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FOR WHAT COMES NEXT

techUK's **Emerging Space Technology** Industry Perspective Report

Supercharging UK Tech and Innovation

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Introduction

Not since the invention of the Internet has industry been presented with such a potentially transformative opportunity to create, re-shape and re-define entire industries, both on Earth and in space.

Whilst space was once the domain of a handful of Governments, recent technological advances have significantly improved the ability of a wide range of actors to access, utilise, and transform the space environment. The aggregation of this increased commercial activity and reduced dependence upon Government is referred to as the 'New Space Economy'.[1]

The UK's technology industry is well positioned to capture a significant proportion of this market and solidify the UK's status as a New Space Superpower.[2] The UK has a long legacy in space, having deployed its first satellite in 1962 and launched its first rocket in 1972.[3] It boasts three of the world's top-ten universities as ranked by overall performance,[4] a world-renowned manufacturing sector, and a legacy of pioneering key emerging technologies such as the turbo-jet engine, radio technology, and powered flight.[5]

However, this will not happen automatically. This publication, techUK's first 'Industry Perspective' report on emerging space technologies, sets out four components that will be critical to the UK's degree of success in the New Space Economy:

1. The emerging space technologies that the UK must successfully develop, apply, and commercialise if it is to stand a chance of maximising the opportunities presented by the New Space Economy. These include Artificial Intelligence (AI), quantum technologies, and robotics.

2. The key industries that will be underpinned by these technologies and that the UK must be equipped to re-shape, re-define, and create. These include satellites and telecoms, defence, and data centres.

3. The six key enablers that will determine the UK's ability to lead in these technologies and industries. These include greater involvement from non-space companies, streamlining regulation, improving domestic and international recruitment, a varied and mature space finance ecosystem, early action on sustainability, and space-related trade policies.

4. Ten policy recommendations that turn these enablers into practical and realistic actions for industry and Government. Listed below, these cover a broad range of topics, from incubators and accelerators to visa applications and trade deals.

These components have been informed by a four-month 'sprint campaign' led by myself on behalf of techUK's Technology & Innovation programme. Only by getting them right can the UK convert its legacy, expertise, and early lead in space technologies and innovation into greater prosperity and security. Doing so should secure its status as a New Space Superpower and enable it to fully realise the immense potential brought about by the growing commercialisation of space.

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Ten recommendations to make the UK a New Space Superpower

1.

Organisations in future New Space industries should encourage and support increasing numbers of non-space companies to participate in space incubators and accelerators

This should result in the development, application, and commercialisation of a wider range of space products and services spanning many of the industries set to underpin the New Space Economy. Trade associations in traditionally non-space industries could launch promotional campaigns or the space programmes themselves could allocate additional resources towards establishing more cross-sector partnerships.

2.

Government should ensure Space Clusters are well equipped to enable a growing number of non-space companies to identify, develop, and exploit cross-sector opportunities

Whilst these already enable cross-sector opportunities by engaging non-space sectors such as health and agri-tech, this function will only become more important and resource dependent as the New Space Economy brings additional industries into the umbrella of the space sector. Such support could take the form of a long-term funding settlement to scale the services provided by Space Clusters gradually, predictably, and ultimately sustainably.

3.

The Civil Aviation Authority (CAA) should continue to streamline its application and review process for space systems

Further accelerating the licensing process, perhaps through reducing documentation requirements, could result in lower deployment times and costs for businesses whilst boosting inward investment. The overhaul of the CAA's Space regulation website in November 2023 was a positive start.

4.

Government must ensure that space and non-space companies can continue to shape the Space Workforce Action Plan following its publication

This is essential if the plan's focus is to evolve alongside the emerging technologies and industries set to underpin the New Space Economy. Government could equip the Space Skills Advisory Panel with the power to continually review the plan or commit every few years to hold additional industry workshops and update the plan accordingly.

5.

Government should look to reduce the cost and complexity of visa applications by promoting and expanding existing visas

This would address the two main barriers to the recruitment of international talent in the space sector. Alternative visas to promote include the UK Graduate visa, High Potential visa, and Youth Mobility visa, whilst Government should expand the eligibility criteria of the last two to a much wider range of universities and countries.

6.

Government should look to diversify the space funding landscape by shaping new financial initiatives, reforms, and support packages with the space sector in mind

Creating a more competitive space finance landscape should improve the terms behind funding, helping space companies to scale and reducing their propensity to relocate abroad. Government should continue to pursue the implementation of the VC Framework for Space and Mansion House reforms in full consultation with industry whilst shaping the scale-up support package to address the funding concerns of space SMEs.

7.

Government should consolidate its space-related purchasing, particularly in EO data, before passing any benefits onto industry

Doing so should stimulate the market by leveraging Government's economies of scale across multiple departments to the advantage of UK SMEs. Making EO data centrally available would provide industry with access to cutting-edge capabilities years sooner than otherwise. This should improve scalability and the UK's ability to shape then capture a significant proportion of the value that is expected to be generated through the emergence of the New Space Economy.

8.

Space and non-space companies should leverage the UK's leadership in space sustainability by getting involved early in Government's technology development schemes, dedicated space technology facilities, and nascent international initiatives

Doing so will enable them to access time-limited resources, iterate their products and services in a lower risk environment, and exploit the commercial opportunities created by a growing UK-led international consensus around space sustainability, regardless of whether they would traditionally call themselves a 'space company'. SMEs should work through organisations such as UKSA, techUK, UKspace, Satellite Applications Catapult, and Space Clusters to aggregate activity and amplify impact.

9.

Government should expand the scope and duration of the ‘Unlocking Space for Business’ programme to better align it with the sustainability requirements of the New Space Economy

Doing so should ensure a dependable and long term offer of support for companies utilising emerging technologies to drive more sustainable outcomes across many of the key industries that are set to underpin the New Space Economy. This could involve widening the programme’s scope outside the Financial Services and Transport & Logistics sectors and extending its duration to well beyond March 2025. The sustainability implications of such a policy could be significant, as demonstrated by the estimated Carbon Dioxide savings enabled through the enhanced use of satellite communications, satellite navigation, and IoT technologies.

10.

Government should push for the inclusion of innovation chapters and negative list systems in future trade deals covering emerging space technologies

Through leveraging international space partnerships such as the UK-Australia Space Bridge, the UK can turn consensus into tangible trade benefits. The inclusion of innovation chapters in Free Trade Agreements (FTAs) would facilitate cooperation around the trade of emerging space technologies whilst the addition of negative list systems would then shield these technologies from international tariffs unless explicitly added by a country to a list. This would pave the way for greater international cooperation around emerging space technologies and reduce the risks faced by the UK companies developing these.

Chapter 1
Seven emerging technologies integral to UK leadership in the New Space Economy

This chapter sets out the seven emerging technologies in which the UK must lead if it is to stand a chance of maximising the opportunities presented by the New Space Economy. This will involve improving its ability to develop, apply, and commercialise these technologies within the broader global trends that have begun to significantly accelerate the shift towards the New Space Economy in recent years. These are the miniaturisation of satellites and the development of reusable rockets.

Due to the electronics revolution and sharing of satellite designs, satellites have reduced from the size of a car to that of a shoebox. As a result, 94% of all spacecraft launched in 2020 were categorised as 'smallsats'.[6]

Equally, rocket reusability enables launch providers to re-fly the most expensive parts of the rocket, subsequently driving down the cost of space access.[7] These rockets are increasingly utilising AI to enable autonomous launch systems, navigation and trajectory optimisation, precision landing, predictive maintenance, and fault detection and diagnostics. This use of AI – combined with advances in propulsion systems, materials science, 3D & 4D printing, CubeSat manufacturing, and mass fabrication technologies – has resulted in a 97% reduction in launch costs from the era of fully expendable Russian Soyuz rockets in the 1960s to almost fully reusable SpaceX rockets in the early 2020s.[8] Launch costs are predicted to fall by a further 89% by 2030.[9]

Today there are nearly 7,500 active satellites in orbit around Earth[10], up from around 2,200 in 2019. This trend will only accelerate as multi-satellite constellations continue to expand and the on-orbit servicing, assembly, and manufacturing (OSAM) sector that is set to underpin the New Space Economy further develops.

The UK Government has set out the five critical technologies that it expects to be most important to its vision of making the UK a science and technology superpower by 2030. These are AI, Engineering Biology, Future Telecommunications, Semiconductors, and Quantum technologies.[11]

techUK member organisations are leading on the development, application, and commercialisation of these. Examples include Airbus's ExoMars rover,[12] Orbit Fab's in-space refuelling interface,[13] Planet Labs' high frequency satellite data fleet,[14] Amazon Web Services' (AWS) high-performance compute for aerospace and satellite,[15] and Reaction Engines' advanced propulsion technologies.[16]

The following chapter sets out seven emerging technologies that techUK members have stated will be crucial to the UK's ability to reap the rewards of the New Space Economy. Throughout, it includes explanations regarding how the technologies may be utilised in practice. Several are also accompanied by an illustrative case study, each provided by a techUK member.

1. Artificial Intelligence

The future of space will be enabled by AI. Satellites are already using edge AI[17] to deliver real-time observation and on-board data processing whilst lunar landers have employed AI-powered sensors to touchdown on the Moon and navigate its topography.[18] The use of AI in space will continue to grow as astronauts increasingly utilise AI assistants to conduct tasks and experiments, satellites become more reactive, agile and autonomous, and as the large volumes of data satellites gather require processing and analysis directly onboard the satellites themselves. In addition, AI will increasingly converge with a wide range of emerging technologies. For example, the technology could be combined with Digital Twins to enable in-Space visualisation and forecasting or robotics to assist with the automation of activities such as navigation and docking.[19] Industry can expect to encounter AI-enabled products, services, and activities in almost every aspect of the New Space Economy.[20]

Case Study

Fujitsu uses AI to support the transformation of space debris removal

Less than a year on from the UK Space Agency (UKSA) first committing funding to combat space debris in 2020,[21] Fujitsu UK successfully combined quantum-inspired computing and AI to support the transformation of space debris removal.

