REGULATORY HORIZONS COUNCIL

The Future Regulation of Space Technologies

Plugging the gaps in space

April 2024


“Space is the province of all mankind”
Outer Space Treaty 1967

Executive Summary

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Regulation is how activities and processes are controlled through a range of measures from mandatory rules (law) to guidance, self-regulation, regulatory bodies and inspectorates, together creating the conditions for effective and safe practices. Regulation can enable innovation by providing the framework to experiment safely and give investors' confidence. The Regulatory Horizons Council (RHC) – an independent council of experts created to advise the UK Government on future technologies[1] – was invited to conduct a review of key current and future technologies and how enabling regulation can support their responsible adoption in the space sector. This report was provided to the UK Government, and their response will be published in due course.

The RHC's key finding is that space regulation is mostly 'missing in action' whilst technologies are racing ahead. Given the range and scale of activities likely in space over the next 10 – 20 years, we will need to develop and mature our regulatory approaches both internationally and domestically. Current and future spacefaring nations need to develop together a proportionate and flexible regulatory approach to space alongside, and not after, the technologies which may create future capabilities in space such as debris removal, solar energy generation, mining, and manufacturing. The RHC is concerned that trends towards the increasing militarisation and commercialisation of space could increase the potential for future conflict, and lead to the degradation and misuse of the space environment. Without clear rules and guidelines setting out *who* can do *what* in space and *how*, humanity will fail to benefit from the opportunities of space. All spacefaring nations need to manage the space environment carefully to prevent over-exploitation and pollution, ensure that peace is maintained, and enable everyone to benefit equitably.

The RHC therefore asks the UK Government to continue to work towards a future for outer space that protects the environment and maintains peaceful and equitable uses of space, through developing a sensible, proportionate, and flexible regulatory regime which supports innovation. While the international community need to work together to develop regulatory approaches, the UK can play a key role through our international influence (formal and informal, including: 'science diplomacy' and co-operation), and by leveraging our legal and financial services sector as well as our strengths in key enabling areas such as data science and analytics and in cutting-edge science and technology. The RHC would like more routes for civil society to shape the future of space, ensuring that a more diverse range of voices are heard and embodying the principle that 'Space is the province of all mankind'.[2] Building on the Government's aim that "the UK will lead the pack on

[1] Regulatory Horizons Council

[2] United Nations Office for Outer Space Affairs (UNOOSA) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967

regulatory standards, promoting competition whilst ending the wild west nature of space today",[3] we propose a whole-of-government approach including:

1. In line with the Space Industrial Plan[4], build on existing work to address the challenges of space sustainability especially preventing overcrowding, and in-orbit servicing including removing debris, both through technology development and creating enabling regulations and guidance governing when and how these technologies can be deployed, ensuring both government and commercial actors operate responsibly;

2. Establish the UK as the global centre for space law, arbitration, insurance and financial products and services, and data science/modelling, which will help establish international norms of responsible behaviour and enable effective and safe space operations;

3. Create new mechanisms for public engagement and collective responsible investment in ethical space technologies and capabilities with shared global benefits.

Why does space regulation matter (now)?

For generations, people have looked to space and wondered about how the Universe evolved and our place in it.[5] Humans have been exploring space for decades in pursuit of scientific enquiry: since the initial landing on the moon in 1969, 676 people have journeyed into space,[6] and humans have continuously inhabited the International Space Station since 2000, conducting over 3,000 experiments.[7] Telecommunications have relied on satellites in orbit around the Earth for decades: the first geostationary satellite was Syncom 3, launched on 19 August 1964. Today, people rely on satellites to provide internet, telecommunications, mapping and navigation services, and financial transactions.

