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Introduction

The Durham University Space Research Centre (SPARC) is pleased to submit evidence to the House of Lords regarding the United Kingdom's Engagement with Space.

SPARC is founded on the principle of open, rigorous and independent research to grow the capacity and capabilities of space applications while protecting the space environment for present and future generations.

Our vision encompasses not only the pursuit of cutting-edge technologies but also the holistic understanding of space and its broader societal, ethical, and environmental impacts. Through responsible, multi-disciplinary research, including novel sensors, environment modelling, machine learning, governance and operations, we aim to address the complex challenges and opportunities of space exploration.

We are committed to contributing valuable insights and recommendations to support the UK's strategic objectives in space, fostering scientific excellence, economic growth, and global leadership in this rapidly evolving domain.

Response to Call for Evidence

The opportunities and challenges relating to the UK space sector, including:

Where the UK's space sector has comparative strengths.

Industry Leadership:

SMEs: The UK is home to industry leaders like Surrey Satellite Technology Limited (SSTL) and Teledyne, which excel in the design, manufacturing, qualification, and operation of small satellites.

Major Aerospace and Defence Companies: Companies such as Airbus, BAE Systems, and Rolls-Royce play a crucial role in the UK space sector. These organizations contribute significantly to large-scale projects, providing advanced technologies and substantial investment.

Research Ecosystem:

World-Class Universities:

The UK space sector benefits significantly from the strengths of its universities, which contribute in several key areas. The UK boasts a thriving research ecosystem supported by top-tier universities and robust funding schemes. UK Research and Innovation (UKRI) funding facilitates early Technology Readiness Level (TRL) development, enabling universities to pursue ambitious projects. However, ensuring consistent and large-scale financial backing for research and development is crucial

for sustained growth. Reliable and consistent funding from UKSA is a challenge for higher TRL activities.

There is strong engagement between universities and industry, fostering innovation and practical applications of research. Academic research presents an excellent opportunity for new technology concepts to be highly disruptive, driving significant advancements and maintaining the UK's competitive edge in space technology.

Space Applications:

Satellite Communications: The UK has a strong traditional satellite communications industry, with companies like Inmarsat/Viasat and Filtronic leading the way. We also have significant research capability in emerging communications technologies such as free-space optical communications and quantum key distribution.

Earth Observation: Emerging strengths in earth observation through small satellites are evident with entities like satVu, and SSTL.

Space Science and Instrumentation: The UK excels in space science instrumentation, mission payloads, and specialised component manufacturing, contributing significantly to major European Space Agency (ESA) missions through its universities and contractors.

Military Sector Strengths:

The UK maintains specific strengths in the following areas, almost always as a result of the US-UK special relationship and the Mutual Defence Agreement of 1958.

Space Tracking and Domain Awareness: Facilities like RAF Fylingdales and the proposed DARC facility enhance the UK's space tracking capabilities. Additionally, RAF High Wycombe and UK Space Command play crucial roles in space domain awareness information management and dissemination.

High-Security Communications: The Skynet program underscores the UK's strength in high-security satellite communications.

Rocketry and Ballistics: The Trident program highlights the UK's expertise in rocketry ballistics analysis.

Downstream applications and integration of NATO (mostly US assets) space systems for UK armed forces (e.g. GPS, space-based Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems).

How the UK may capitalise on new space technologies, such as nuclear engines, space-based solar power, in-space manufacturing, resource extraction, active debris removal, in-orbit servicing and artificial intelligence.

The UK should explore "moon-shot" technologies that, while high-risk, have the potential to be transformative. However, this exploration should not come at the cost of essential, proven, commercially, or viable next-generation technologies, such as communications, intelligence gathering, Positioning, Navigation, and Timing (PNT), or Earth Observation systems.

It is important to approach this analysis pragmatically, recognizing that some high-risk ventures may ultimately prove unfeasible whilst other space capability programmes need resources to close capability gaps between the UK and other middle space powers. In such cases, it is crucial to avoid disproportionate investment. However, independent analysis is difficult in many cases due to the lack of transparency and multidisciplinary scrutiny.