Fujitsu's prototype – which was in collaboration with AWS, Astroscale, and the University of Glasgow – was designed to improve mission planning so that a single spacecraft can utilise AI to efficiently select which pieces of space debris to remove and at a faster rate than is currently possible. The removal of space debris is key to sustainability in space, as this practice reduces, or even prevents, the risk of obsolete spacecraft colliding with new and existing satellites.

What's more, supporting debris removal missions with Fujitsu's technology will help to reduce the risk of catastrophic collisions in orbit which could create thousands of other pieces of new debris, all of which pose a real threat to working satellites in orbit.

By optimally deciding which debris is collected and when, Fujitsu's AI and quantum-inspired offering, powered by the Digital Annealer, optimises the mission plan to determine the minimum-fuel and minimum-time required to bring inoperable spacecrafts or satellites safely back to the disposal orbit. Finding the optimal route to collect the space debris saves significant time and cost during the mission planning phase, and consequently improve commercial viability.

With around 2,500 non-working satellites currently in orbit, and more than 35,000 pieces of debris being tracked by Space Surveillance networks,[22] Fujitsu's technology will help the UK to grow its market share in the space sector. It will also further support the UK Government's commitment to a more sustainable future.

2. Quantum Technologies

Quantum technologies will play a key role in underpinning the New Space Economy by improving the collection, generation, and processing of information in ways not possible with existing technologies.[23] Quantum sensors will enhance the sampling, latency, and data quality of sensing technologies while chip-scale atomic clocks could enable increasingly sophisticated and large constellations of low-cost satellites.[24] Companies should begin exploring the potential of quantum technologies early as their use is predicted to have significant and wide-ranging implications.[25]

The UK should view its commitment to building a quantum innovation ecosystem as one of its key successes since the National Quantum Technologies Programme (NQTP) was established in 2014.[26] This pioneering programme has already delivered £1 billion of investment and will be instrumental in investing the £2.5 billion necessary to secure the UK as a world-leading quantum-enabled economy by 2033, as set by the National Quantum Strategy.

techUK welcomed the publication of a National Quantum Strategy to build upon this early success and champion the UK's position as a pioneer in quantum technologies[27] Now, Government, industry, and academia must leverage the recommendations of the Quantum Strategy to facilitate clear, long-term, and commercially driven action.

Case Study

UK companies develop Quantum Key Distribution (QKD) satellite systems to enable quantum safe cryptography

One consequence of an increasingly interconnected world is the growing threat and destructive potential of cyberattacks that leverage quantum computers. These are expected by major national security agencies to 'break' or 'hack' current public key encryption systems.

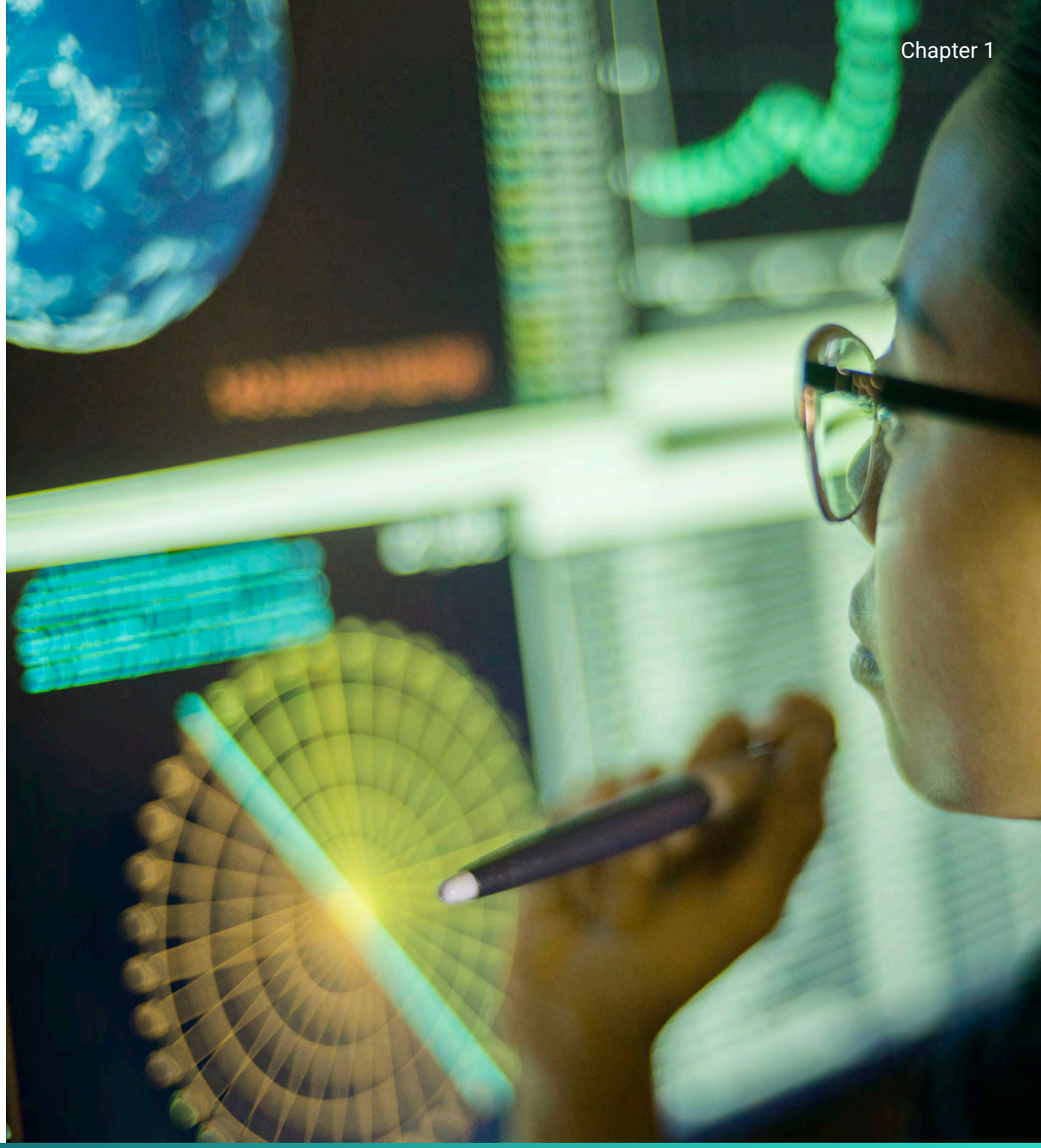
Several Quantum Key Distribution Satellite (QKDSat) projects have been undertaken by various UK organisations, including those co-funded by UKRI, UKSA, UKNQTT schemes.[28] Over the coming years, these will demonstrate how a space-based infrastructure employing the laws of quantum mechanics can be used to enable the secure exchange of sensitive information between several parties at end points located in the UK or internationally.

Such projects would provide secure cryptographic key delivery services to customers on the ground for a range of applications, serving private and government sectors where the security and confidentiality of shared information is crucial.

They will also significantly boost the UK's capabilities in cybersecurity and secure communications. This will help to reinforce UK scientific leadership and excellence in quantum enabled secure communication and will increase the UK's and Europe's autonomy in this strategic field. This is crucial given that major states such as China, India and Russia are already very active in the field.

3. Sensing and Data

Increasingly sophisticated sensing technologies are revolutionising the collection, capabilities, and applications of space data. Since 2020, the incorporation of Light Detection and Ranging (LiDAR), radar, and compound multimodal sensor arrays has resulted in an exponential increase in data collected from space. An estimated 2000 to 3000 Earth Observation (EO) sensors will be deployed in space by the end of the decade, most likely necessitating the use of AI and synthetic data[29] to automate data processing and analysis.[30] In situations in which it is impractical to use physical sensors, these can be replaced by virtual ones. Virtual sensors are coded into the software of embedded systems within real-world objects such as satellites. They consume less power and can be combined with edge AI models to add extra sensor capabilities.[31] The field of sensing and data will have profound implications for businesses, both on Earth and in space, provided these can effectively sort, interpret, and action said data.



Case Study

Planet Labs unharnesses commercial space data

The past decade has seen seismic growth in the commercial space sector. Commercial remote sensing companies are building smaller satellites, taking advantage of affordable and assured space launch and secure cloud technologies, making data widely shareable and accessible. It is now commonplace for companies to use this data alongside AI at scale to measure crop health and maximize crop yields, monitor forest canopy change, and track infrastructure and land use change.

Organisations now have access to a range of commercial space data including Electro-Optical, Synthetic Aperture Radar, Radio Frequency and Thermal capabilities. Sensors today are being launched with increased frequency, improved resolution, faster revisit times, with the ability to capture changes on Earth multiple times a day. Planet, a leading provider of global, daily satellite imagery and geospatial solutions, collects millions of new images each day, contributing to their 30 Petabyte archive - and that is just one company.

So how can businesses possibly make sense of this data?

Many recognise that due to the vast quantities of commercial data available, in some cases 'human-first' analysis of data may no longer be sufficient. In the Defence & Intelligence domain, the former Director of the National Geospatial Intelligence Agency (NGA), Robert Cardillo, stated that he estimated roughly eight million analysts would be required to purpose the data now available from commercial space collectors.[32] Realising the problem, organisations have created strategies to ingest commercial datasets alongside AI, gaining insights from data not possible with humans alone.

Notably, is the ability to find previously unknown objects from these datasets. In one example, Planet and its partners at Synthetaic were able to find and subsequently track the Chinese balloon that flew over the continental US this year, back to its launch site using a radically new AI approach.[33] If the balloon was a needle in the data, Synthetaic was like bringing a magnet to the search, making nearly trivial what was otherwise nearly impossible.