The primary international space regulations were developed over the 1960s and 1970s, with the Outer Space Treaty (OST) 1967, the Rescue Agreement 1968, the Liability Convention 1972, the Registration Convention 1975, and the Moon Agreement 1979. The OST is a mix of broad principles, providing flexibility to develop over time, with important rules such as banning nuclear weapons in space. Article 3 of the OST ensures that international law applies in space, including the UN Charter and international humanitarian law which are critical for international peace and security. This provides an important foundation which can be built upon through the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS)[8] and, in the case of satellite telecommunications

[3] UK Government National Space Strategy In Action, 2023
[4] https://www.gov.uk/government/publications/space-industrial-plan
[5] European Space Agency (ESA) About Space Science February 2024
[6] Astronomy magazine How Many People Have Gone to Space? November 2023
[7] NASA Five Space Station Research Results Contributing to Deep Space Exploration, January 2022
[8] United Nations Office for Outer Space Affairs (UNOOSA), Space Law Treaties and Principles

through the United Nations' (UN) International Telecommunication Union (ITU).[9] While the OST and other international regulations are non-binding treaties between signatories, many have been translated into domestic law by the major spacefaring nations, including in the UK the Outer Space Act 1986, Space Industry Act 2018, and Space Industry Regulations 2021[10], and enacted through bilateral and multilateral agreements such as the Artemis Accords.[11] However, international regulation was developed in an era when nobody imagined the enormous potential for private sector interests in space. Work needs to be done now to develop the governance arrangements which will enable the variety of activities envisaged in future, including environmental protection, managing orbital overcrowding, space 'traffic management', data sharing, Earth observation, space mining, debris removal, energy generation, colonisation, deorbiting, and 'in-orbit asset' trading or managing the ramifications of bankruptcy.

The commercialisation of space is a key trend, with huge potential benefits for medicine, science and more. Over the past decade we have seen the emergence and flourishing of a thriving global space industry ('NewSpace') as costs and barriers to entry have reduced, with ventures such as private launch companies, small satellite constellations, and sub-orbital tourism[12]. Since 2019, SpaceX has launched more than 5,800 satellites into space, making the internet available to 70 countries. On 8 January 2024, a US space company launched the first commercial Moon lander, whose cargo controversially included the cremated remains of at least 70 people, including Star Trek creator Gene Roddenberry, and one dog, thanks to companies which sell people the opportunity to be interred on the Moon (a propellant leak caused the spacecraft to turn around and return to Earth).[13] While commercialisation will yield huge benefits for society, excessive and unfettered profit-driven exploitation could degrade the space environment and pitch competing State and private interests against one another, with unintended consequences such as the *de facto* occupation/ ownership of strategically important space territories and orbital areas.

The other key trend is the potential for increasing militarisation of space. Military organisations have always been part of space exploration and rely on satellites for secure communications, intelligence, surveillance, and reconnaissance (ISR) and position, navigation and timing (PNT) services for ground-based operations. Ukraine, despite not being a spacefaring nation, has made effective battlefield use of space-based communications and ISR to defend itself against the Russian invasion. Over the next decade, defence activities in space are likely to increase. The US, China, and Russia have all created large and well-funded military units specialising in space operations and are ramping up investment in space technologies: the requested budget for the US Space Force in 2024 was over $30 billion. In recent years, China has tested hit-to-kill interceptor missiles, and Russia has conducted successful flight trials of anti-satellite missile

[9] UN International Telecommunication Union (ITU) Constitution and Convention of the International Telecommunication Union, December 1992

[10] UK Space Agency, Spaceflight Legislation and Guidance

[11] https://www.nasa.gov/artemis-accords/

[12] European Space Policy Institute, The Rise of Private Actors in the Space Sector, 2017

[13] Nature World View, Stop sending human remains to the Moon, 16 January 2024

systems.[14] In February 2024, there were concerns over the possibility that Russia could put a nuclear weapon into space.[15] The issue of potential weapons in space is complicated by the fact that almost any manmade object in space is 'dual use' i.e., it could be used for military purposes. Maintaining peace in space in future may become more difficult than it has been up to now, with potentially severe consequences. There is the possibility of an escalating 'arms race' in space between states and factions. Many states will feel it necessary to defend their commercial and sovereign interests and assets in space as well as defending themselves from the potential for space-based assets to be deployed by adversaries, for example GPS jamming. There is the potential for irresponsible or reckless behaviours, non-compliance with guidance, and the exercise of 'soft power', influence and use of proxies by states and private actors. Making space a dangerous and unpredictable environment will also deter scientific and commercial activities, and investors in non-defence space capabilities, delaying the benefits of space for humanity.