*Opportunities, challenges, and potential for growth in the different sub-sectors operating in the space sector, including:
Satellite communications services;*

The UK has an excellent opportunity to play a leading role in novel communications technologies such as free-space optical communications and quantum key distribution. These next generation techniques are technically feasible but are not in current regular operation due to challenges with optical propagation through the Earth's atmosphere. In the UK have world-leading expertise in this field but we lack the R&D infrastructure and consistent R&D funding models as compared to France, Germany and the USA. There is therefore a risk that many of the technology and techniques coming out of UK universities ends up with foreign companies.

The collaboration between academic institutions, government, and commercial space firms in the UK, including but not limited to space research and development and space spin-out and start-up firms.

In comparison to European peers, the UK lacks a large, state funded space development laboratory such as ONERA and DLR in France and Germany respectively. This leaves a development gap between idea generation (at universities) and system productization (by industry). This does not necessarily require the creation of a large state laboratory however – the gap can be filled by providing opportunities for universities and industry to come together and perform technology transfer and demonstrations.

The importance of the provision of a safe operating environment in space, and how the UK can contribute to this, in particular regarding space weather and space debris.

The UK has expertise and capability in advanced instrumentation relevant to direct monitoring and modelling of the space environment. This is a young field with huge potential for the emergence of disruptive technology given appropriate nurturing. In this regard there is an opportunity for the UK to lead the way in terms of space sustainability technology and governance. The challenge here is that disruptive technology naturally comes with a high-risk. It is therefore important to

support novel technology development in a manner that allows for failure and reconsideration.

The impact of space on national security and resilience, for example:

- *The national security benefits of a strong commercial space sector.*
- *The dual-use nature of space technology.*
- *The implications of geopolitical developments on the UK's activity in space.*
- *Potential threats to the UK's assets in space.*

The knowledge and tools of space warfare – to attack satellites and their supporting infrastructure – are spreading. Space systems are crucial to our modern ways of warfare and sustaining critical national infrastructure, therefore it is strategically “natural” that possible adversaries are seeking ways to harass, disrupt, or destroy UK and allied space systems during crisis or wartime.¹ Attacks on satellites and their associated ground infrastructure can have significant impacts on civil infrastructure, the general functioning of the economy, government communications, and a wide array of military capabilities.

In Earth orbit, the proliferation of anti-satellite (ASAT) or “counterspace” weapons has continued horizontally and vertically. These weapons include a diverse range of attack methods, in particular 1) “hard-kill” kinetic energy (ramming) vehicles designed to destroy satellites and produce clouds of lethal orbital debris; 2) “soft-kill” weapons such as reversible electronic warfare, signal spoofing, and computer network operations and attack (cyber) on the radio and computer systems satellites depend upon; 3) sophisticated close orbital manoeuvres between “inspection” satellites that could be used for grappling, ramming, or close projectile fire against other satellites. Notably, China (2007), USA (2008), India (2019) and Russia (2021) have demonstrated a direct-ascent (Earth-based) ASAT kinetic kill capability. Other ASAT flight tests without intercepts have been conducted.² Israel is reported to have intercepted an Iranian-made Houthi Medium Range Ballistic Missile (MRBM) in its midcourse phase of flight in outer space with an Arrow-3 interceptor missile³ – a technology that could be repurposed for a kinetic energy ASAT capability, like the Aegis Ballistic Missile Defence Systems on US and Japanese Aegis-equipped destroyers.

The UK needs to move away from the convenience and financial efficiency of civilian “just in time” logistics which severely hampers resiliency when systems break down or an intelligent enemy changes behaviour to defy

¹ On the strategic logics of space warfare, see: Bleddyn E. Bowen, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press, 2020); Bleddyn E. Bowen, *Original Sin: Power, Technology and War in Outer Space* (Hurst, 2022) pp. 195-323

² Comprehensive details of all ASAT tests can be found here: Brian Weeden and Victoria Samson, ed. *Global Counterspace Capabilities Report 2024* (Secure World Foundation, 2024) <https://swfound.org/counterspace/>

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expectations and exploit our material disadvantages.⁴ As well as preparing to act without Critical National Infrastructure, the MoD should be ready to reconstitute such infrastructure at short notice which require stockpiled replacements and spare parts on UK soil, e.g. submarine telecoms cables, National Grid transformers substations, positioning, navigation and timing (PNT) reference systems.

