomous construction systems that must perceive, decide, and act without waiting for instructions from earth.

As space operations scale and missions venture further from home, the ability to think locally rather than depend on distant ground support will be a defining capability.



UK Capability

Industrial edge computing deployments exist in smart manufacturing and utilities monitoring, with UK talent in AI chip design. Neuromorphic deployment is an earlier stage (TRL 3-5), with the SpiNNaker platform (hosted by University of Manchester working with international partners) being the most mature example. Space-grade neuromorphic deployment remains nascent. The UK has pockets of strength in low-power AI chip design, neuromorphic research, and model compression techniques.

Critical enablers are space-qualified AI hardware demonstrators and international partnerships to accelerate development and validation.

Outcome

Within the next five years, commercial off-the-shelf processors with radiation shielding should enable significantly more on-board AI than today; within ten, neuromorphic and purpose-built AI accelerators could deliver complex inference at milliwatt power levels in orbit; and within fifteen, edge computing may support fully autonomous spacecraft that process, decide, and act without any reliance on ground-based computation.

The shortlisted AI technologies and functionalities covered earlier are not standalone, and developments across them all are set to continue over the next ten years and more. Within these, there are areas at lower TRL, including communication-latency-aware autonomy, causal and world-model reasoning, decentralised planning and multi-agent coordination at scale, few-shot learning outside of NLP and neuromorphic hardware for space environments – areas where the UK has research foundations but limited UK-led demonstrator or operational activity specific to the space context.

Global AI-for-Space Technology Readiness Level Mapping

Based on the shortlisted AI technologies and functionalities covered earlier, a comprehensive mapping of the Technology Readiness Level (TRL) range for selected space use-cases is provided in the TRL heatmap, as shown in Figure 4. For benchmarking purposes, the TRL ranges identified here are based on the global maturity scale rather than the UK-specific TRL. There is clear evidence of operational use for certain AI technologies and functionalities; however, such deployment is often confined to specific use cases, applications, or market segments. In other contexts, adoption may be considerably more limited, corresponding to lower TRL levels. Within this TRL heatmap, ratings of TRL 7-9 indicate that the state-of-the-art has achieved system demonstration or operational deployment in at least some instances. These ratings should not be interpreted as representative of maturity across all potential applications of a given technology.

The shortlisted AI technologies and functionalities are the following:

- AI 1. Computer vision/image analytics (especially image segmentation and classification and object detection)**
- AI 2. AI for simulation and testing (especially simulation-to-real and digital twins)**
- AI 3. AI for analytics, forecasting and discovery (including anomaly detection, causal inference and predictive analytics)**
- AI 4. Machine Learning (including one-shot or few-shot ML)**
- AI 5. AI for planning, optimisation and scheduling**
- AI 6. Agentic/autonomous AI for behaviour and control**
- AI 7. Human-AI interaction**
- AI 8. Edge computing**



TRL Range:								
Low (TRL 1-3)		Low-Mid		Mid (TRL 4-6)		Mid-High		High (TRL 7-9)
Space Applications	AI 1	AI 2	AI 3	AI 4	AI 5	AI 6	AI 7	AI 8
1. Satellite Communications	High (TRL 7-9)	Mid-High	High (TRL 7-9)	Mid-High	High (TRL 7-9)	Mid (TRL 4-6)	Mid (TRL 4-6)	Mid (TRL 4-6)
2. Space Domain Awareness	High (TRL 7-9)	Mid (TRL 4-6)	Mid (TRL 4-6)	Mid (TRL 4-6)	Mid-High	Mid-High	Mid (TRL 4-6)	Mid-High
3. Earth Observation	High (TRL 7-9)	Mid (TRL 4-6)	Mid (TRL 4-6)	High (TRL 7-9)	Low (TRL 1-3)	Low-Mid	Low (TRL 1-3)	Mid-High
4. Position, Navigation and Timing	Mid-High	Mid (TRL 4-6)	High (TRL 7-9)	Mid (TRL 4-6)	Mid-High	Low-Mid	Mid (TRL 4-6)	Mid-High
5. Mission and System Architecture	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	Mid-High
6. Spacecraft, Payload and Launch Vehicle Design	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	High (TRL 7-9)	Mid-High	Mid-High	High (TRL 7-9)	Mid-High
7. Manufacturing	Mid-High	High (TRL 7-9)	Low-Mid	High (TRL 7-9)	Mid (TRL 4-6)	Low-Mid	Low (TRL 1-3)	Low (TRL 1-3)
8. Assembly, Integration & Testing	Mid-High	High (TRL 7-9)	Mid (TRL 4-6)	High (TRL 7-9)	Mid (TRL 4-6)	Low-Mid	Low (TRL 1-3)	Low (TRL 1-3)
9. In-orbit Servicing, Assembly and Manufacturing	High (TRL 7-9)	High (TRL 7-9)	Mid-High	High (TRL 7-9)	Mid-High	Mid (TRL 4-6)	Low-Mid	Low (TRL 1-3)
10. Space Science and Exploration	High (TRL 7-9)	High (TRL 7-9)	Mid-High	High (TRL 7-9)	High (TRL 7-9)	Mid-High	Mid (TRL 4-6)	Low (TRL 1-3)
11. Space Surveillance and Tracking	High (TRL 7-9)	Mid (TRL 4-6)	Mid (TRL 4-6)	Mid (TRL 4-6)	Mid-High	Mid-High	Mid (TRL 4-6)	Mid-High

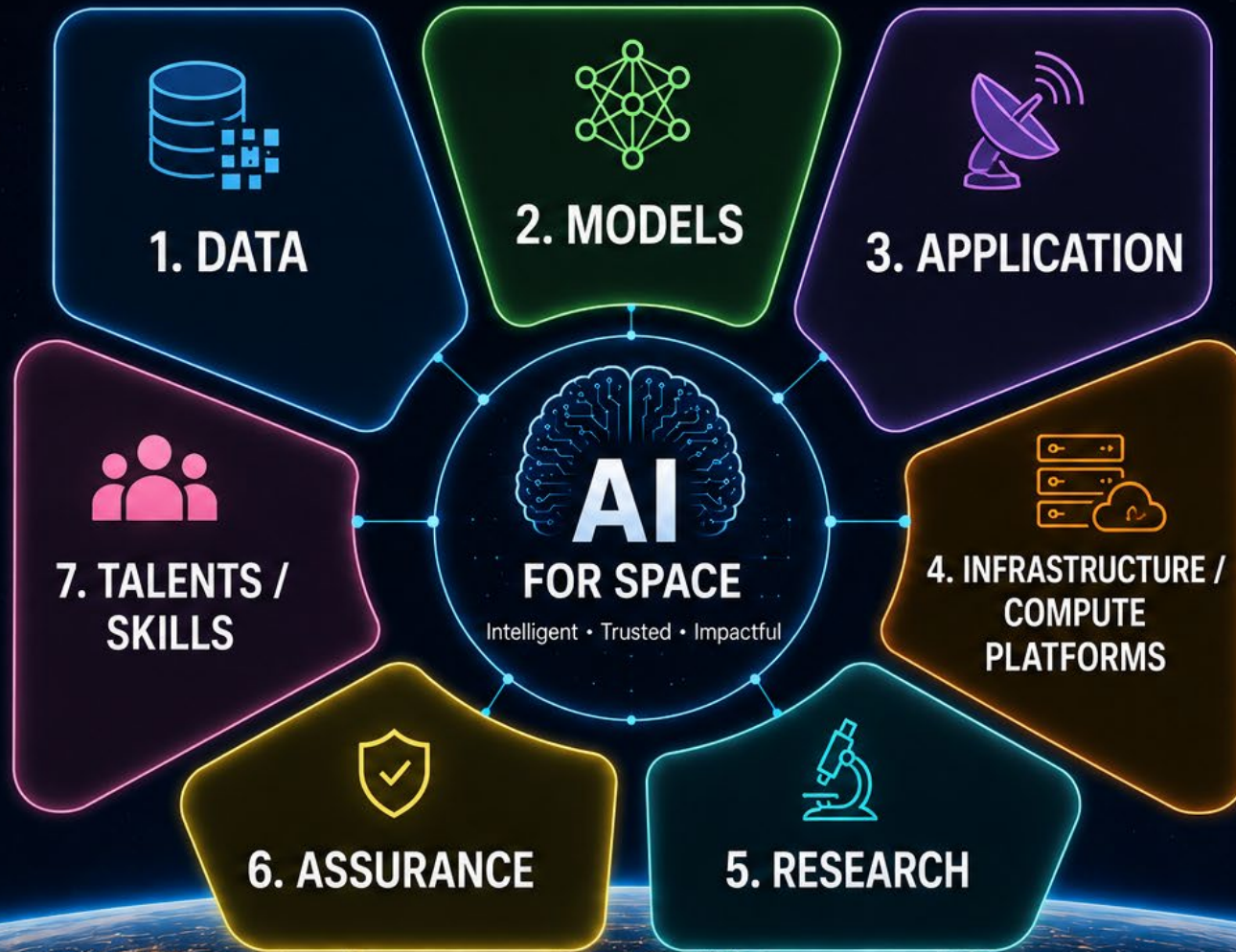
The Opportunities through the UK AI Supply Chain