As a result of this expanding use of the space environment, the international treaties and corresponding domestic legislation do not cover many of the activities which are now – or soon will be – possible in space. The treaties which exist are not enforceable, and at present there is no international court for space activities, or formal means for dispute arbitration other than bilateral agreements. Good licensing regimes, compliance and dispute arbitration mechanisms will be critical to manage the future uses of space responsibly. The UN has been clear that the governance of space needs addressing: "The human presence in outer space has fundamentally changed in the past 10 years, and this change is likely to accelerate in the coming decades. We need to develop further the existing governance so that we can sustainably accelerate innovation and discovery."[16] While good work is already underway, including the UNCOPUOUS[17] and the Inter-Agency Debris Coordination Committee (IADC),[18] which are focused on voluntary measures for managing orbital activities, the lack of international consensus on what the rules should be, weak international governance, and lack of clarity over liabilities, risk slowing progress in deploying key future capabilities such as debris removal.

Like other countries, the UK has invested in growing its space economy and the space sector is now worth over £16.4 billion per year, employing over 45,000 people across the UK. The UK plays a key role in UN and international space policy development, including the Working Group on Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours,[19] such as sponsoring the UN General Assembly initiative on space behaviours adopted in 2020.[20] The UK Space Command (part of the RAF) was established in 2021 and was the first formal partner in the US-led Operation Olympic

[14] Ministry of Defence, Defence Space Strategy: Operationalising the Space Domain, February 2022

[15] New York Times US Fears Russia Might Put a Nuclear Weapon into Space, 18 February 2024

[16] United Nations, Our Common Agenda Policy Brief 7, For All Humanity – the Future of Outer Space Governance. May 2023

[17] United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)

[18] Inter-Agency Space Debris Coordination Committee (IADC)

[19] Aidan Liddle, 'Responsible behaviours in outer space: towards UNGA 76,' Foreign, Commonwealth and Development Office Blogs, 8 June 2021

[20] United Kingdom, National Submission on Space Threats, 30 April 2021

Defender, a multinational coalition formed to strengthen deterrence against hostile actors in space and reduce the spread of debris in orbit.[21] Placing sustainability at the core of space activity is the purpose of King Charles' Astra Carta initiative, which aims to convene the private sector in creating and accelerating sustainable practices across the global space industry.[22] There is a lot of excellent work going on across Government, in UK Space Agency, Satellite Applications Catapult, Civil Aviation Authority Space Team and others, and the RHC commends everyone for their efforts and dedication.

What was the RHC's approach?

The RHC's approach to this report explored the opportunities and challenges of 11 current and future technologies which are relevant to space. Technologies themselves are neutral and can be used in many ways across multiple sectors (space is simply a potential application of these technologies), so it is not sensible to develop regulatory recommendations for specific technologies in outer space. The right approach is to regulate the space *capabilities* that the combination and applications of these technologies create, in the wider context of the international regulatory environment and geopolitics. We therefore identified current and potential future capabilities and their benefits and risks, and used horizon scanning techniques to explore future trends, drivers, and scenarios with inputs from industry, academia and government departments and executive agencies. Our recommendations set out where the UK Government can leverage our strengths and opportunities to the greatest effect.