The UK relies on access to the 'global commons' of international seas, air, outer space, and the globalised but increasingly Balkanised internet infrastructure for the economy and critical infrastructure to function. The MoD should support UK and allies to "command the commons" which enable core functions at home and enable military actions abroad.⁵ "Commanding the Commons" means little if that command is not exploited for strategic effect on land and in the political dimension. The exploitation of supporting effects to where people live – the land – has to occur for long-term political objectives to be met and victory to be achieved and imposed by land forces.⁶ ^[1] Conversely, land forces have a role and duty to support the command of the commons where they are able to, such as in littoral dimensions and in air and space control missions with ground-based capabilities.

Given the recent political difficulties between Europe and the United States regarding approaches to Russia, Ukraine, and military equipment, it is imperative that Britain begin negotiations with the European Union (EU) over access to the Galileo PNT system's Public Regulated Service (PRS). Whilst it is unreasonable to seek or expect UK industrial participation due to Brexit, user access for the British military and approved government users is feasible and will provide a secure, resilient, and accurate alternative to the American GPS. Galileo's PRS will be a crucial backup or alternative should GPS' military signals become unavailable for UK MoD and Government usage. Norway and Switzerland would be natural partners for a joint PRS access negotiation strategy, and should also feature in any renewal of UK-EU relations and any defence cooperation agreement.

The USA had begun to move in this direction following the 2021 Space Policy Directive 7⁷ and the first meeting of EU-US satellite navigation operators and technical teams in July 2024.⁸ However progress on this front is looking less likely given the more recent policy choices made by

⁴ Mark Erbel and Christopher Kinsey, "Think again – supplying war: reappraising military logistics and its centrality to strategy and war", *Journal of Strategic Studies*, 2018, 41:4

⁵ Barry R. Posen, "Command of the Commons: The Military Foundation of U.S. Hegemony", *International Security*, 2003, 28:1

⁶ Colin S. Gray, *The Navy in the Post-Cold War World* (Pennsylvania State University Press, 1994); Bledwyn E. Bowen, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press, 2020) pp. 54-98

⁷ White House, Memorandum on Space Policy Directive 7, 15/01/2021, available at: <https://www.transportation.gov/pnt/space-policy-directive-7-united-states-space-based-positioning-navigation-and-timing-policy>

⁸ On the DLR EU-US meeting: <https://www.linkedin.com/feed/update/urn:li:activity:7207252641112846336/>

the second Trump administration towards the EU, certain members of the EU, and Ukraine. PRS access is a relatively low-cost but long-term option to boost resiliency and redundancy in military PNT services which will also benefit UK national security in the homebase in domestic crises should GPS fail. The 2022 Defence Space Strategy makes no indication as to which resilient PNT concepts are being explored in the MoD. This is concerning as many concepts of alternative/backup PNT services already exist, though none will be a full replacement for GPS. An all-British like-for-like alternative to Galileo or GPS is simply not financially feasible nor industrially possible on sovereign grounds at this time.

The Skynet satellite communications (SATCOM) system remains the exception to the general British rule of dependency on the United States for military and intelligence space infrastructure and capabilities. Skynet 6 remains the single biggest UK military space acquisition in the current 10-year plan, and the exception to the rule of dependency in space.⁹ It is critically important for the MoD and UK Government that there is a UK-sovereign secure SATCOM channel available at almost any point on Earth with a suitable terminal for the most important strategic communications, command and control, and power projection requirements. However, with a small number of Skynet satellites in geostationary orbit (5 or 6), the constellation and with it the only space-based secure and UK Eyes Only command and control system is at risk from a concerted attack by enemy counterspace actions, both from ground-based anti-satellite weapons and space-based close-orbiting weapons or satellites. Deterring by denial – increasing redundancy – could be considered to reduce the risks to such satellites by deploying additional Skynet satellites or a new type of complementary, relay, or augmenter secure UK satellite communications systems in other orbits. On-board countermeasures such as electronic warfare and guidance systems interference methods may also be considered in future platforms to protect against unwanted close orbital visitors. In the immediate term, MoD should have plans in place to reroute command and control to alternative allied military satellite communications systems and trusted commercial platforms, or where appropriate, rely on terrestrial alternatives such as cables and terrestrial Very High Frequency radio repeater networks.