The question is where attention and/or investment are needed to advance, direct, or accelerate the benefits and impacts for space applications. Assessment of the critical enablers needed to advance, direct or accelerate AI innovation for space applications suggests the UK has the following opportunities:

DATA	It is critical that the UK researchers and innovators have access to real-world data with which to train, test and assure new AI models and algorithms for space applications. This would ensure new AI developments are fit-for-purpose, meeting the specific requirements of space, and reducing the need for retraining cycles in the earliest stages.
MODELS	UK engagement in the development of relevant models and algorithms, for example, large language and action models, including through international partnerships, would ensure strong expertise and know-how in how these can be tailored and applied in a range of circumstances, accelerating innovation and adoption.
APPLICATION	Clear and strong narratives linking the application of AI to Space applications to economic, commercial, and societal value could incentivise the broader AI community and a wider range of investors and partners to accelerate the required innovation (e.g., in energy-efficient AI) and levels of private investment.
INFRASTRUCTURE/ COMPUTE PLATFORMS	The UK is unlikely to be able to compete with the top global players in compute power so focus on resource efficiency could provide competitive advantage. Relevant testing and demonstration platforms for testing and demonstrating systems integration, resilience and efficiency at the appropriate scale could benefit the whole ecosystem.
RESEARCH	The UK is strong in AI research overall, but it is dispersed across some of the most relevant areas for Space applications. Support for connecting and consolidating research and fostering more collaboration between research groups and with commercial partners could accelerate AI applications in space, including the latest developments in terrestrial AI.
ASSURANCE	There is a major opportunity for the UK to lead in an emerging market for AI assurance for Space and other sectors with similar assurance requirements. Stronger partnering and cooperation among the Space industry, government and standards institutes could underpin this to accelerate commercial experimentation and application.
TALENT/SKILLS	The UK is recognised for its space and AI talent, but there are limited opportunities to bring these together. Physics skills could be brought into this too, and these can be found across many leading sectors in the UK, including automotive, Formula 1 and gaming. Opportunities could be created by bringing talent together around compelling missions or challenges, and by designing and commissioning space sector-specific training programmes.

AI-for-Space: Key Opportunities

Turning Space Data into Intelligence for a Smarter, Safer, and Sustainable Space Ecosystem



**From Data
to Decisions**

Empowering missions,
protecting our planet,
Advancing Humanity.

**Built on Trust.
Driven by Innovation.
Shaped by people.**

Enablers Across All Opportunities



Policy & Governance
Supportive policies,
standards & regulations



International Collaboration
Open innovation & global
partnerships



Ethics & Sustainability
Responsible AI for a
sustainable space future



Industry & Ecosystem
Startups, industry, academia &
public sector collaboration



Investment & Funding
Strategic investment for
long-term impact



THE SPACE SECTOR DRIVERS

Downstream Space Applications

Across Satellite Communications, Earth Observation, Position, Navigation & Timing, and Space Domain Awareness, the role of AI is converging on a common pattern. AI delivers the greatest value where systems have become too data-rich, dynamic, and operationally coupled to be managed effectively through manual processes or static rules. In each domain, AI's primary leverage lies not in altering the physics of the space segment, but in enhancing the performance, resilience, and economic yield of the ground and service layers where data is integrated, interpreted, and acted upon.

A central cross-cutting theme is the emergence of assurance as both a technical and commercial differentiator. In SatCom and PNT, the challenge is no longer solely to provide connectivity or positioning and timing, but to provide demonstrable confidence that these services remain reliable under contested or degraded conditions, and to enable safe, governed degradation when they do not.

AI supports this shift by enabling continuous monitoring, anomaly detection, confidence estimation, and decision support, forming the basis of assurance regimes that can be audited and procured within public-sector constraints. In this sense, AI moves from a discretionary optimisation tool toward a foundational governance enabler, particularly in multi-vendor, multi-orbit, and cross-sector environments where no single actor has complete visibility or aligned incentives.

A second shared theme is the relationship between scale and specificity in analytics. Earth observation illustrates this most clearly: data volumes have grown faster than the skilled analytical capacity to process them, and AI provides the means to move from

bespoke, labour-intensive interpretation to scalable, market-specific analytics engines.

Similar pressures arise in SDA, where heterogeneous sensor data must be fused continuously to generate decision-relevant insight, and in SatCom, where LEO-driven growth expands the number of links, terminals, and operational states beyond the reach of traditional network operations models. In each case, AI enables automation and triage, ensuring that scarce expert attention is focused where it adds the greatest value while maintaining coverage across high-volume, high-tempo operations.

A third common element is that the most defensible near-term opportunities lie above the signal- or sensor-layer. For investors, services that depend on access to third-party-owned, controlled data carry inherent risk: value can be rapidly eroded if data access is restricted, repriced, or withdrawn altogether. For the UK in particular, this aligns with structural realities identified elsewhere in the evidence: the UK is unlikely to compete on constellation-scale SatCom ownership and does not control foreign Global Navigation Satellite System signals for PNT.

The strategic alternative is to build sovereign capability in interpretation, integration, and response; functions that sit above underlying infrastructures and can be delivered through software, data stewardship, and operational governance. This framing supports a UK industrial approach that is lower in capital intensity, higher in skills intensity, and more readily exportable as services, standards, and accredited assurance approaches.

These opportunities, however, are shaped by recurring ecosystem constraints. Evidence across domains highlights skills gaps, fragmented tooling and infrastructure, limited access to high-quality operational data (including rare but safety-critical events), and immature assurance and certification pathways for AI-enabled systems.

Where the UK has invested in enabling infrastructure (such as SDA sensor modernisation or nationally distributed timing), the commercial opportunity for AI is strengthened by increased data availability, operational pull, and credible test and validation environments. Therefore, there is an argument for an additional layer of ecosystem-enabling AI, perhaps organised at the intersection of government and trade associations, where goals for the sector's overall growth are actively managed and optimised.

Taken together, the evidence supports a view of AI not as a collection of isolated application projects, but as a shared capability layer that must be built with common infrastructure, data governance, and trusted assurance frameworks. This approach supports early value delivery through bounded deployments while creating the conditions for longer-term commercial advantage in trusted “control and assurance layers” that can be adopted across suppliers, sectors, and allied systems.