The 'Space 11' technologies identified are:[23]

AI and Machine Learning will improve data analytics and decision-making, and enable innovation in many of the other technologies

Data science underpins many current and future technologies such as AI, automation, robotics, and telecommunications, enables spaceflight and, in future, will help us to optimise bandwidth and orbital capacity

Energy, launch, and propulsion technologies allow spacecraft to take off and manoeuvre in space, and could potentially lead to sustainable solar and other energy sources for Earth

Engineering biology may help us develop novel food and medicines to sustain future human life in space, with spin-out benefits for health services on Earth

[21] Penny Mordaunt, 'Defence Secretary outlines future space programme,' RAF News, 18 July 2019

[22] His Majesty The King. 'The King unveils the Astra Carta seal at a Space Sustainability Reception at Buckingham Palace.' The Royal Family, 28 June 2023

[23] There is no generally accepted definition or groupings of space technologies.

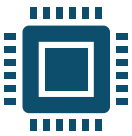
Future telecommunications technologies will drastically improve global connectivity, data sharing and data transmission

Human sciences can inspire us, help us develop the diverse workforce and ethics we need in the space sector, help future human crewed missions operate together, and eventually help us to create new communities in space

Novel materials and nanotechnology will build lightweight, high-strength components for satellites and improve design and performance, and are an enabler for in-space manufacture and recycling

Quantum technologies have the potential to hugely improve communication, computing, and sensing, and may enhance – or undermine – data security and the encryption of satellite communications. Quantum metrology (atomic clocks) would enable more accurate instrumentation and future spacecraft navigation

Robotics, software, and automation activities for uncrewed missions will help us to operate more cheaply, safely, and efficiently, and enable active debris removal and in-orbit servicing, especially when enabled by AI



Semiconductors are critical to the Space Sector supply chain and need to be adapted (radiation-hardened) through novel design and materials to enable the breakthrough technologies we describe – especially future communications

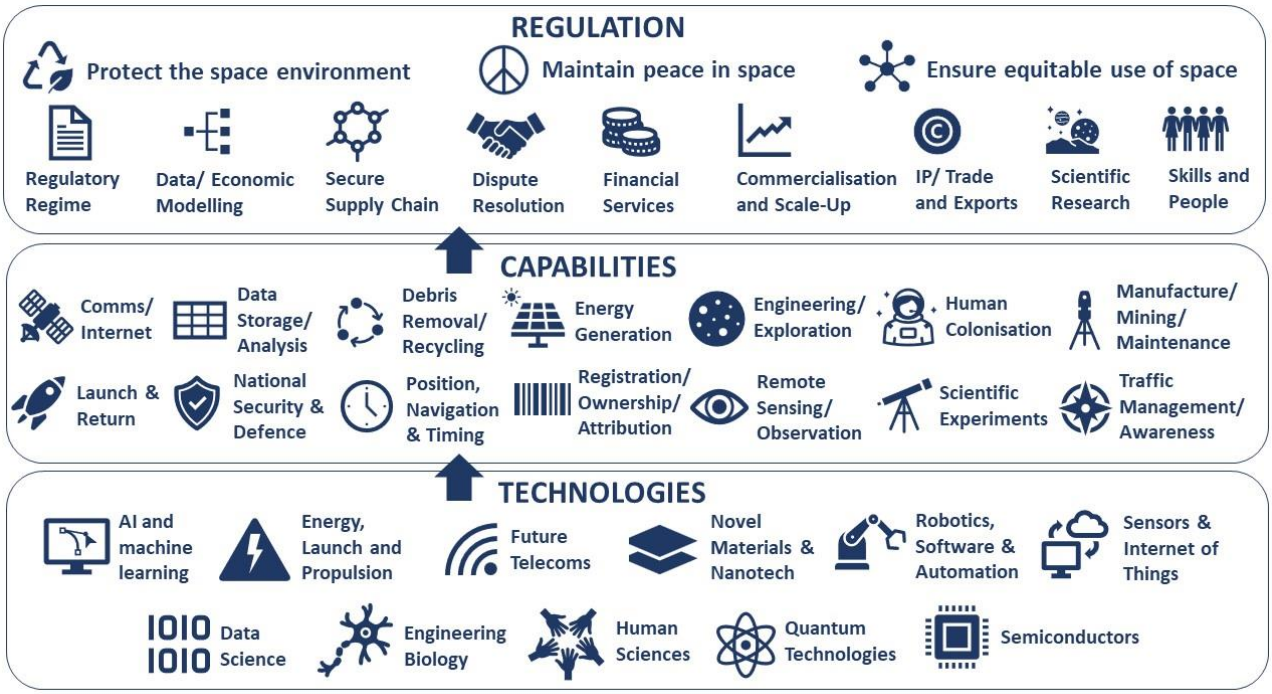
Sensors and the Internet of Things will improve our ability to detect and track what is happening, including radio and optical telescopes for astronomy