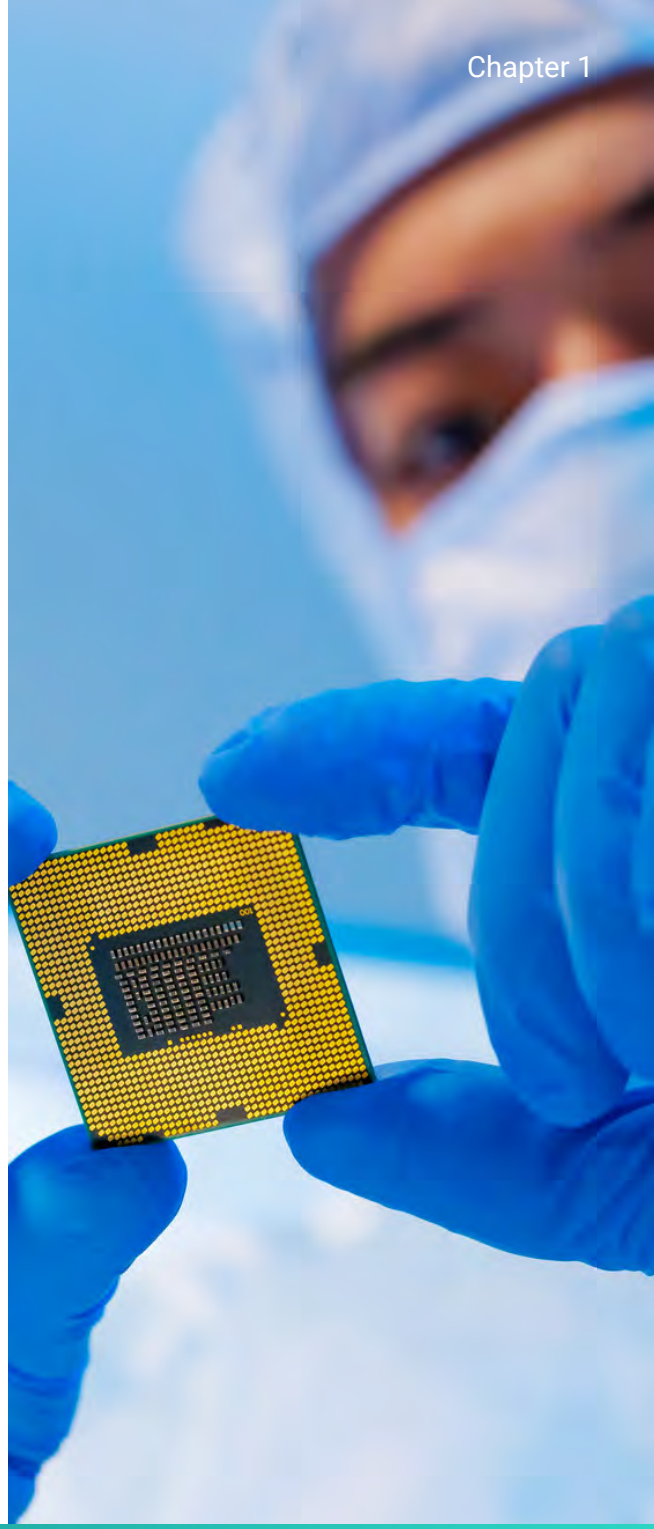
In another case, Planet satellite data was used by NASA Harvest to better understand the conditions of the crops planted and harvested in Ukraine on a bi-weekly basis. This output was then used to measure food production and the effect of the ongoing conflict. Initially, they discovered that far more crops were being harvested that had been originally expected.[34] The combination of these datasets and AI is helping to unlock the true potential of EO data and the future is bright.

4. Robotics

Few emerging space technologies will be as fundamental to the operation of the New Space Economy as robotics. Automated robots will assemble rocket components on Earth at the scale required to further reduce launch costs whilst autonomous robots will utilise AI and Machine Learning in space to perform more 'intelligent' tasks. Many of these tasks will be integral to the in-orbit servicing and manufacturing sector, which due to its openly available set of standards for robotic interconnectors will see widespread industry engagement. The UK already has strong robotics capabilities in non-space domains whilst its leadership in robotics software will prove crucial as robotic systems become increasingly intelligent, integrated, and interoperable.[36] On Earth, space-based data and services will empower robots to perform a far broader range of tasks, with notable applications in agriculture, logistics, and maintenance.[37] Businesses should view robotics as an enabler for other emerging technologies and begin exploring its use cases.

5. Semiconductors

The unique properties of space, namely microgravity and the presence of a natural vacuum, present promise for the semiconductor industry. Whilst the benefits of in-space fabrication could be relatively small, a reduction or absence of gases could facilitate innovations in thin-layering techniques and result in smaller semiconductor structures.[38] New semiconducting materials, such as gallium nitride, will be better suited to space missions by offering higher power capacities and greater resistance to radiation and extreme temperatures.[39] Whilst the potential benefits of semiconductors in space are currently limited, even a small improvement in the quality or performance of advanced chips could have profound implications for a wide range of industries.[40]



6. 3D & 4D printing

Additive manufacturing, or '3D printing', can transform our ability to manufacture everything from food and clothes to satellites and rocket engines. Boeing and Airbus, for example, have employed the technology to create lighter and more complex satellite components. In addition, astronauts on the International Space Station (ISS) have conducted experiments into whether bioprinting could be used to support medical treatment during long-term space expeditions and planetary settlements,[41] whilst in 2021 the ESA announced that it would conduct tests into 3D printing in a micro-gravity environment.[42] In the longer term, 4D printing will introduce new capabilities for in-space assets as materials can be printed with the ability to change form or function over time in response to various stimuli such as heat, current, water or light. This could reduce the size and weight of deployable structures, such as antennas or sensors, by removing the need for deployment mechanisms.[43]

7. Space Systems

All emerging technologies will be incorporated in Space Systems. These are vehicles and infrastructure that perform a specified task within the space environment. Over the coming decade, Space Systems will form increasingly large, complex, and autonomous constellations in which on-orbit assets utilise self-diagnostics, robotics, and AI to conduct repair and servicing operations. We will see the introduction of the first commercially owned and operated space stations.[44] These will replace and augment the functions of the ISS, due to be decommissioned by 2030,[45] and serve as a launchpad for companies seeking to exploit the opportunities unlocked by the New Space Economy within and beyond Earth's orbit.

This chapter has explored the seven emerging technologies that the UK must successfully develop, apply, and commercialise if it is to stand a chance of maximising the opportunities presented by the New Space Economy. Crucially, these will increase the UK's capabilities in areas such as space debris removal, quantum communications and cryptography, and in-orbit servicing and manufacturing. Integral to maximising such opportunities is the UK's ability to lead in the key industries set to be underpinned by these technologies. The following chapter explores five of the most significant, as set out by techUK experts operating in the industries in question.

Chapter 2
The key industries that the UK must be equipped to transform

The emergence of the New Space Economy will have profound implications for virtually every industry. Some will be re-shaped, with the introduction of new products, services, producers, or consumers. Other industries will be re-defined as their business model or purpose evolves. Many more industries will be created as new solutions to problems emerge as a by-product of the growing commercialisation of space.

Whilst it is too early to conclude the fate of specific industries, this chapter sets out several that are predicted to undergo significant transformation due to the emergence of the New Space Economy. In doing so, it incorporates all the emerging technologies set out in Chapter 1 and outlines how such transformations are expected to translate into significant opportunities for the UK and its technology industry. Each section has been written by techUK's experts from the industry in question. The chapter ends by touching upon several other industries, including in-space manufacturing and energy, before moving on to the key enablers that will determine the UK's ability to lead in these technologies and industries.

Satellites and telecoms

Tales Gaspar, Programme Manager for the UK Spectrum Policy Forum and Satellite, techUK

Satellite technologies play a crucial role in providing broadband connectivity, particularly for rural and isolated communities, by offering a cost-effective and operationally efficient solution spanning a wide area with a high degree of service performance. DSIT's Future Telecoms Programme adopts a 'network of networks' approach to tackle this 'digital divide'[46] and in November 2023, Building Digital UK[47] announced the launch of its £5 billion Project Gigabit programme to give hard-to-reach communities access to lightning-fast gigabit-capable broadband.[48]

In the short term, 5G-compliant satellite backhaul will provide Open Radio Access Network capability and reliable connectivity. This will enable Internet of Things (IoT) devices, automated farming machinery, remote healthcare, and other vital community services. Advancements in EO, alternative satellite communications beyond radio frequencies (such as optical laser enabled free space communications), and ground system terminal technologies are poised to herald a new era in super high-capacity satellite capabilities. This encompasses developments in higher-resolution imaging and the implementation of optical satellite communication and quantum tech-enabled communications through the exploitation of laser transmission. Such innovations will enable new applications or services for in-orbit systems.

Satellites will increasingly operate at lower-earth and very-low-earth orbit (VLEO), plus other Non-GEO orbits (such as MEO), offering greater observational capability or communications capacity density. These will require novel design paradigms, including the integration of advanced materials, power generation, propulsion, and orbital manoeuvring capabilities.

In the medium term, the UK must build upon its leadership in satellite communications, software, data, manufacturing (particularly of smallsats and sub-systems) and quantum technologies to compete in the approaching era of large LEO constellations. One model for industry to consider is Planet Labs' 'agile aerospace' method. This involves frequently releasing new designs, testing them in space, then making rapid changes.[49] Another is mass fabrication. The Zero Capital Factory, located outside Glasgow, can already develop around 50 smallsats in one production run.[50]

> ***"I suppose that if one were to go down to Texas to the Starlink factory, I suspect that Mr Musk has some sort of mass fabrication capability where he is developing a lot of satellites at pace. We don't have that".***
> Dan Jones, Future Markets Lead, UKSA[51]

As we continue toward ubiquitous wireless intelligence, 6G represents the next iteration of cellular network technology. Projected for deployment in the early 2030s, LEO, MEO and GEO satellite systems promise to deliver new horizons for 5G-Advanced and 6G through integrating terrestrial and non-terrestrial networks.