AI Applications to Downstream Markets

Possible AI applications relevant to satellite downstream markets are significant and numerous. Examples are presented below.



Satellite Communications

AI enables resilient, assured, multi-orbit connectivity services and differentiated managed service offerings through:

- Automated monitoring of network and ground telemetry to detect degradation early
- Anomaly and interference detection/classification in contested RF environments
- Predictive congestion/failure assessment and proactive mitigation
- Dynamic routing and optimisation across orbits/providers, including policy-driven trade-offs
- Continuous, auditable assurance evidence suitable for multi-vendor environments and procurement/oversight.



Space Domain Awareness

AI enables scalable, decision-relevant space safety and security insight (tracking, characterisation, risk) through:

- Automated object detection, cataloguing, and improved orbit prediction from heterogeneous sensors
- Fusion and cross-validation of radar, optical, and RF observations across heterogeneous sensor modalities
- Anomaly detection and behavioural modelling (“patterns of life”) to flag non-routine activity
- Intelligent sensor tasking and alert triage to prioritise scarce sensing and analyst attention
- Probabilistic risk assessment with confidence metrics under partial observability constraints.



Earth Observation

AI enables scalable, market-specific intelligence from EO data (moving from manual analytics to operational services) through:

- Automated production of analysis-ready data, mitigating the impact of different capture regimes across sensors, times, and quality, delivering value across multiple markets and applications
- Object detection for assets and activity relevant to specific sectors (e.g., property, crops, vehicles, etc.), providing insight into the agricultural, environmental and security markets
- Change detection that characterises the nature and significance of change, not just presence or absence
- Individual “tuned” analytics engines operated in parallel, targeted at defined market questions (e.g., damage identification for Insurance and humanitarian aid or natural resource identification)
- Wide-area triage that removes “background” unimportant change and focuses expert review on likely events material to the purpose of the analysis (e.g., a critical service for defence, security, commodity finance and border monitoring).



Position, Navigation and Timing

AI enables sovereign control over trust, integrity and response for time/position services (without owning a Global Navigation Satellite System):

- Detection and characterisation of interference (jamming/spoofing) and differentiation of benign vs hostile patterns
- Confidence estimation and integrity monitoring that sit above the signal layer
- Decision support for safe degradation and fallback modes in automated/autonomous systems
- Fusion of heterogeneous data sources (Global Navigation Satellite System, local oscillators, terrestrial signals, sensor fusion) for verification
- Translation of technical integrity states into operational advisories suitable for cross-sector coordination.

Barriers to Adoption and Value Extraction

Evidence across downstream space applications indicates that while AI capabilities are technically mature and increasingly necessary, adoption remains uneven due to a set of structural barriers. These barriers relate not only to the technical deployment of AI, but also to the enabling conditions required for its operational use.

Key constraints include challenges in integrating AI into existing workflows, high upfront investment and uncertain return timelines, evolving regulatory and assurance requirements, and shortages in the skills needed to deploy and manage AI systems effectively. Together, these factors shape the pace and scale at which AI is being adopted across downstream space domains.

The UK could turn skills and training into a competitive advantage by building a workforce fluent in trusted AI deployment within regulated, multi-stakeholder space environments.



Technology Adoption Barriers

- Integration gap between AI techniques and operational workflows
- Limited access to high-quality, shareable datasets
- Compute, infrastructure, and tooling constraints
- Low trust/assurance pathways for operational decision use.



Investment & Cost Barriers

- High upfront costs (skills, compute, data engineering, integration)
- Uncertain time-to-value and weak demand signals
- SMEs constrained by co-funding and early financial risk.



Regulatory Barriers

- Licensing restrictions on data use and resale
- Emerging AI regulations and cross-border compliance uncertainty
- Assurance, auditability, and accountability requirements for safety-critical use.



Skills Gap & Training Needs

- Limited AI literacy across the downstream space workforce
- Shortage of interdisciplinary AI-domain integration skills
- Lack of practical deployment pathways, tools, and training environments
- Need for broader workforce upskilling and reskilling to adopt and trust AI tools.

Upstream Space Applications

AI is not merely an efficiency tool for existing upstream space activities; it is a market-enabling technology with various advanced functionalities that will reshape how space systems are designed, produced, verified, and operated sustainably. Over the next decade, AI adoption is expected to unlock new commercial opportunities across the upstream value chain by changing cost structures, enabling scale where it was previously impractical, and supporting missions that are not viable with human-centric operations alone.

In the long term, widespread AI adoption will enable a paradigm shift from project-based upstream delivery to platform and service-based models, in which design tools, autonomy software, digital twins, and operational analytics are reused across multiple missions and customers. This transition has the potential to create more resilient, scalable, and globally competitive UK upstream space businesses.

Enabling scalable satellite and launcher production

One of the most immediate commercial impacts of AI will be its role in enabling scalable, repeatable production of space systems while maintaining the reliability demanded by mission assurance. I-driven design optimisation, manufacturing analytics, and automated inspection allow satellite and launcher manufacturers to move beyond bespoke, craft-based production models toward semi-industrialised production, even at relatively low volumes. By reducing design iteration time, improving first-pass yield, and shortening integration and test campaigns, AI lowers unit costs and compresses delivery schedules.

Adoption of AI will create commercial opportunities for UK manufacturers to compete more effectively in constellation supply chains, responsive launch markets, and government programmes that demand rapid replenishment or surge capacity. For launch systems, AI-enabled simulation, propulsion test analytics, and production planning are particularly valuable in supporting higher flight rates, reusability concepts, and cost predictability, which are essential for commercial launch competitiveness.

Supporting In-orbit Servicing, Assembly and Manufacturing (ISAM) based orbital infrastructures and services

AI is a foundational enabler for In-orbit Servicing, Assembly and Manufacturing (ISAM) missions and services, which represents one of the most significant new upstream commercial markets. Autonomous rendezvous, proximity operations, robotic manipulation, and on-orbit inspection are all heavily AI-dependent. As these capabilities mature, they enable entirely new business models, including satellite life extension through refuelling, in-orbit repair and upgrade, debris mitigation services, assembly of large structures (e.g. antennas, telescopes, space-based solar power), and the development of orbital logistics infrastructures, such as space-based data centres and warehouses.

For the UK industry, this opens opportunities not only for end-to-end ISAM mission and service providers but also for specialist suppliers of robotics, autonomy software, perception systems, digital twins, and assurance tools. AI thus expands the

upstream commercial landscape beyond traditional spacecraft manufacturing into service-based and platform-based offerings.

Reducing cost barriers for deep space and exploration missions

High operational costs, long timelines, and limited human intervention capability have traditionally constrained deep-space science and exploration missions. AI-enabled autonomy fundamentally changes this equation. By enabling onboard decision-making, adaptive planning, autonomous fault management, and intelligent data prioritisation, AI reduces reliance on ground operations and allows missions to operate effectively with fewer human interventions. This lowers lifecycle costs and enables more ambitious missions within fixed budgets.

Commercially, adoption of AI will create opportunities for UK organisations to participate in exploration missions as providers of autonomy software, intelligent science instruments, and mission support systems, rather than solely as hardware suppliers. Over time, this also supports the emergence of commercial exploration services, including privately led science missions, prospecting activities, and precursor missions for crewed lunar and planetary exploration.

Strengthening UK competitiveness in high-value, low-volume manufacturing

The UK's upstream space sector has a strong heritage in high-value, low-volume engineering, where quality, reliability, and intellectual property are more important than sheer production scale. AI aligns particularly well with this industrial profile. By augmenting skilled engineers and technicians rather than replacing them, AI enables UK companies to maintain high standards while mitigating skills shortages and cost pressures.