These technologies together create new and emerging capabilities which will need regulation. Over the next 10 years we are likely to see an expansion of existing space activities such as Earth observation and remote sensing, a broader range of telecommunications capabilities, and new space exploration including tourism. In the next 10 – 20 years, we may see the emergence of novel capabilities in space such as active debris removal, solar energy generation, mining, and manufacturing (including novel medical devices and pharmaceuticals), data storage, new defence capabilities, and more. In the further future, we might see humans reside on spacecraft, the Moon, or other planets.

All these activities will need to be governed by a flexible regulatory regime which covers monitoring and ‘traffic management’ systems to ensure safe launch, operations, and return and prevent overcrowding or collisions. We will need to have regulation for environmental

protections, including requiring operators to properly dispose of defunct equipment and reduce space junk and pollution, and to ensure responsible practices to manage the growing in-space economy, including insurance and in-orbit asset trading. To ensure resilience, regulations will need to cover foreseeable potential situations such as managing emergency situations where a State or another company may have to quickly take over the assets of a company which can no longer operate them. Key areas for future regulation, therefore, include setting out how the international community will protect the space environment, maintain peace in space, and ensure the equitable use of space including creating a flexible and proportionate regulatory regime, developing data and economic modelling tools, securing the supply chain, managing dispute resolution and arbitration, creating financial products and services for the space sector, commercialising and scaling up innovation, further developing the Intellectual Property regime and managing international trade and exports (including restricted technologies), supporting scientific research in and using space, and developing the pipeline of skills and diverse talent needed (Figure 1).

Figure 1: Overview of Technologies, current and future Capabilities and Regulation



Recommendations Summary

The RHC suggest a series of recommendations to:

1. Use the UK's international platforms to advocate for and prioritise environmental protection, peace, and equitable use of outer space;

2. Make the UK the go-to place for space regulation, arbitration and enabling services; and

3. Ensure that the UK is at the forefront of a few key enabling technologies and capability development.

1. Use the UK's international platforms to advocate for and prioritise environmental protection, peace, and equitable use of outer space

Environmental Protection of Space

The UK Government should work with the international community to:

1. Establish strong legal protections for the space environment to limit pollution, mitigate future environmental risks and preserve 'clean zones' for future use
2. Restrict the number of objects put into space to a sustainable level, with agreed quotas for spacefaring nations

The UK Government should:

3. Signal the intention to put into future domestic legislation in 10 years the requirement for space objects and components to be made from materials which meet specified standards for non-pollution and minimise impact on the space environment
4. Rapidly scale up existing work for a national space debris removal and recycling programme and develop associated regulations, guidance, standards and financial investment, insurance, and legal regime to operate them
5. Develop a framework and functions for a future 'Space Traffic Control' system and civil tracking capability

Promote Peace in Space

The UK Government should work with the international community to:

6. Establish a multinational specialist capability ('International Space Safety Organisation') to inspect and enforce internationally agreed regulations
7. Prevent and deter conflicts in and using space through an effective international non-proliferation space weapons treaty
8. Create an international space arms regime based on existing non-proliferation treaties