Finally, the National Quantum Strategy Missions aim to pioneer the future of quantum Internet by deploying the world's most advanced quantum network at scale by 2035.[52] This would include quantum-enabled satellite communications, plus time transfer and sensing systems. The UK should therefore look to achieve scale computing, nationwide connectivity, early commercialisation, and international leadership. techUK welcomed this approach of integrating quantum technologies within our digital infrastructure to transform how we secure, transmit and compute our data.

Cyber

Jill Broom, Programme Manager for Cyber Security, techUK

Dan Patefield, Head of Programme for Cyber and National Security, techUK

Robust cyber security will underpin UK industry's success in the New Space Economy by enabling businesses to unlock the full potential of many critical emerging space technologies.

Over the past decades, space infrastructure has become an integral part of our lives, facilitating connectivity, weather forecasting, climate modelling, and positioning, navigation and timing (PNT) services. This trend, combined with an ever-evolving threat landscape and a history of piecemeal cyber security protocols in the sector,[53] has meant that the risk of compromise or destruction of these systems is becoming increasingly likely and costly.

As such, emerging technologies used in space must be Secure by Design, with security built in from the very outset of their conception. By considering the potential harm caused by emerging technologies during the design phase, businesses can proactively plan for contingencies, whilst prioritizing ethics to mitigate the risks.

The shift towards modern software-defined satellites and cloud-based systems, combined with the emergence of blockchain and IoT technologies, has created the possibility for industry to fix long-standing security issues in the sector.[54] One example of an innovative UK-based SME doing this is CyberHive. Their product, CyberHive Connect, secures connections to IoT, OT (operational technology) and IT devices with quantum-safe cryptography and can tolerate working over poor networks such as those with intermittent connections, high packet loss and high latency in satellite and mobile networks.[55]

Only by preparing for cyber-attacks will businesses be both able and ready to respond to and recover from them. There is no silver bullet to becoming cyber secure, but a holistic approach that encompasses people, processes, and technology will help companies to significantly lower the risk of a successful attack.[56]

Whilst cyber skills are a critical resource for the space sector, the cyber sector continues to face a significant gap between the supply of skilled individuals and considerably greater demand. According to ISC2's 2023 Cybersecurity Workforce Study, the gap has reached a record four million people, a 12.6% increase since 2022.[57] The UK must continue to invest in this resource and build upon the success of existing cyber education and work experience initiatives such as CyberFirst.[58] It should also find innovative ways to address this skills gap to ensure that there is a pipeline of skills to address future cyber security requirements.

Government has a role to play in setting cyber security standards and best practice for the New Space Economy. It is critical that the UK does not make siloed interventions, particularly around regulation, instead continuing to work closely with like-minded international partners such as the US, Five Eyes (FVEY), and the EU to share best practice and take a coordinated approach where appropriate.

This will help shape an optimum ecosystem in which the space industry of tomorrow can access the latest innovative cyber solutions unhindered by unintentional barriers to market entry. This is particularly important for SMEs. Industry will also play a key role in offering an expert practical lens through which to develop and assess any new standards, rules, or regulations.

Defence

Fred Sugden, Associate Director for Defence and National Security, techUK

The New Space Economy is driving a period of rapid change within the Defence sector.

The alignment of the National Space Strategy (NSS)[59] and Defence Space Strategy (DSS)[60] underpins this and is indicative of the willingness across civil Government and defence to work together to deliver optimal outcomes for the UK as a meaningful space actor.

Early evidence of this joined-up approach has come with the publication of the Cross Government Space Domain Awareness (SDA) Requirements.[61] Risks to the space environment affect all operators across civil and Defence. Situational awareness can determine whether space objects may interfere with satellites in orbit, prevent a returning space object from triggering a false alarm in missile-attack warning systems, or provide data for potential anti-satellite weapons systems. As such, SDA will mitigate the risks associated with an increasingly congested space environment in which incidents of unscheduled close-proximity manoeuvres are rising. Such manoeuvres may allow for listening in to communications satellites, to achieve contact using robotic arms, or, at its most devastating, to enable anti-satellite testing (ASAT). This was last demonstrated by Russia in November 2021, creating a debris field of over 1,500 pieces.[62]

Businesses and Government must collaborate and invest in SDA to pre-emptively identify potential threats to space systems which could enable actors to recognise suitable countermeasures. As the volume and variety of SDA data increases, industry must develop sufficiently sophisticated AI technologies to determine intent of action and enable conjunction warning analysis. Similarly, as cis-lunar activity increases, the UK must also maintain awareness in the lunar domain, potentially via close collaboration with FVEY partners.

The UK and its allies will continue to integrate future space-based assets into Land, Sea, Air and Cyber capabilities. Doing so will enhance situational awareness by enabling rapid and informed decision-making. As new assets and technologies come online, space intelligence capabilities will provide real-time insights into threats. In addition, secure communications systems will ensure resilient and encrypted channels for seamless information exchange.

Over the coming decades, embracing and investing in cutting-edge space-based assets and technologies will position the UK at the forefront of Defence Space sector innovation.

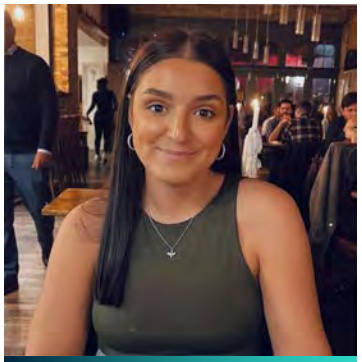
To achieve this, the procurement of space-based technologies and platforms must move faster. The MOD has recognised this and is evolving procurement rules, processes, and systems to boost commercial agility, reduce negotiation timescales and enable more rapid delivery of capabilities. techUK's Defence & Security Board[63] remains committed to working with the MOD and its Delivery Agencies to improve the speed of Defence procurement.

As military groups reflect on the benefits of private space data within conflicts, the future of space

business will head further towards partnerships and information-sharing coalitions. These will consist of Defence organisations and industry, akin to FVEY agreements enabling the UK and allies to share space data. By partnering with industry, Defence can benefit from access to leading innovations and fast-paced development pathways, while industry can benefit from the security and stability of Government contracts. This collaboration already occurs in several sectors of space, including research, shared access to infrastructure, and joint programmes to launch or develop space missions.

Finally, the UK should maintain its leading position on norms of behaviour in space through the UN Open-Ended Working Group[64] and further develop industrial capability across SDA.

National Security



Raya Tsolova, Programme Manager for National Security, techUK

Leadership in the New Space Economy is a prerequisite for ensuring and maintaining the UK's national security. This is particularly important given an increasingly contested space environment, hostile geopolitical landscape, and rapid emergence of new threats to essential UK capabilities, most notably intelligence and space research (ISR) and PNT.

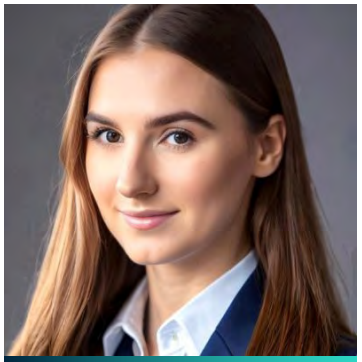
Satellites, typically located in LEO or MEO, enable Earth imaging capabilities for both intelligence purposes and essential Internet and radio communications services. As such, hostile actors are increasingly investing in new space capabilities, such as anti-satellite weapons, as evidenced by Russia's cyber-attacks on Ukrainian satellite communications technologies. Adaptive AI techniques could be employed to continually monitor satellite performance and detect anomalies whilst the use of synthetic data and software simulations could facilitate the training, tuning, and testing of these models.[65] This will bring many 'non-space' companies into the sector, particularly those in Machine Learning and virtual sensors.

The proliferation of satellites designed for the rendezvous and proximity operations (RPO) integral to the development of a commercial on-orbit servicing sector will present new challenges (and opportunities) for space and Defence companies. As such, companies that anticipate a dependence upon such infrastructure should engage early with systems manufacturers, the cyber security industry, UKSA, and MOD.

An emphasis on participation with key allies and structures, including NATO, NASA and the European, Canadian, Australian, and Japanese space agencies will demonstrate global leadership on reducing space threats. This will require working with like-minded nations through well-established partnerships and bilateral or multi-lateral frameworks to shape the international debate and regulations around threats to space systems. Industry should push for meaningful involvement in the creation, shaping, and resourcing discussions that surround these.

The key units in the UK Defence and Security Space ecosystem include the UKSA, MOD, Royal Air Force, Defence Science and Technology Laboratory (Dstl), UK Space Command, Defence and Security Accelerator (DASA) and UKSpace. These stakeholders must all work in conjunction to invest in advanced technology demonstrations for space whilst enhancing security measures. Integration of the core space security principles within the NSS, DSS, and Defence and Security Industrial Strategy,[66] will ensure the UK is collectively promoted as one of the most attractive and innovative Space economies, speaking with one voice across these diverse but interconnected areas.

Data Centres



Weronika Dorociak, Programme Manager for Sustainability, techUK

Luisa Cardani, Head of Data Centres Programme, techUK

In-space data centres have the potential to become a core component of the infrastructure that enables the New Space Economy to function.