AI-supported design, inspection, and test tools allow firms to deliver complex systems more efficiently, protect margins, and differentiate on performance and reliability rather than price alone. This is especially important for export-oriented markets, defence-adjacent missions, and institutional customers, where confidence in quality and assurance is a key commercial differentiator.

Reducing operator burden while moving towards Space Traffic Management

In space surveillance and tracking and the wider space domain awareness market, AI is expected to drive the transition from data provision to decision-centric, service-based offerings. Over the next decade, commercial opportunities will increasingly centre on AI-enabled analytics for collision risk prediction, behaviour and intent inference, interference detection, and resilience planning, delivered as continuous services rather than episodic alerts or raw observations.

Advances in machine learning will enable scalable multi-sensor fusion, automated sensor tasking, and adaptive model updating, allowing providers to support growing satellite populations and more complex orbital behaviour without proportional increases in infrastructure or staffing. This shift will underpin new commercial models, including subscription-based SDA services for operators and insurers, managed space traffic coordination, and exportable intelligence products for government and allied customers. As a result, AI will position SST and SDA as high-growth, software-led upstream markets, where competitive advantage is defined by data quality, model performance, and trust, rather than by sensor ownership alone.



AI Applications to Upstream Markets



Mission and System Architecture

AI enables faster mission concept of operation selection, improved decision quality and reduced early-phase risk through:

- Automated requirements analysis and model-based traceability checking
- Large-scale trade-space exploration using optimisation and surrogate models
- Cost, schedule, and risk estimation from historical programme data
- Early identification of supply-chain and mission risks.



Manufacturing

AI-enabled digital manufacturing will improve yield, reduce rework and enhance workforce productivity through:

- Computer vision for quality assurance (solder joints, composites, fasteners, coatings)
- Process optimisation for composites, welding, and additive manufacturing
- Robotic and assisted assembly with vision and force feedback
- Knowledge capture from skilled technicians and digital work instructions.



Spacecraft, Payload and Launch Vehicle Design

AI enables shortened design cycles, mass and power optimisation, and improved performance margins through:

- Generative design of structures and mechanisms
- ML-accelerated Computational Fluid Dynamics, Finite Element Modelling, thermal and electromagnetic simulations
- Payload and instrument parameter optimisation
- Propulsion system design and test data analytics
- Guidance, navigation and control algorithm tuning and validation in high-fidelity simulation and digital twinning.



Assembly, Integration & Testing

Digitalising AIT using AI will reduce test duration, detect faults early, and lower risk through system-level integration using:

- Automated test procedure generation and validation
- Real-time anomaly detection during functional and environmental tests
- Root-cause analysis across telemetry, logs, and configuration data
- Test planning, optimisation and coverage assessment.



In-orbit Servicing, Assembly and Manufacturing

The adoption of AI for ISAM missions will facilitate the life extension of orbital assets, the construction of new orbital infrastructure, the reduction of space debris, and the development of new in-space service markets utilising:

- Vision-based navigation and pose estimation for uncooperative targets
- Autonomous rendezvous, proximity operations and docking
- Robotic manipulation, grasp planning and contact-rich operations
- Assembly sequence planning for large space structures
- On-orbit inspection, digital twins and health monitoring
- AI-enabled additive/subtractive in-space manufacturing and process control.



Space Science and Exploration

Scaling up the deployment of autonomous systems will increase scientific return, reduce reliance on ground operations, and improve mission resilience through:

- Operation of autonomous rovers under long communication delays
- Onboard data processing and science prioritisation



Space Surveillance and Tracking and Space Domain Awareness

- Planetary navigation, hazard avoidance and sample selection
- Instrument calibration, noise reduction and anomaly detection. AI integration in pre-mission planning, sensor optimisation, and data processing improves the speed and quality of planning complex environments, accelerates large-scale data analysis, and reduces the operator burden in extracting time-critical information through:
- High-speed analysis of raw optical and Radar data to identify and correlate observations
- Multi-sensor data fusion and sensor tasking optimisation
- Fragmentation event detection and debris evolution modelling
- Design-stage orbital risk and survivability modelling
- Verification, Validation, and Assurance of SDA-relevant behaviours
- Sustainable mission architecture and End-of-Life planning.

Barriers to Adoption and Value Extraction

Despite clear technical potential and early demonstrations, the widespread adoption of AI across upstream space applications faces a set of interrelated barriers that limit both deployment and the ability to extract sustained commercial and operational value. These barriers span technology, investment dynamics, regulation and assurance, and workforce capability, and are particularly acute in upstream contexts where reliability, safety, and long mission lifetimes are paramount.



Technology Adoption Barriers

- Fragmented engineering data across organisations and lifecycle stages
- Limited access to labelled, flight-relevant datasets
- Difficult validation and certification of probabilistic AI systems for safety-critical missions.



Regulatory Barriers

- Lack of clear AI assurance and certification standards for space systems
- Limited explainability and traceability of AI models for mission assurance.



Investment & Cost

- High upfront costs for data infrastructure, model development, and integration
- Long payback periods that exceed individual programme cycles.



Skills Gap & Training Needs

- Shortage of professionals with both AI and space engineering expertise
- Need for broader workforce upskilling and reskilling to adopt and trust AI tools.

The background is a dark blue field with a faint, light blue grid. Overlaid on this are numerous glowing orange and yellow particles of varying sizes, some of which are connected by thin, vertical lines, creating a sense of dynamic movement and data points.

THE INVESTMENT THEMES

The National Space Investment Themes

A structured review of the UK national space strategy, the space industrial plan, the defence space strategy, the integrated review refresh, and relevant national resilience and environmental policy frameworks formed the starting point for identifying the investment themes for the AIRS roadmap. This review was complemented by a targeted gap analysis examining areas where AI could materially strengthen sovereign capability, economic growth, or risk management within the UK space ecosystem.

Rather than organising the roadmap around technology categories (e.g. computer vision, autonomy, foundation models) or around traditional industrial segments (upstream vs downstream), a service-oriented architecture was adopted. Specifically, Treasury-commissionable national space services were identified that represent enduring public-interest functions capable of being specified, measured and procured over multi-year time horizons.

On this basis, **seven investment themes** structured around a range of national space service capabilities are presented.



Space Domain Awareness & Orbital Security

Positioning, Navigation & Timing Resilience

Secure & Intelligent Satellite Communications Infrastructure

Earth Observation & Intelligent Climate Services

Space Infrastructure & Autonomous Operations

Secure Space Access & Launch Support Services

Cross-Cutting: National Space Data & AI Infrastructure

This approach is both defensible and strategically advantageous for several principal reasons:

- **Alignment with existing government policy:** Each service directly maps to priorities already articulated in national strategy documents, ensuring continuity rather than divergence.
- **Treasury compatibility:** By framing capabilities as measurable services that manage clearly defined risks (e.g., orbital collision, Global Navigation Satellite System denial, climate risk), they can be specified in terms of outputs, availability, resilience metrics, and value-for-money criteria, consistent with Green Book principles.
- **Industrial clarity:** A service-based structure enables industry-led delivery within a defined performance envelope, encouraging competition and innovation while maintaining a minimal sovereign core.
- **Long-term infrastructure logic:** National services are inherently persistent. This provides a stable framework for AI investment and capability maturation over a ten-year horizon, reducing fragmentation and short-termism.
- **Exportability and compounding economic value:** Services designed for sovereign resilience (e.g., SDA, secure SatCom, PNT resilience) are also in high demand internationally, supporting allied collaboration and industrial export growth.



Investment Theme 1: Space Domain Awareness & Orbital Security

The increasing congestion, competition, and potential contestation of the space environment pose material risks to UK civil, commercial, and defence assets. The UK has declared its intention to play a responsible and active role in space sustainability and security. A National Space Domain Awareness and Orbital Security service has therefore been included as a core swim lane.