The UK Government should:

9. Amend domestic terrorism legislation giving law enforcement and intelligence agencies remit and powers to address and prevent planning or intending to carry out unlicensed launches or illegal interference with satellites or satellite communications
10. Develop plans to prepare for and recover from any major future conflict or accident that may occur in space through 'wargaming' and future scenario development
11. Create a space cybersecurity programme with industry, including developing and publishing domestic guidance and standards

12. Develop and publish advice to the space sector on how to manage and respond to supply chain and security threats

Ensure equitable use of space

The UK Government should work with the international community to:

13. Develop an international regime to govern, authorise, and manage future space mining and manufacturing activities
14. Continue to define and promote responsible space behaviours, drawing on multidisciplinary expertise
15. Protect and preserve sites in space of historical and cultural significance

The UK Government should:

16. Establish a Citizens' Space Assembly
17. Explore the potential for public 'Space Bonds' or community shares for ethical investment in space technologies
18. Instil the long-term thinking required to develop space capabilities and mitigate against the risks of short-term economic incentives through multi-year budget settlements attached to clearly defined outcomes

2. Make the UK the go-to place for space regulation, arbitration and enabling services

The UK Government should:

19. Build on the UK's common law approach as the preferred choice of law internationally, and put in place arrangements for the exchange of information between the UK Courts and the UAE Space Court
20. Establish a Space Arbitration Faculty
21. Encourage UK investors to invest in UK space capabilities and accelerate the scale-up of technologies into deployment
22. Further establish the City of London as the global leader for the space insurance industry, including creating a Space Reinsurance Pool
23. Create a positive investment climate for scale-ups and address the gaps in scale-up equity and non-equity funding
24. Implement the recommendations set out in the RHC's report on the *Role of regulation in supporting scaling-up*
25. Develop and mature a comprehensive Intellectual Property regime for space technologies in UK law and create a menu of standard space contracts
26. Define and agree on clear definitions for military, non-military, quasi-military and dual-use space capabilities and create a proportionate classification scheme to manage them appropriately at the lowest classification necessary

27. Extend the remit of the National Security and Investment Act to cover the future in-orbit trade of assets, goods, and services
28. Iteratively develop and evolve a comprehensive regulatory regime for future space activities with appropriate law and associated guidance, authorities, accountability, and enforcement regimes
29. Extend current and future domestic law and push for the extension of international law, to the activities of private actors and consortia operating in space
30. Consider whether the range and complexity of future space activities may require the creation of a separate specialist space regulator
31. Establish clear leadership and accountabilities across Government
32. Agree a legal definition for outer space and definitions and terminologies for different kinds of space areas, environments, and objects

3. Ensure that the UK is at the forefront of a few key enabling technologies and capability development

The UK Government should:

33. Invest in novel semiconductor materials and fundamental design for space, establish an assured onshore integration capability in atomic clocks and timing with a clear assurance approach, and create a terrestrial PNT distribution network.
34. Develop a deployable debris tracking and removal service, a global civil ‘space traffic management’ system, and continue to develop ‘data as a service’ capabilities
35. Commission a programme of work overseen by HM Treasury to develop and publish economic and data modelling frameworks and standards for the space sector and subsectors and establish key datasets providing empirical evidence to understand and predict the evolution of the space environment
36. Create a programme of work with the private and public sector to ensure that the UK Space sector supply chain is secure

4. Investing in Skills and People

The UK Government should:

37. Fund universities to create ‘space bursaries’ aimed at encouraging a wider range of students to take space science and create a Young Peoples’ Panel on Space Futures
38. Explore ‘Space Visa’ exemptions for specialist space technology experts
39. Commission UK Space Agency to create an educational scheme to raise awareness and excite people about career opportunities in the space sector
40. Partner with universities and relevant industries to co-create authentic learning opportunities that are integrated into academic programmes giving students and graduates opportunities to explore and potentially solve mission-led space challenges