Major players in the technology industry are already making strides in this direction. In 2021, Hewlett Packard Enterprises (HPE) sent their Spaceborne Computer-2, equipped with NVIDIA's T4 GPUs, to the ISS. This marked the first successful deployment of a conventional data centre in space.[67] In addition, Microsoft has partnered with LEOcloud to deliver cloud services onboard Axiom Space's commercial space station.[68]

At present, experts predict that Earth-like data centres may reside in space as soon as 2025, commencing commercial operations the following year.[69]

Sustainability emerges as the most compelling driver of this phenomenon. The European Commission Horizon programme, which has commissioned a feasibility study led by Thales Alenia Space, aims to explore the environmental benefits of powering space-based data centres directly from the Sun.[70] At present, data centres on Earth account for 2.5% of the UK's energy consumption, largely using electricity to cool servers.[71] The space environment, with its extremely low temperatures and easy access to solar power, could accommodate scaling energy-intensive technologies such as AI or quantum computing. Whilst this scenario would lead to reduced operational costs for data centres, the initial investment associated with launching data centre capabilities into space would be significant.

Industry will face considerable challenges when seeking to make in-space data centres commercially feasible. The familiar architecture of data centres on Earth faces significant hurdles when adapted for space, especially when there is no crew present to rectify issues. Overcoming technological hurdles involves the development of specialised equipment, such as autonomous robotic systems, capable of withstanding extreme temperatures, radiation, and micrometeoroid impacts. This demands a significant level of innovation to create resilient solutions for the distinct challenges posed by the space environment. Physical risks, including micrometeorite impacts, geomagnetic storms, and collisions, along with the proliferation of mega-constellations of satellites, all increase the potential for frequency clashing and signal degradation. There are also ethical risks around the creation of space debris, equitable access to lunar resources, geopolitical debate over lunar infrastructure, and humanity's impact on the indigenous space environment. Despite companies such as AWS investigating the possibility of automatic in-space servicing and governments considering regulations to mitigate the proliferation and impact of space debris, addressing these risks remains a complex task.

While the notion of establishing data centres in space at scale remains speculative, it is on Earth where data centres are currently proving to be instrumental in shaping and supporting the development of technologies destined for space.

In November 2023, the Centre for Modelling and Simulation and UKSA announced a groundbreaking pilot data centre designed for the advancement of next-generation space engineering, robotics, simulation, and AI. The Collaborative Space Data Centre (CoSDaC) pilot project serves as a prime example of the indispensable role data centres play in advancing space technology. CoSDaC is set to offer computing capabilities on par with traditional data centres, tackling diverse challenges in space engineering.

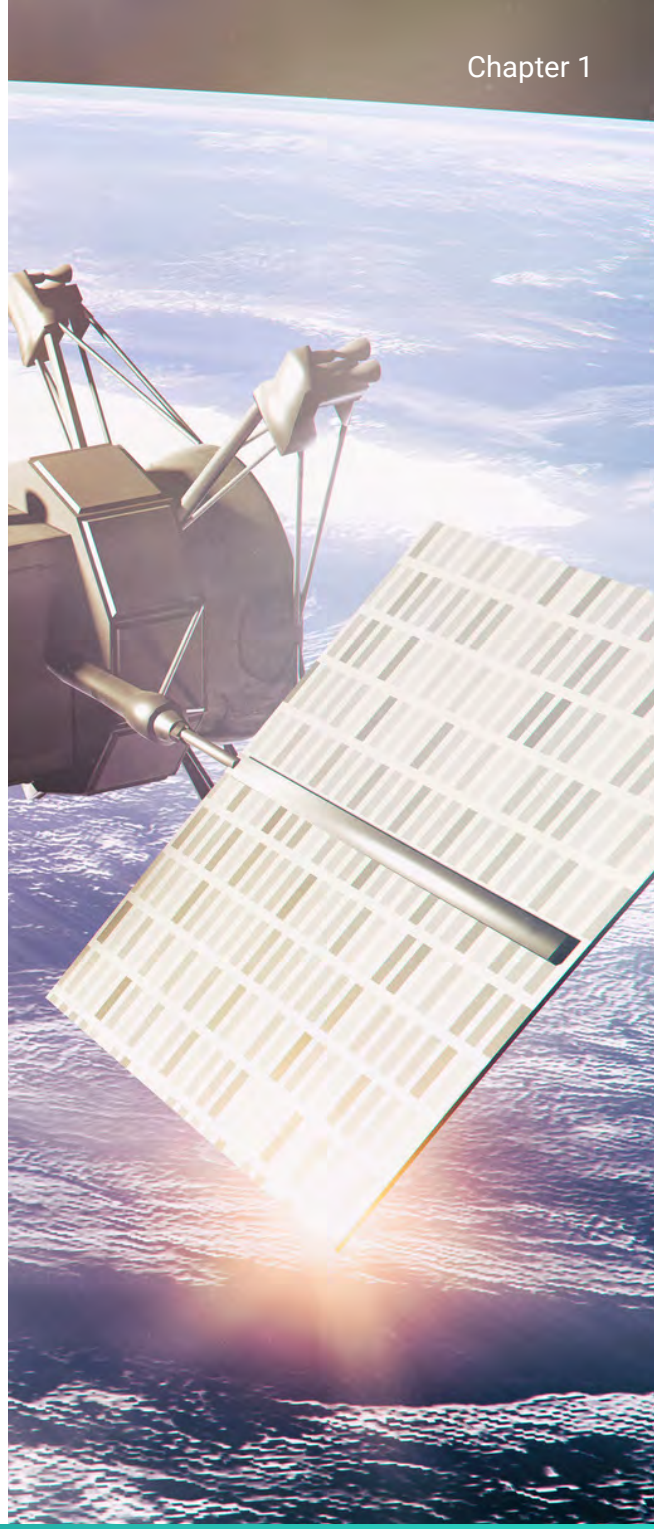
As data centres play a pivotal role in advancing emerging space technologies, it is essential that the UK fosters strategic collaborations among governments, international organisations, and industry leaders to ensure their resilience against threats such as physical or cyber-attacks and space debris.

Future key industries in the New Space Economy

Manufacturing will increasingly shift off Earth as advanced materials are produced in space to take advantage of microgravity and vacuum conditions before being returned to Earth. This promises to improve product quality, reduce defects in products such as semiconductors and fibre optic cables, and enable significant carbon reductions. In addition, in-space research and development (R&D) – soon to be enabled by the realisation of commercial space stations, successors to the ISS – will unlock discoveries not possible on Earth. Pharmaceutical companies, for example, could utilise the unique microgravity environment to develop treatments for diseases. This shift is already underway, with the number of patents containing the term "microgravity" in the title or abstract increasing from 21 in 2000 to 155 in 2020.[72]

Virtually all elements of the New Space Economy will be dependent upon the generation, storage, and transmission of energy. This, combined with the fact that global power consumption is set to more than double by 2050,[73] has prompted industry to explore novel space-based energy solutions. Solar power satellites will harness the inexhaustible energy of the Sun, converting this to microwaves and continually beaming the energy to Earth. These should offer scalable power, low environmental footprint, and export potential. Recent advances in wireless power transmission and robotic assembly are enabling Space-Based Solar Power (SBSP) to become a commercial reality. Space-Based Nuclear Power (SBNP) technologies are also progressing. In March 2023, UKSA announced £2.9 million of funding for a project exploring how nuclear power could be used to support a future lunar astronaut base. Industry expects to have a micro-reactor ready to send to the Moon by 2029.[74]

As stated in the introduction, none of these industries will be re-shaped, re-defined, or created automatically. The next chapter sets out the six main enablers that will determine whether the full potential of the emerging technologies outlined in Chapter 1 and the industries above can be realised.



Chapter 3
Key enablers that will determine the UK's success in the New Space Economy

Only through the six key enablers can the UK truly lead on the emerging technologies and industries set to underpin the New Space Economy. Doing so would see the UK become a New Space Superpower capable of converting its legacy, expertise, and early lead in space technologies and innovation into greater prosperity and security.

The key enablers are:

1. **Encouraging more non-space companies to develop emerging space technologies**
2. **Streamlining regulation for space products and services**
3. **Tackling the skills gap by improving domestic and international recruitment**
4. **Building a more varied and mature space finance ecosystem**
5. **Championing space sustainability through early involvement and adoption**
6. **Leveraging international space partnerships to influence trade policies covering emerging space technologies**

The following chapter explores why each of these enablers will play a critical role in supporting the UK to become a global leader in the New Space Economy. Each is accompanied by recommendations regarding practical and realistic actions that can be implemented by Government or industry to enable UK leadership in the emerging technologies and future industries set out in previous chapters.