This service manages risks associated with collision, interference, hostile activity and debris proliferation. It integrates ground-based sensors, space-based observations, data analytics and decision-support systems. AI technologies – including multi-sensor data fusion, behavioural anomaly detection, predictive modelling and operator-assist systems – are central to enhancing detection latency, tracking accuracy and response coordination.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- Human-AI interaction
- AI for planning, optimisation and scheduling
- Machine Learning
- AI for analytics, forecasting and discovery
- Computer vision, e.g. for text classification or translation.

In addition, Physical AI will be critical in enabling collaborative robotics and control optimisation.

Inclusion of this service reflects both national security priorities and export potential. SDA capability is increasingly valued among allies and commercial operators and has potential benefits for aligned markets, such as space-based insurance. Establishing a sovereign, AI-enabled SDA service positions the UK as both a responsible space actor and a high-value provider within allied frameworks.

Investment Theme 2: Resilient Positioning, Navigation & Timing

The UK economy is critically dependent on reliable PNT signals for telecommunications, financial systems, transport, energy distribution and defence operations. Disruption – whether accidental or malicious – would have a significant systemic impact.

The Assured PNT & Resilience service is therefore included to manage national exposure to Global Navigation Satellite System denial, spoofing and timing degradation. This service encompasses signal monitoring, interference detection, alternative timing architectures, and the integration of complementary systems (e.g., LEO augmentation, inertial systems).

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- Human-AI interaction
- Agentic AI
- Edge computing
- AI for planning, optimisation and scheduling
- AI for analytics, forecasting and discovery
- AI for testing and simulation e.g. digital twins/sim2real.

In addition, Physical AI, for example, in the form of physics-enhanced learning and the use and integration of large action models, will be important in interpreting and responding to data.

AI plays a decisive role through anomaly detection in signal space, correlation-based spoof-identification, multi-source data fusion, and predictive interference modelling. By structuring PNT resilience as a commissionable service with defined detection and continuity metrics, the roadmap anchors AI development to measurable national resilience outcomes.

Investment Theme 3: Secure & Intelligent Satellite Communications Infrastructure

Satellite communications underpin sovereign connectivity, defence operations and commercial growth. As networks become more complex and dynamic - particularly with LEO constellations - manual optimisation and static allocation models become insufficient.

The Secure & Intelligent Satellite Communications Infrastructure service provides assured, adaptive and cyber-resilient connectivity. AI technologies – including reinforcement learning for beam management, traffic prediction, spectrum monitoring and autonomous ground operations – enable efficiency gains, resilience and reduced operating costs.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- AI for planning, optimisation and scheduling e.g. cooperative multi-agent systems
- Agentic AI, e.g. autonomic (self-healing) behaviour
- Human-AI interaction

This service has been included due to its dual-use importance and strong UK industrial heritage in ground systems and secure communications. An AI-managed SatCom service model is both nationally strategic and exportable, supporting growth in global managed space services markets.

Investment Theme 4: Earth Observation & Intelligent Climate Services

Earth observation is central to a wide range of mapping, modelling, monitoring and measuring applications across 10's of markets. Central to almost all of these is change, especially driven by significant events such as climate change, which is driving change, risk, and the need to better understand how this change affects significant physical and financial assets. However, the economic value of EO is realised not solely through data acquisition, but through timely, interpretable intelligence. National EO & Climate Intelligence Services are therefore defined as operational intelligence capabilities rather than merely a data collection function.

AI technologies – including advanced computer vision, change detection, predictive modelling and data assimilation – transform raw imagery into actionable insight across a host of risk (flood management, storm damage assessment, wildfire, etc.), land management (agriculture, infrastructure planning), security, defence and sustainability applications.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- Computer vision, e.g. image segmentation
- AI for simulation and testing e.g. digital twins
- Machine learning.

In addition, Cloud AI will be important for storing and managing data across organisations and programmes.

These services (likely to be delivered across multiple organisations) align directly with environmental and economic resilience objectives and will have an impact across key markets and applications on which UK wealth is founded. By formalising EO as a virtual national service i.e. not a single service from a single provider but an ecosystem of providers supported centrally), the roadmap ensures integration between satellite assets, analytics providers and end-users, maximising public value and industrial opportunity.

Investment Theme 5: Space Infrastructure & Autonomous Operations

Sovereign capability requires not only access to services but also control of critical space infrastructure assets. As constellations scale and mission complexity increases, autonomy becomes essential for safety, efficiency and cost control.

The Space Infrastructure & Autonomous Operations service encompasses spacecraft manufacture, asset ownership models, in-orbit services and autonomous mission management for earth orbits and planetary exploration. AI technologies such as digital

twins, predictive maintenance, on-board autonomy and constellation

coordination algorithms underpin this transition.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- Computer vision
- AI for simulation and testing, e.g. immersive technology in the case of space science and exploration, physically-aware rendering
- AI for planning, optimisation and scheduling
- Agentic AI
- Human-AI interaction
- Edge computing
- Machine learning, specifically reinforcement learning.

In addition, Physical AI will be crucial for robot motion planning, control optimisation, and mobile robotics, among other areas.

This service has been included to ensure that the UK does not remain solely a downstream consumer of space services. It provides a structured pathway to build industrial depth and enable AI-native mission architectures over the next decade.

Investment Theme 6: Secure Space Access & Launch Support Services

Secure Space Access and Launch Support Services are critical enablers of the UK's ambition to strengthen sovereign launch capability and compete in an increasingly dynamic global market. The integration of AI across launch operations – from predictive

maintenance of ground infrastructure and autonomous range safety monitoring to real-time trajectory optimisation and weather risk modelling – can significantly reduce operational costs, turnaround times, and mission risk.

By enhancing reliability while lowering per-launch expenditure, AI-driven optimisation supports a shift toward more economically viable and competitive launch services from UK spaceports. This, in turn, contributes to cheaper and more responsive access to space for domestic and international customers, reinforcing national security, commercial resilience, and the growth of a high-value space economy.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- Computer vision
- AI for analytics, forecasting and discovery, e.g. anomaly detection or causal inference
- AI for simulation and testing
- AI for planning, optimisation and scheduling.

In addition, ML will be useful for rapid adaptation of models to new launch vehicles or configurations, rare-event modelling and continuous performance improvement from operational data.

Including this service area within a 10-year AI roadmap for space ensures long-term investment in sovereign, intelligent launch infrastructure that compounds economic and strategic advantage over time. It also positions the UK Space Agency to shape standards, regulatory frameworks, and public-private innovation pathways early, ensuring that AI-enabled launch services become a core pillar of the UK's competitive space offering.

Investment Theme 7: Cross-Cutting: National Space Data & AI Infrastructure

Finally, the roadmap recognises that all services depend on secure data architectures, trusted AI models and robust compute infrastructure. The National Space Data & AI Infrastructure Layer provides the enabling backbone for data governance, federated analytics, sovereign model development, assurance frameworks and digital simulation environments.

Based on the shortlisted AI technologies and functionalities, the following areas are of high relevance to this investment theme:

- AI for simulation and testing, e.g. immersive technologies to support training and synthetic environments, and for verification of systems
- AI for analytics, forecasting and discovery, e.g. to support cyber security of Space systems and uncertainty quantification
- AI for planning, e.g. for resource optimisation across programmes and missions
- Agentic AI, e.g. for lifecycle risk management that supports accountability and governance and to create and execute testing regimes for complex systems.

In addition, AI for content generation will be required to support model and code development, as well as visualisations of missions and artefacts.

This cross-cutting layer ensures interoperability, security and auditability across all services. It reduces duplication, strengthens resilience and provides the foundation for scaling AI safely and responsibly within the UK space sector.

A satellite with solar panels and a parabolic dish is shown in space. The Earth's horizon is visible in the bottom left. A large, glowing blue field of concentric circles and dots emanates from the satellite, representing a data field or signal. The text "THE ROADMAP AND RECOMMENDATIONS" is centered over the image.

THE ROADMAP AND RECOMMENDATIONS

The Roadmap - A Guide

Building on the taxonomy of AI capabilities, the roadmap identifies how core AI technologies and functionalities – such as machine learning, optimisation, autonomous systems, and hybrid physics-informed models – can be progressively embedded across space activities.

The national space investment theme-based swim lane structure provides a coherent framework for mapping both upstream and downstream space activities. Upstream capabilities are aligned with the services that depend on them. Downstream applications are similarly mapped to the services that generate the underlying data or infrastructure.

The swim lanes, therefore, act as integration corridors: within each lane, upstream hardware, software and infrastructure developments can be assessed alongside downstream applications, and AI technologies can be phased according to operational maturity. This avoids duplication, reduces siloed innovation, and ensures AI investment is demand-led rather than technology-led.

The roadmap structures development across three time horizons: Short-term (2026-2030) - focusing on embedding and demonstrating AI adoption by the space sector; Medium-term (2031-2036) - focusing on scaling and certification; and the long-term (2037+), when AI-for-space applications and services become a well-established standard.

For each space investment theme, development pathway titles for each time period are illustrated as horizontal arrows across the roadmap. For each, a range of activities and technology developments (each within a white box) reflect the critical areas for investment consideration. Note that they do not follow a fixed sequence (neither sequential nor parallel) and may commence or conclude at any point within the respective timeframes.

The eight shortlisted AI technologies and functionalities (AI 1 to AI 8) are colour-coded to map against each of the investment themes. Within each

investment theme, the most relevant shortlisted AI technologies and functionalities are identified to the right of the roadmap as coloured boxes relating to the key at the bottom. These are presented with equal weighting and are not ranked by priority. Furthermore, all shortlisted AI technologies and functionalities are relevant to the development pathways identified in each white box and are therefore not explicitly labelled.

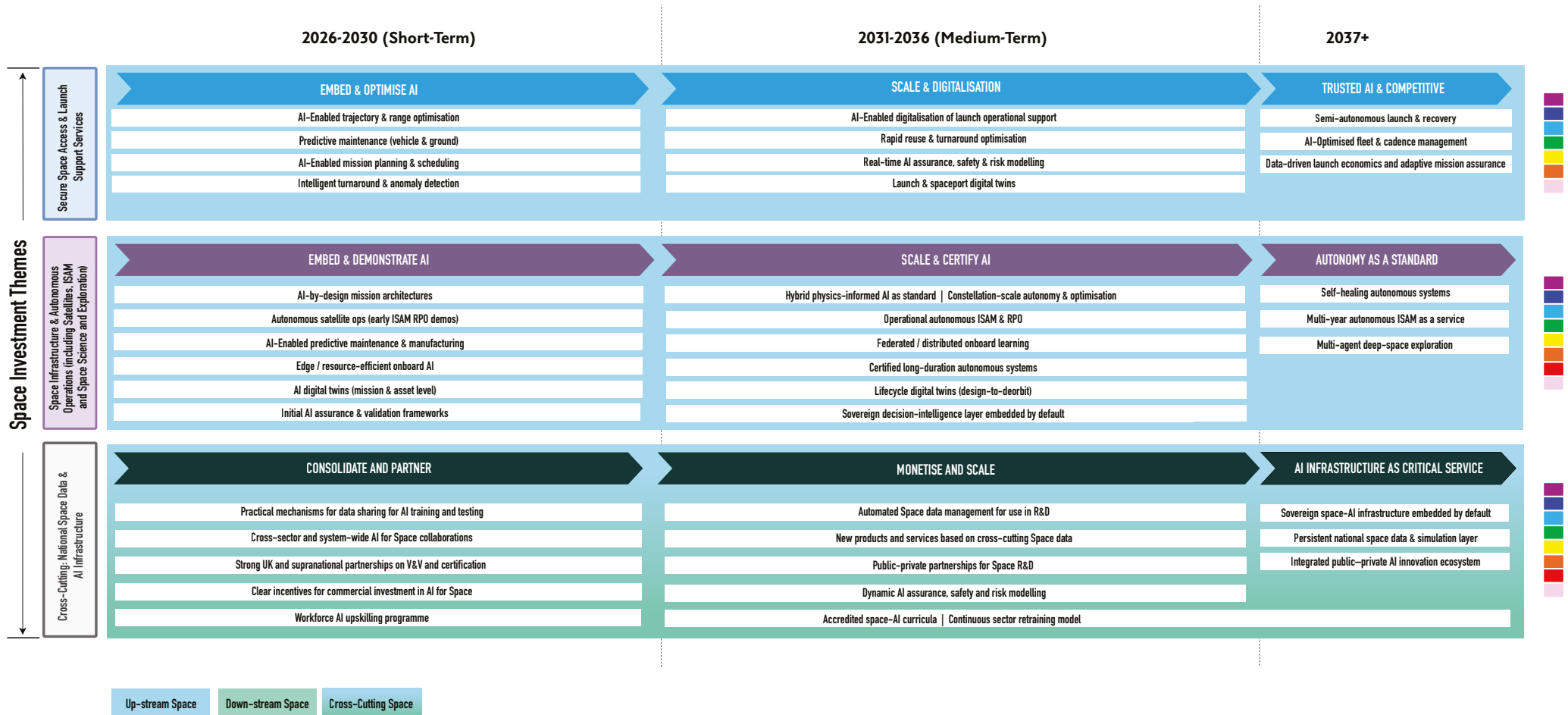
The roadmap highlights current adoption patterns to address capability gaps across satellites, space infrastructure, including launchers, earth observation (EO), satellite communications (SatCom), positioning, navigation and timing (PNT), space domain awareness (SDA), space surveillance and tracking (SST), in-orbit servicing assembly and manufacturing (ISAM), space science and exploration, etc.

It captures mission-and service-led applications where AI delivers the greatest value, including autonomous satellite operations, ISAM services, intelligent EO analytics, resilient PNT, integrated multi-domain sensing for SDA, and AI-enabled launch optimisation. The roadmap accounts for the strategic impacts of these capabilities, particularly in strengthening sovereign decision-intelligence, improving operational resilience, and unlocking high-value commercial services. The roadmap also emphasises cross-cutting national capabilities (such as shared space data platforms, AI infrastructure, workforce skills, and validation and certification frameworks) to enable adoption at scale.

The AIRS roadmap positions the UK to differentiate not through hyperscale infrastructure, but through trusted, resource-efficient, and certifiable AI integrated into national space services. Over time, this enables autonomous operations, secure communications, resilient navigation, and competitive launch capabilities, reinforcing the UK's leadership in responsible and mission-aligned AI-for-space.

AI-for-Space Roadmap





AI 1 Computer vision/image analytics
 AI 2 AI for simulation and testing
 AI 3 AI for analytics, forecasting and discovery
 AI 4 Machine Learning
 AI 5 AI for planning
 AI 6 Agentic/Autonomous AI
 AI 7 Human - AI interaction
 AI 8 AI for non - functional requirements

Shortlisted AI Technologies and Functionalities

Recommendations

R1. Establish a high-assurance AI-enabled national space surveillance, satellite tracking and awareness capability.

The UK Space Agency should prioritise AI development focused on strengthening orbital security and sovereign decision-making in an increasingly congested and contested space domain. This would include using data from multiple sources and employing emerging risk analytics.

Actions include:

- Deploy AI for real-time collision avoidance and hostile activity detection
- Integrate explainable AI and uncertainty quantification into operational SDA/SST tools
- Develop certification pathways for AI-enabled orbital security systems
- Position the UK as a trusted provider of high-assurance SDA/SST analytics internationally.