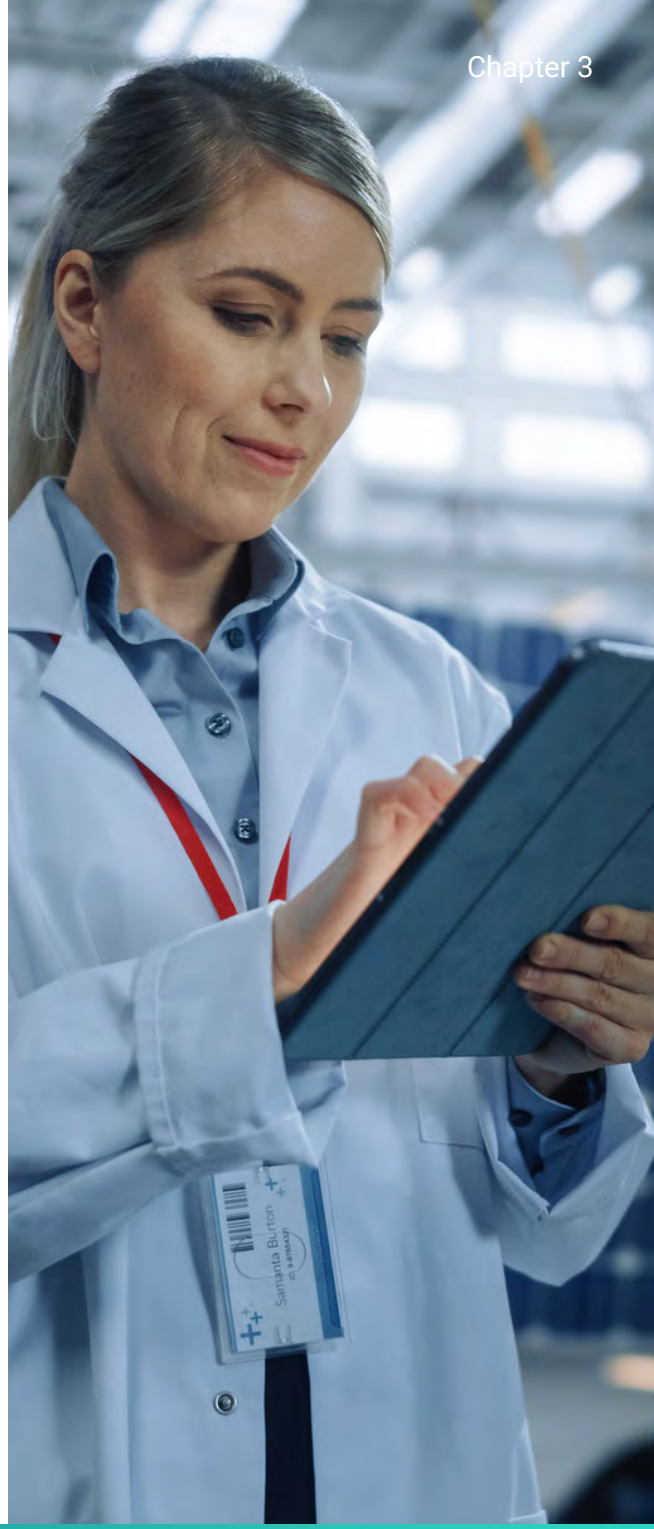
Enabler 1: Encouraging more non-space companies to develop emerging space technologies

In September 2021, Government published the National Space Strategy (NSS). For the first time, this outlines the UK's ambitions in space and brings together civil and defence policy. It emphasises the UK's ability to defend its interests, shape the space environment, and solve domestic and international challenges. Several departments and executive agencies (EAs) – notably the Department for Science, Innovation and Technology (DSIT), Ministry of Defence (MOD), and UKSA – have expanded upon the NSS by releasing further strategy papers. These include the National Space Strategy in Action (July 2023)[75] and Space Exploration Technology Roadmap (September 2023).[76]

Whilst these have gone some way towards providing a much-needed sense of direction and purpose, the UK's space strategy is articulated and pursued by only a handful of Government departments and bodies. Crucially, the UK must view the space sector through a far broader lens than that of space, science, and defence if it is to maximise the opportunities presented by the New Space Economy. As set out in Chapter 2, this will involve being prepared to lead in a wide range of key industries including cyber, data centres, and manufacturing.

Perhaps the most obvious solution is to call for an all-of-Government approach in which space is incorporated throughout every department and EA. However, the recommendations in this chapter take a less drastic approach, instead suggesting actions regarding established space programmes and networks.

Some of the most common space programmes are accelerators and incubators. The Satellite Applications Catapult, for example, can count its Westcott Business Incubation Centre and Innovation Centre,[77] the Space Commercialisation Engine at Leicester Space Park,[78] plus additional programmes run through its Harwell Head Office.



In addition, UKSA runs an Accelerator supported by a consortium led by Entrepreneurial Spark and Exotopic[79] while ESA's UK Business Incubation Centre network is managed by the Science and Technology Facilities Council (STFC).[80]

Now, the UK must leverage this broad network of space accelerators and incubators by encouraging and supporting increasing numbers of non-space companies to participate in such programmes. This should result in the development, application, and commercialisation of a wider range of space products and services. These, crucially, will span many of the industries that are explored in Chapter 2 and set to underpin the New Space Economy. Encouraging and supporting these companies could involve trade associations in traditionally non-space industries launching promotional campaigns or the programmes themselves allocating additional resources towards establishing more cross-sector partnerships.

The UK's 15 Space Clusters can also be leveraged to achieve this aim.[81] These look to support stakeholders to connect, collaborate, and innovate by providing access to local nuanced knowledge, shared facilities, and business and innovation services – both locally and nationally. Doing so helps to retain regional skills and talent, accelerates technology development, and enables businesses to find and attract investment.[82] They also enable cross-sector opportunities by engaging non-space sectors such as health and agri-tech. However, as the New Space Economy continues to emerge, Government should ensure that Space Clusters are well equipped to support an increasing number of traditionally non-space companies from non-space industries to identify, develop, and exploit cross-sector opportunities. This could take the form of a long-term funding settlement to scale services gradually, predictably, and ultimately sustainably.[83]

Recommendation 1: Organisations in future New Space industries should encourage and support increasing numbers of non-space companies to participate in space incubators and accelerators

This should result in the development, application, and commercialisation of a wider range of space products and services spanning many of the industries set to underpin the New Space Economy. Trade associations in traditionally non-space industries could launch promotional campaigns or the space programmes themselves could allocate additional resources towards establishing more cross-sector partnerships.

Recommendation 2: Government should ensure Space Clusters are well equipped to enable a growing number of non-space companies to identify, develop, and exploit cross-sector opportunities

Whilst these already enable cross-sector opportunities by engaging non-space sectors such as health and agri-tech, this function will only become more important and resource dependent as the New Space Economy brings additional industries into the umbrella of the space sector. Such support could take the form of a long-term funding settlement to scale the services provided by Space Clusters gradually, predictably, and ultimately sustainably.

Enabler 2: Streamlining regulation for space products and services

As the UK's space regulator, the Civil Aviation Authority (CAA) plays a crucial role in enabling the New Space Economy by prioritising safety, sustainability, and security across the sector.[84]

Following the Space Industry Act 2018 and Space Industry Regulations Act 2021 – both of which have gone a long way towards ensuring a Twenty-First Century regulatory environment – the CAA introduced its Regulator's Licensing Rules. These set out the licensing requirements for spaceports, launch vehicles/providers, spacecraft operations, and the return of objects from space. They cover cyber security, environmental aspects, de-orbiting, and orbital manoeuvring whilst requiring review of the people performing the 'space activity' (e.g. launch control, satellite operations) and the technical aspects of the equipment being licensed.[85] The CAA recently updated the Regulators Licensing Rules in response to feedback from industry.

These regulations, through their flexible and pro-innovation approach, have set the global standard for the control and administration of safe and responsible space activities. This has resulted in many companies coming to the UK to license their satellites. However, they have also imposed additional costs on UK businesses. Several applicants have noted that a satellite can be built in less time than it may take to apply for and receive a UK licence.

As such, the continued development of a more streamlined application and review process should further accelerate the licencing process for space systems. This could involve reducing documentation requirements, adopting international best practices, or directly involving industry in decision-making processes. For example, the CAA could create clear guidance and regulations to enable a streamlined approval process for use of high-capacity free space optical laser-based LEO/MEO/GEO space communications systems (including their associated extensively deployed optical ground terminals). This would likely improve airspace safety.

Such actions should enable businesses to better commercialise space products or services and increase the UK's attractiveness as a destination for space sector operations and inward investment. The overhaul of CAA's space regulation website in November 2023[86] is a positive start, making it simpler, clearer, and more helpful for companies seeking a space licence. However, a company's online experience is only one part of the licensing process. The National Space Strategy in Action has committed to reviewing the regulations governing space to ensure they are effective, beginning with the Orbital Regulatory Review.[87] Any review recommendations should be rapidly implemented and Government should work with the sector to ensure that these are agile and fit for purpose.

> ***"The CAA works to assist the sector on their regulation journey - we offer a range of support to help you get into space, from safety workshops to online guides, and recommend you familiarise yourself with the licensing process as early as possible during the development of your missions."***
> Colin Macleod, Head of UK Space Regulation, CAA

Recommendation 3: The CAA should continue to streamline its application and review process for space systems

Further accelerating the licensing process, perhaps through reducing documentation requirements, could result in lower deployment times and costs for businesses whilst boosting inward investment. The overhaul of the CAA's Space regulation website in November 2023 was a positive start.

Enabler 3: Tackling the skills gap by improving domestic and international recruitment

Nimmi Patel,
Head of Skills, Talent and Diversity, techUK

Skills and talent will be a critical component of the UK's leadership in the New Space Economy.

As of March 2023, the UK's fast-growing space sector employed approximately 48,800 people and supported an estimated 126,800 jobs across the wider supply chain.[88]

However, a lack of suitable candidates with technical skills or knowledge (in particular, degrees in a STEM subject), sufficient experience, and industry knowledge poses a major threat to this leadership. techUK has already seen a growing imbalance between the supply of and demand for digital skills in the UK and the proliferation of technologies such as AI, data analytics, and cloud are creating requirements for specialist skills that the UK's labour market is struggling to supply, resulting in a 'skills gap' and intensifying competition for talent.

The Space Sector Skills Survey 2023 found that nearly every organisation (95%) experienced skills-related challenges. This represents a large increase from 67% in 2020. Of the 52% reporting skills gaps in their current workforce, 72% indicated a gap in software and data skills (this figure is significantly higher than in any other technical area) whilst 97% said the gaps had some impact on business performance and growth.[89] In addition, the 2020 Space Census highlighted a persistent diversity gap, with 29% of workers identifying as women (largely reflecting the trend among STEM students and graduates) and 11% as ethnic minorities (versus 14% of the population at large).[90]

To address these domestic skills challenges, the National Space Strategy in Action has committed to publishing a Space Workforce Action Plan in 2024. Informed by a series of space sector workshops across 2023 and 2024, this will clarify the roles of Government, industry, and academia, improve collective understanding of the barriers preventing supply from meeting demand, agree responsibilities, and discuss necessary actions.[91] Whilst industry has welcomed its involvement in the development of this long-term plan, Government must ensure that following publication space and non-space companies can continue to provide feedback and shape the plan's outputs. This is essential if its focus is to evolve alongside the emerging technologies and industries set to underpin the New Space Economy. This could be achieved through equipping the Space Skills Advisory Panel with the power to continually review the plan or committing every few years to hold additional industry workshops and update the plan accordingly.

The recruitment of technical experts from abroad also plays a vital role in sustaining ongoing innovation, competitiveness, and employment opportunities in the UK. However, the Space Sector Skills Survey identified two main barriers

to UK companies filling the skills gap through this approach: Visa and paperwork costs (said 58% of respondents) and paperwork complexity (47%).[92] All in and as of October 2023, a five-year work visa costs around £9,000 and a two-and-a-half-year partner visa is £5,000.[93]

As such, Government should look to reduce these barriers by promoting and expanding existing visas. This is particularly important given the high cost of Skilled Worker visas deters many skilled workers from coming to the UK and companies from investing in the visa route. This could involve promoting alternatives such as the UK Graduate visa (which permits work in the UK in any role, for any employer and without salary thresholds for two years after a MA or three years after a PhD), High Potential Individual visa (for top global university graduates to stay in the UK for two years and work in any role) and Youth Mobility visa (which was expanded to new categories of applicants in January 2024). In addition, the last two should be expanded to include a much wider range of eligible universities and countries, particularly those within Europe.

Recommendation 4: Government must ensure that space and non-space companies can continue to shape the Space Workforce Action Plan following its publication

This is essential if the plan's focus is to evolve alongside the emerging technologies and industries set to underpin the New Space Economy. Government could equip the Space Skills Advisory Panel with the power to continually review the plan or commit every few years to hold additional industry workshops and update the plan accordingly.

Recommendation 5: Government should look to reduce the cost and complexity of visa applications by promoting and expanding existing visas

This would address the two main barriers to the recruitment of international talent in the space sector. Alternative visas to promote include the UK Graduate visa, High Potential visa, and Youth Mobility visa, whilst Government should expand the eligibility criteria of the last two to a much wider range of universities and countries.

Enabler 4: Building a more varied and mature space finance ecosystem

The UK's space finance ecosystem has matured significantly over the past decade. Between 2017 and 2022, private investors increased from 10 to 59[95] whilst 13 of the largest VCs and eight of the largest private equity firms have invested in space sector organisations.[98] In 2022, UKSA capitalised upon this by forming an Investment Directorate and hiring its first Director of Investment.[97]

The UK has received 17% of the $47 billion in private capital invested across the global space sector since 2015. This makes it the world's second-most attractive destination for private space investment, behind the US.[98] However, there are still significant barriers to investment in the UK's space industry, particularly a lack of investor diversity.

As of 2022, the top two UK space sector investors (both VCs) made more investments than the next four combined, three of which are Government Agencies.[99] This lack of competition makes it harder for UK space companies to scale as they have little choice but to accept funding on poorer terms than those available abroad. Many choose to relocate abroad, exacerbating the UK's skill gap and reducing its portfolio of national space capabilities. A healthier investor landscape would include major institutional investors (such as large corporates and pension funds) and more generalist or Deep Tech VCs.

The National Space Strategy in Action's commitment to developing a new VC Framework for Space is a positive start. This aims to determine the mechanisms through which the UK can facilitate more inward investment and private finance in the sector.[100] So are the 2023 Mansion House reforms, which look to commit pension providers to allocating at least 5% of their default funds to unlisted equities such as VC firms.[101] However, these must be targeted towards specific, strategic verticals in which the UK has sovereign space capability and strong academic intellectual property. This will be largely determined by the list of planned investors. In addition, DSIT's new scale-up support package, which includes a forum to enable the co-designing of new business policies and a service to provide targeted support,[102] should be designed to address some of the funding challenges outlines above. Therefore, Government must continue to pursue the implementation of the VC Framework for Space and Mansion House reforms in full consultation with industry whilst shaping its scale-up support package to address the funding concerns of space SMEs.

Government should also stimulate the market by consolidating its space-related purchasing across multiple departments before passing any benefits onto industry. Whilst it is moving in this direction, it should do so faster and at a greater scale. Doing so could involve implementing the commitment, outlined in the Geospatial Strategy,[103] to consolidate its purchasing power for EO data. By making this centrally available, SMEs across many sectors could access cutting-edge capabilities years sooner than otherwise and more effectively scale. This should position them at the forefront of the industry-wide transformations that will underpin the emergence and growth of the New Space Economy. It would also reassure investors regarding the utility and viability of data from the UK's space industry and is aligned with the UK's ambition to become a global centre for trusted EO data.[104]

Recommendation 6: Government should look to diversify the space funding landscape by shaping new financial initiatives, reforms, and support packages with the space sector in mind

Creating a more competitive space finance landscape should improve the terms behind funding, helping space companies to scale and reducing their propensity to relocate abroad. Government should continue to pursue the implementation of the VC Framework for Space and Mansion House reforms in full consultation with industry whilst shaping the scale-up support package to address the funding concerns of space SMEs.

Recommendation 7: Government should consolidate its space-related purchasing, particularly in EO data, before passing any benefits onto industry

Doing so should stimulate the market by leveraging Government's economies of scale across multiple departments to the advantage of UK SMEs. Making EO data centrally available would provide industry with access to cutting-edge capabilities years sooner than otherwise. This should improve scalability and the UK's ability to shape then capture a significant proportion of the value that is expected to be generated through the emergence of the New Space Economy.

Enabler 5: Championing space sustainability through early involvement and adoption

Mia Haffety,
Programme Manager
for Telecoms and Net Zero,
techUK

Emerging technologies in space play a vital role in enabling sustainable outcomes for Earth and achieving net zero (or 'carbon neutrality') goals, with space technologies offering the opportunity to achieve one-sixth of emissions cuts needed to reach net zero by 2050.[105]

One major element of space sustainability is the drive towards more sustainable emerging space technologies. This is being largely driven by the increasing degree of rocket reusability, as outlined at the start of Chapter 1. A second element is the introduction of reusable satellites. To date, the total value of single-use satellites abandoned over the past decade is $100 billion. Orbit Fab, for example, has developed the RAFTI™ (rapidly attachable fluid transfer interface), a drop-in replacement for spacecraft fill and drain valves, to enable low cost in-space refuelling.[106]

A third element is space debris removal.[107] There are currently around 130 million pieces of space debris measuring between 1mm and 1cm in orbit. These must be monitored (and, if necessary, removed) to protect space assets as by 2030 there will be an estimated 100,000 satellites in operation.[109]

The UK is already a world-leader in this field. UKSA is funding industry to continue developing the technology and capability necessary to remove unprepared inactive satellites from LEO. This includes two Active Debris Removal (ADR) Phase B mission studies totalling £4 million and awarded to industry in September 2022. This will culminate in 2026 with a demonstration of the UK's capability to rendezvous, dock with, and deorbit two defunct satellites.[110] The UK also boasts a National In-Orbit Servicing Control Centre, hosted at the Satellite Applications Catapult in Harwell, which provides the UK with its own dedicated mission control centre for in-orbit servicing missions, including ADR. It was from this Centre in 2022 that the active debris removal demonstration mission, Astroscale's ELSA-d, took place.[111] In addition, His Majesty the King's Astra Carta initiative, launched in 2023, aims to shape a future of responsible and sustainable space exploration, development, and cooperation by catalysing private investment and sustainable practices across the global space industry.[112] Industry has responded positively to this and is working on sustainability standards under the Earth-Space Sustainability Initiative (ESSI).[113]

These three elements demonstrate that the UK is at the forefront of space sustainability. This creates significant opportunities both for dedicated space sustainability companies and non-space companies that are well positioned to take advantage the UK's leadership. These could include robotics or AI companies seeking a new and rapidly growing market in which to apply their technologies. Therefore, both space and non-space companies should leverage this UK leadership by getting involved early in Government's technology development schemes, dedicated space technology facilities, and nascent international

initiatives. This will enable them to access time-limited resources, iterate their products and services in a lower risk environment, and exploit the commercial opportunities created by a growing UK-led international consensus around space sustainability. SMEs should work through organisations such as UKSA, techUK, UKspace, Satellite Applications Catapult, and Space Clusters to aggregate activity and amplify impact.

Another element of space sustainability concerns how in-space applications are facilitating efforts to drive sustainability on Earth. This has been explored in more detail in previous chapters, most notably regarding space-based solar power involving wireless power transmission and robotic assembly.

Sustainability on Earth could also be enabled through the enhanced use of satellite communications, satellite navigation, and IoT technologies. According to one report, the use of these three technologies is saving 1.5 gigatonnes of Carbon Dioxide equivalent per annum across three major sectors contributing 60% of global carbon emissions. In addition, the universal adoption of satellite technologies in these sectors could save an extra four gigatonnes per annum.[114] EO technologies provide over half the Essential Climate Variables used by the United Nations to monitor climate change[115] whilst the global EO market is forecast to grow at 10% per annum from 2020 to 2040, totalling $17 billion in annual sales.[116]

UKSA's 'Unlocking Space for Business' programme supports companies to deliver operational, customer, and environmental benefits using such innovative satellite data and services. It does so by increasing their levels of understanding, connecting key stakeholders, and assisting with Government funding applications.[117] Government should support companies seeking to leverage these key technologies to address sustainability on Earth by committing to widen the programme's scope outside the Financial Services and Transport & Logistics sectors and extend its duration to well beyond March 2025. This would ensure a dependable and long term offer of support for companies utilising such technologies to drive more sustainable outcomes across many of the key industries that are set to underpin the New Space Economy.