R2. Employ AI to improve sovereign position, navigation and timing resilience.

Rather than focusing on constellation ownership, the UK should lead in AI-enabled signal integrity, monitoring, and validation. This reframes sovereignty as trusted decision intelligence and resilience rather than infrastructure scale.

Actions include:

- AI detection of spoofing, jamming, and signal degradation
- Fusion of Global Navigation Satellite System, terrestrial timing sources, and alternative navigation signals
- Certification frameworks for AI-enabled PNT assurance systems
- Deployment of integrity monitoring for critical national infrastructure sectors.

R3. Embed AI across satellite communications, supporting security, control and quality

The UK Space Agency should catalyse AI adoption in network integration and secure communications. This enables premium services, strengthening the resilience of secure communications for both civil and defence requirements.

Actions include:

- AI-driven dynamic bandwidth allocation and interference management
- Automated fault detection, predictive maintenance, and cyber-resilience monitoring
- Edge AI deployment for latency-sensitive applications
- Development of assurance standards for AI-managed SatCom systems.

R4. Build and support a national AI-for-earth observation ecosystem for decision support across commercial and government applications

The UK should prioritise downstream earth observation analytics that align with its strengths in climate modelling, risk analysis, and intelligence provision to improve decision-making. This positions the UK as a global leader in AI-powered climate intelligence applied across multiple key markets, including (but not limited to) finance, asset management, food security and defence.

Actions include:

- Establishing coordinated EO-AI ecosystems linking industry, academia, and public-sector users
- Identifying and connecting centres of excellence as “knowledge hubs”
- Developing AI-enabled climate and resilience applications for domestic and export markets
- Creating shared datasets and benchmark challenges to accelerate innovation.

R5. Accelerate AI-enabled autonomy and hybrid Physics-AI systems

The UK should embed AI into spacecraft lifecycle management and autonomous operations. This enhances mission longevity, reduces operational cost, and strengthens upstream competitiveness.

Actions include:

- Autonomous satellite operations (self-diagnosis, optimisation, adaptive tasking)
- Hybrid physics-informed AI for predictive maintenance and anomaly detection
- AI-enabled digital twins for spacecraft and constellations
- Formal validation and certification for long-duration autonomous systems.

R6. Integrate AI into launch economics and spaceport operations

To improve launch competitiveness, AI must be embedded into planning, safety, and turnaround operations. This reduces per-launch costs, increases cadence, and improves reliability in global markets.

Actions include:

- AI-driven trajectory optimisation and weather modelling
- Predictive maintenance for launch vehicles and ground infrastructure
- Digital range safety monitoring and risk modelling
- Digital twin simulation environments for launch operations.

R7. Develop a trusted national space data and AI infrastructure layer

A cross-cutting AI infrastructure layer is essential to support all space services. This infrastructure layer ensures AI is scalable, trusted, certifiable, and aligned with UK strengths in governance and safety-critical systems.

Actions include:

- Federated learning across constellations and ground systems
- Investment in resource-efficient, low-power, and edge AI hardware
- National AI testbeds and simulation environments
- Formal collaboration with the AI Security Institute, Alan Turing Institute, BSI, and UKRI to lead AI assurance and certification innovation
- Embedding AI validation and performance standards in the UK Space Agency funding calls
- Launching challenge programmes focused on frugal AI and low-input models.

R8. Create a specialised national AI central hub to coordinate AI-led activities

A focused hub coordinating UK Space Sector AI-led engagements can help promote the AI agenda within the Space community, driving the national space service capabilities presented in this report. This will benefit both AI-specific ambitions and the UK's wider national space strategy.

A specialised central hub (or national AI-for-space coordination) is justified by the fact that AI adoption in the space sector may struggle if treated merely as an individual, siloed organisational problem.

The UK's space ecosystem is currently highly distributed across SMEs, academia, and government, meaning it requires active ecosystem creation to pool expertise, share risks, and overcome high development costs and fragmented data. The primary benefit of a central coordination hub is its ability to align AI investments directly with the proposed National Space Service capabilities, driving both AI-specific ambitions and the broader UK national space strategy. By designating and connecting these, the UK can effectively upskill the workforce, bridge the gap between academic research and commercial mission deployment, and maximise the return on public and private investment.

Ultimately, this coordination ensures AI is integrated cohesively across the sector rather than remaining trapped in isolated, fragmented pilot projects.



SPACE SECTOR IMMEDIATE PRIORITIES

Immediate Priorities

Investment over the next decade should be targeted, galvanising, and aligned with the UK's comparative advantages rather than attempting to compete on hyperscale infrastructure.

To achieve significant economic growth in AI-enabled space, priority should be given to ensuring that the UK space industry has the resources needed to effectively embed AI across operational activities, as well as in the development of products and services.

The six immediate priorities identified below reflect mission alignment, ecosystem leverage, and long-term sovereign capability. They are explicitly linked to the seven investment themes discussed earlier.

1. AI Assurance, Validation and Certification for Space

The UK should invest strategically in AI verification, validation, qualification, and certification frameworks tailored to safety-critical and autonomous space systems.

This includes:

- Development of space-specific AI performance benchmarks
- Explainability, uncertainty quantification, and risk modelling tools
- Certification-ready digital twins and simulation environments
- Commercial translation of AI V&V research into deployable mission toolkits.

This priority leverages UK strengths in governance, safety-critical systems, the AI Security Institute, the Alan Turing Institute, and BSI-linked standards leadership.

2. Downstream EO Analytics and Decision-Intelligence Platforms

Investment should prioritise AI-enabled earth observation analytics, particularly climate intelligence, risk modelling, resilience planning, and environmental monitoring.

Focus areas include:

- Scalable SaaS-based analytics platforms
- Multi-modal data fusion (optical, SAR, hyperspectral, LIDAR)
- Hybrid physics-informed AI models
- Public-sector demand anchoring to de-risk commercial scaling.

This aligns with the UK's strengths in analytics, financial services, environmental science, and digital innovation.

3. AI-Enabled National Security Capabilities (SDA and PNT Integrity)

Targeted investment is required to strengthen sovereign decision layers in:

- Space domain awareness (multi-sensor fusion, anomaly detection)
- AI-enabled intent inference and probabilistic risk modelling

- AI-based spoofing/jamming detection for resilient PNT
- Federated learning across distributed sensors and constellations.

This reinforces national resilience and creates an exportable assurance service.

4. Resource-Efficient and Edge AI Hardware-Software Co-Design

Given UK constraints in hyperscale compute, priority should be placed on:

- Neuromorphic computing and spiking neural networks
- TinyML and low-power embedded AI
- Photonic and alternative compute architectures
- Model compression, sparse attention, and efficiency-focused ML research
- Radiation-tolerant AI hardware development.

This is essential for autonomous spacecraft, edge deployment, and long-duration missions.

5. Autonomous Operations and Digital Twins for Upstream Infrastructure

Investment should accelerate AI integration into:

- Autonomous satellite health monitoring and reconfiguration
- Predictive maintenance and AI-augmented manufacturing
- Launch trajectory optimisation and turnaround modelling
- Mission-level digital twins for validation and lifecycle optimisation.

These investments improve cost-efficiency, reliability, and competitiveness in global launch and infrastructure markets.

6. Cross-Cutting National Space Data and AI Infrastructure

A shared AI infrastructure layer is critical across all national space services.

Investment priorities include:

- Federated learning architectures
- Secure shared datasets and benchmarking environments
- AI testbeds and simulation frameworks
- Skills pipelines and translational funding mechanisms linking UK Research and Innovation and UK Space Agency.

This ensures interoperability, ecosystem coordination, and scalable adoption.