Recommendation 8: Space and non-space companies should leverage the UK's leadership in space sustainability by getting involved early in Government's technology development schemes, dedicated space technology facilities, and nascent international initiatives

Doing so will enable them to access time-limited resources, iterate their products and services in a lower risk environment, and exploit the commercial opportunities created by a growing UK-led international consensus around space sustainability, regardless of whether they would traditionally call themselves a 'space company'. SMEs should work through organisations such as UKSA, techUK, UKspace, Satellite Applications Catapult, and Space Clusters to aggregate activity and amplify impact.

Recommendation 9: Government should expand the scope and duration of the 'Unlocking Space for Business' programme to better align it with the sustainability requirements of the New Space Economy

Doing so should ensure a dependable and long term offer of support for companies utilising emerging technologies to drive more sustainable outcomes across many of the key industries that are set to underpin the New Space Economy. This could involve widening the programme's scope outside the Financial Services and Transport & Logistics sectors and extending its duration to well beyond March 2025. The sustainability implications of such a policy could be significant, as demonstrated by the estimated Carbon Dioxide savings enabled through the enhanced use of satellite communications, satellite navigation, and IoT technologies.

Enabler 6: Leveraging international space partnerships to influence trade policies covering emerging technologies

> ***"Ultimately space is about partnerships, and if we want to be successful in global challenge areas such as sustainability, the only way we can do that is through international collaboration."***
> Stuart Naylor, International Director, Satellite Applications Catapult

The UK recognises that to achieve success in New Space Economy, it must look outwards and forge purpose-driven international partnerships.

In 2017, UKSA launched a five-year, £152 million 'International Partnership Programme' aimed at investing in emerging space technology solutions to solve societal and economic issues in low-income countries. These projects involved techUK members including Inmarsat, Avanti Communications, and Satellite Applications Catapult.[118] In April 2023, UKSA announced a £20 million 'International Bilateral Fund', seeking to help UK space organisations collaborate with countries including the US, Germany, Japan, and South Africa.[119] Funding was allocated to a diverse range of initiatives, from utilising superconductors in spacecraft control to managing space traffic.[120]

One of the UK's closest bilateral partners is Australia. The inaugural UK-Australia Space Bridge aims to revolutionise access to trade, investment, and academic research in the space sector, improving advice for businesses and fostering innovative partnerships. It also creates opportunities for joint governmental and corporate initiatives in emerging space technologies, including the exchange of EO data or joint ventures in space-focused robotics and AI. Industry welcomes Government's commitment to develop future Space Bridge initiatives.

A growing international partner for the UK is the Kingdom of Saudi Arabia (KSA). The Kingdom aspires to be among the top five space agencies by 2030 and will launch its first space strategy in 2024.[121] The British Embassy works closely to support this UK-KSA relationship by promoting UK values and positioning the UK as a key partner. Significant UK-KSA space partnerships include a $200 million joint venture between NEOM and Eutelsat OneWeb to bring high-speed satellite connectivity to NEOM and the wider region.[122] In 2022, a memorandum of understanding was developed to provide a framework for collaboration in the peaceful uses of outer space.[123]

Daniel Clarke, Policy Manager for International Policy and Trade, techUK

Sabina Ciofu, Associate Director for International, techUK

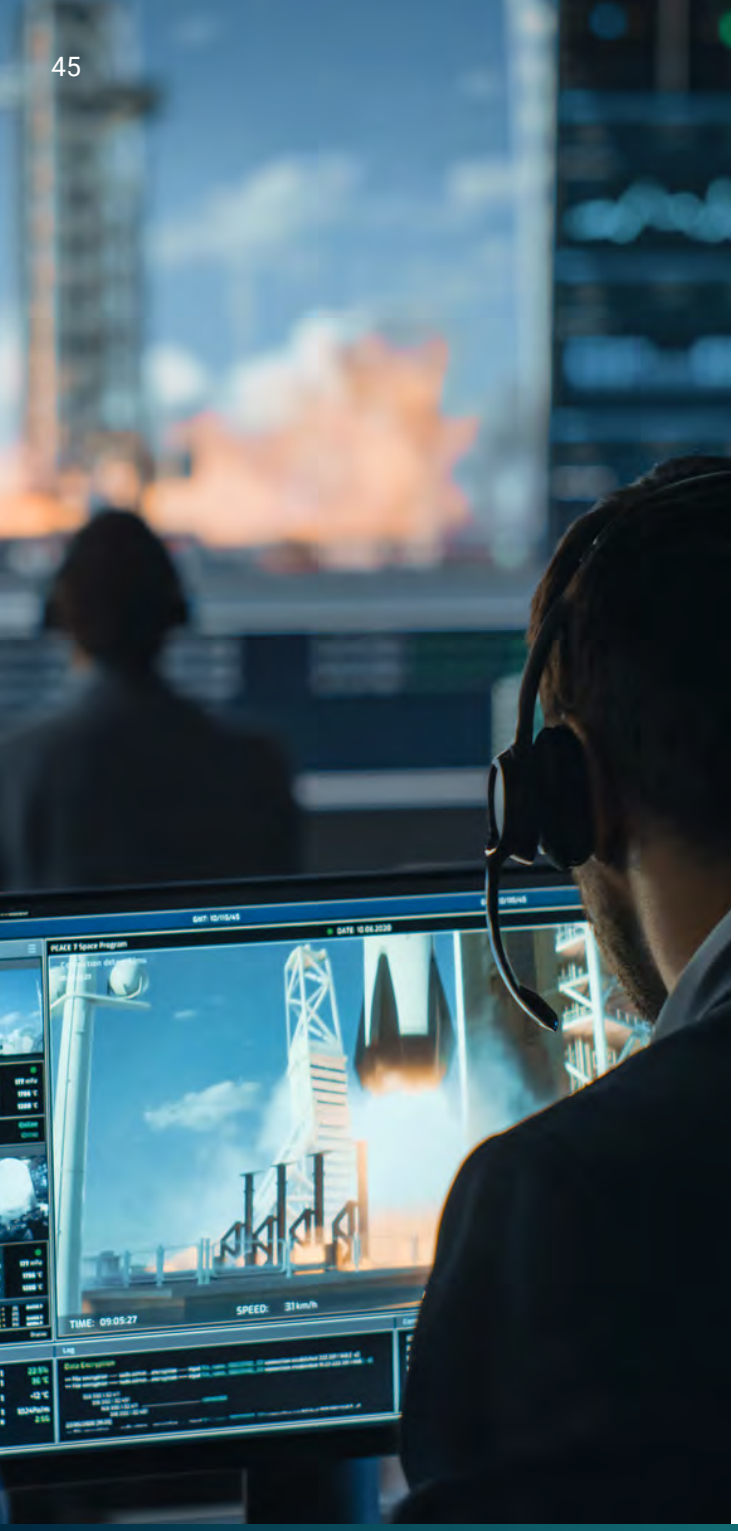
Despite the UK's broad range of space partnerships, certain trade policies can have detrimental impacts for the development and adoption of emerging space technologies.

The UK should look to leverage these established partnerships to push for favourable trade policies. These could include the addition of innovation chapters to space-related free trade agreements (FTAs), as seen in the Australia-UK FTA. Such chapters would help to create the framework for international cooperation on innovative space-related products and services. Another option is the inclusion of a negative list system in future UK trade deals. This would ensure that only explicitly listed items are subject to duties, making emerging space technologies tariff-free by default and unless explicitly added to the list. This is crucial to shielding these technologies, plus the burgeoning New Space Economy, from the imposition of tariffs by the UK's trading partners. By imposing crippling costs, such tariffs often threaten to reverse many of the benefits the UK accrues from the above examples of international cooperation.

Recommendation 10: Government should push for the inclusion of innovation chapters and negative list systems in future trade deals covering emerging space technologies

Through leveraging international space partnerships such as the UK-Australia Space Bridge, the UK can turn consensus into tangible trade benefits. The inclusion of innovation chapters in FTAs would facilitate cooperation around the trade of emerging space technologies whilst the addition of negative list systems would then shield these technologies from international tariffs unless explicitly added by a country to a list. This would pave the way for greater international cooperation around emerging space technologies and reduce the risks faced by the UK companies developing these.

Whilst many of these enablers are well known to Government and industry, there is much still to do if the UK is to maximise their potential. These ten recommendations would go some way towards positioning the UK as a future leader in the New Space Economy.



Conclusion

This report has explored the four main components that through techUK's 'sprint campaign' have been identified as critical to the UK's degree of success in the New Space Economy.

As set out in Chapter 1, the development, application, and commercialisation of emerging technologies such as AI, quantum, and robotics will facilitate UK-led space debris removal missions, quantum communications and cryptography, and in-orbit servicing and manufacturing capabilities. These will underpin the key New Space industries, explored in Chapter 2, that the UK must be equipped to re-shape, re-define, and create. Examples include satellites and telecoms, cyber, and manufacturing. Crucially, UK leadership in these technologies and industries will depend upon getting the six key enablers right.

Set out in Chapter 3, these range from streamlined regulation and improved domestic and international recruitment to early involvement and adoption in sustainability and a more varied and mature space finance ecosystem. Finally, the ten policy recommendations in Chapter 4 turn these enablers into practical and realistic actions for industry and Government. These cover a broad range of topics, from incubators and accelerators to visa applications and trade deals.

techUK remains well positioned to push for the implementation of this report's ten policy recommendations and will work with our members, UK Government, and wider stakeholders over the coming years to do so. After all, the opportunity for the UK to become a New Space Superpower is too great to forgo.

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About techUK

techUK is a membership organisation that brings together people, companies and organisations to realise the positive outcomes of what digital technology can achieve. We collaborate across business, Government and stakeholders to fulfil the potential of technology to deliver a stronger society and more sustainable future. By providing expertise and insight, we support our members, partners and stakeholders as they prepare the UK for what comes next in a constantly changing world.

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