Action Plan

Building on the investment themes outlined earlier, the following action plan sets out a phased approach to delivering impact across the UK's AI-enabled space sector. It distinguishes between short-term, medium-term, and long-term priorities to ensure that investment remains targeted, coordinated, and aligned with national strengths. This structured roadmap is designed to translate strategic intent into measurable outcomes, supporting sustainable growth, innovation, and sovereign capability over the coming decade.

Short Term Action Plan (2026-2030)

Objective	Build foundations, demonstrate value and embed standards.
	AI embedded in pilot missions, certification frameworks under development, ecosystem coordinated, and the UK positioned as a credible leader in AI assurance and downstream EO intelligence.
The Spending Review 2025 period should focus on catalytic investment, ecosystem coordination, and early mission integration, accounting for the following: • Establish governance and infrastructure foundations • Build the national space data & AI infrastructure layer • Strengthen the EO AI ecosystem • Skills and workforce development	

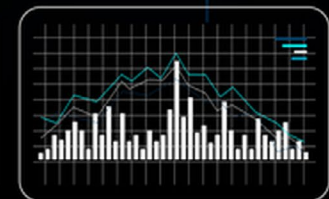
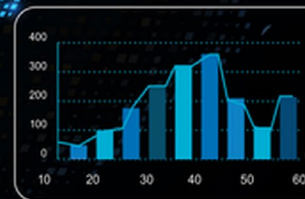
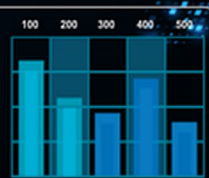
Medium Term (2031-2036)

Objective	Scale integration, export capability and lead in standards.
	AI is fully integrated into UK-supported missions, export revenues from AI-enabled services are increasing, and the UK is recognised as a global authority in AI-for-Space assurance.
By this stage, AI transitions from pilot deployments to operational integration. This spans the following: • Operationalise AI across national space services • Establish global leadership in AI certification for space • Scale commercial platforms • Deepen hardware and efficiency leadership	

Long Term (2037 and beyond)

Objective	Sustain global influence and strategic autonomy.	Beyond 2037, focus shifts from capability building to strategic dominance and resilience covering, but not limited to, the following: • Maintain Sovereign Decision-Intelligence Leadership • Influence International Norms • Sustain Ecosystem and Talent Leadership
	The UK is recognised as a trusted global leader in AI-enabled space systems – defined not by hyperscale compute dominance, but by certified autonomy, resource-efficient AI, decision-intelligence authority, and ecosystem strength.	

METRICS SUCCESS INDICATORS



AI-for-Space Metrics Success Indicators

Success should be measured across five dimensions: technical maturity, economic growth, sovereign resilience, ecosystem strength, and international influence. Over the next ten-year horizon, success should reflect not only technological deployment but also systemic integration and global positioning. The following metrics could be used as guidelines for measuring success:

1. Technical and Mission Metrics

- Number of AI-enabled missions deployed across swim lanes.
- Percentage reduction in manual satellite intervention.
- Demonstrated multi-year autonomous operation in orbit.
- Reduction in onboard power consumption per AI inference.
- AI systems achieving formal validation or certification for space use.
- Deployment of AI integrity monitoring in PNT-critical infrastructure.

2. Economic and Commercial Metrics

- Growth in UK AI-for-space revenues (domestic and export)
- Number of AI-enabled downstream EO platforms reaching commercial scale
- Increase in recurring SaaS-based revenue models
- Inward investment secured in AI-for-space ventures
- Number of UK AI-space SMEs scaling beyond Series B funding
- Number of AI-enabled ISAM missions reaching commercial scale
- Major UK involvement in autonomous exploration missions to the Moon/Mars.

3. Sovereign and Security Metrics

- Deployment of operational AI-enabled SDA/SST systems
- Reduction in time-to-detection for orbital threats
- Demonstrated resilience improvements in PNT systems
- Reduced dependency on non-sovereign AI decision layers.

4. Ecosystem and Skills Metrics

- Number of recognised AI-for-space Centres of Excellence
- Volume of collaborative projects between academia, industry, and government
- Growth in AI-space hybrid skill programmes and doctoral outputs
- Adoption of AI assurance requirements in the UK Space Agency-funded missions
- Evidence of value created through partnership (reduced cost, speed of deployment etc).

5. International Influence Metrics

- UK leadership roles in AI space standards bodies
- Adoption of UK-developed AI certification frameworks internationally.

A low-angle, upward-looking photograph of a satellite being mated to the International Space Station (ISS) inside the payload bay of a Space Shuttle Orbiter. The satellite is covered in gold thermal insulation and has various instruments and antennas visible. It is being positioned by a robotic arm. The background is the blue, curved structure of the orbiter's payload bay, with white structural elements and cables. The word "CONCLUSIONS" is overlaid in white text on a dark blue rectangular background.

CONCLUSIONS

Picture courtesy of ESA

Conclusions

Artificial Intelligence is no longer an experimental add-on to space systems; it is becoming foundational to how space missions are designed, operated, assured, and monetised. The AIRS roadmap demonstrates that AI will shape every layer of the UK space ecosystem – from onboard autonomy and resilient PNT, to EO analytics, secure satellite communications, SDA, SST, ISAM, space exploration, and launch operations.

The UK entered this decade with significant strengths: a top-tier global AI research base, recognised leadership in safety-critical systems, regulatory credibility, and a dynamic innovation ecosystem. However, it does not compete on hyperscale compute or capital intensity with the United States or China. The strategic conclusion of this roadmap is therefore clear: the UK must differentiate through trusted, certifiable, resource-efficient, and mission- and service-aligned AI.

Across downstream applications, the greatest near-term economic opportunity lies in AI-enabled decision-intelligence – particularly in EO analytics, climate services, and SDA – where the UK's software, modelling, and analytical capabilities can scale globally through digital platforms.

In upstream domains, AI will increasingly determine competitiveness by reducing lifecycle costs, extending mission duration, enabling autonomous operations, and improving launch economics. Sovereignty in this new era is defined less by asset ownership and more by control over intelligence, assurance, and trusted decision layers.

The AIRS roadmap highlights that adoption barriers are rarely technical alone. They relate to validation and certification, investment structure, skills gaps, procurement mechanisms, and ecosystem fragmentation. As such, the central requirement is not isolated technology funding but coordinated ecosystem development aligned to mission priorities. Embedding AI assurance requirements into procurement, connecting centres of excellence as national knowledge hubs, investing in frugal and edge AI, and anchoring public-sector demand will be essential to scaling adoption.

By 2036, success should not be measured solely by the number of AI-enabled satellites in orbit. It should be defined by whether the UK has:

- Embedded AI as a default design principle across its national space services.
- Established global leadership in AI assurance and certification for safety-critical space systems.
- Scaled commercially competitive AI-enabled EO, security and ISAM services.
- Strengthened sovereign resilience in SDA, SST and PNT integrity.
- Built a coordinated, skills-rich AI-for-space ecosystem capable of sustained innovation.

Internationally, the UK has a unique opportunity to lead in AI governance, verification, and certification for space systems. By collaborating strategically while retaining sovereign control over assurance layers, the UK can shape global norms for safe and responsible AI in space. Over the next decade, influence in standards-setting may prove as important as technological deployment.

CLOSING REMARKS

Evidence suggests that the UK may not out-scale global AI or constellation leaders, but it can out-integrate and out-govern them. If executed coherently, the AIRS roadmap positions the UK not as a follower in hyperscale AI, but as a trusted architect of intelligent, secure, and resource-efficient space systems. The next ten years will determine whether AI becomes a transformative growth engine for the UK space sector or remains a collection of isolated pilots. The strategic choice is now one of coordinated action, sustained investment, and mission- and service-led implementation.

ARTIFICIAL INTELLIGENCE ROADMAP FOR SPACE

Strategic Priorities for the UK Sector 2026 - 2036