A second major space acquisition is the proposed Deep Space Advanced Radar Capability (DARC) facility at Cawdor Barracks in Wales. Though it is framed as part of the AUKUS agreements, this acquisition was not suggested or mentioned in the 10-year capability plan, nor was a new, dedicated military space tracking radar explicitly referred to in the 2022 Defence Space Strategy. In addition to the UK Government's surprise \$500m OneWeb bailout in 2020 (and sale to EUTELSAT in 2022), this acquisition again calls into question the role of such documents in public

⁹ UK MoD, "The defence equipment plan 2022-2032", <https://www.gov.uk/government/publications/the-defence-equipment-plan-2022-to-2032>

communications when a major acquisition is not discernible from abstracted and generic public strategy documents which tend to be used to support any subsequent policy decision.

It appears that the DARC's hardware will be funded by the US Space Force.¹⁰ Whilst it is true that more Space Situational Awareness (SSA) capabilities are needed to track more sophisticated Russian and Chinese orbital manoeuvres and a generally busier Earth orbit, that capability gap is not always in hardware or data collection and the three AUKUS radars are not enough to fully address such a threat. The human dimensions of analysis and dissemination, and operations are just as important, as well as other technical space tracking methods using different radar and optical observation methods. It is unclear whether the MoD is going to make the necessary investments in analysts who need to make good use of the data they already have. Concerns have been raised that the US Space Force's methods of space tracking *analysis and dissemination* is inadequate, rather than the amount of data collected.¹¹ The UK must avoid a similar problem and ensure that the data it gathers from RAF Fylingdales, DARC in future, and the wealth of "raw" space tracking data provided by the US for the UK Space Operations Centre can be understood and exploited to its fullest by MoD analysts and provide reliable UK Eyes Only analysis and insight. This should be a recruitment and training priority for UK Space Command – only with a greater in-house (not allied, not contractor) understanding of the threat and space operations in-house can the MoD expand and develop appropriate responses and be more useful to allies in the space domain. The human dimension remains as important as ever, even in the space domain.

It is unclear at this stage what role the ISTARI and Minervia research and development programme will play in the future defence space portfolio. These projects are researching a range of ISR capabilities. These projects (£1.4bn over 10 years) are large relative to the MoD's total space activities. Yet such spending is not approaching the level needed should the UK decide to pursue even a single type of ISR constellation for full operational capability in an increasingly contested orbital environment that Minerva or ISTARI is testing. The major ISR technology categories that the UK could invest in have been well known – and used by the MoD – for decades due to our partnership with the USA. Which space-based ISR investment is best for the UK MoD remains unclear as long as the UK MoD and UK Government more widely has not outlined the major combat and theatre priorities for the terrestrial military forces as a whole.¹²

¹⁰ Sandra Erwin, "Space Force awards \$200 million contract to Northrop Grumman for UK radar site", *Space News*, 23 August 2024,

<https://spacenews.com/space-force-awards-200-million-contract-to-northrop-grumman-for-uk-radar-site/>

¹¹ Sandra Erwin, "U.S. military space domain awareness lags behind expectations", *Space News*, 26/08/2024, <https://spacenews.com/u-s-military-space-domain-awareness-lags-behind-expectations/>

¹² Bleddyn E. Bowen, "The Integrated Review and UK Spacepower: The Search for Strategy", Freeman Air and Space Institute, October 2020, <https://www.kcl.ac.uk/security-studies/assets/kcl-fasi-british-spacepower-and->

Simply put, ISR requirements for a land war Eastern Europe are very different to a maritime confrontation in the GI-UK gap, the Taiwan Strait, or an air-led intervention in North Africa. In the current financial climate, the UK cannot afford to pursue a sovereign major ISR capability in all ISR technology areas. Therefore decisions must be taken on which, if any, ISR capability is not being provided for UK needs from allied states or the commercial sector. A more prudent option, like Space Situational Awareness, may be to invest in analysts and experts to make better use of the data we already have access to and invest in political relationships, as was determined with the Zircon signals intelligence satellite in the 1980s.¹³ As such space has been something of a “missing link” in UK military and security strategy where decisions have traditionally been made without reference to space dependencies, and vice versa.¹⁴

Regarding military space, Japan is in many ways similar to the UK regarding its decades-long dependency on the United States for C4ISR capabilities that underpin its modern fighting forces. The 2023 Japanese Space Security Initiative has inaugurated a significant investment in Japanese military space acquisition and personnel training with a view to greater autonomy and a reduced dependence on the United States – signifying an end to the pacifist and non-interventionist ‘Yoshida doctrine’ in space.¹⁵ The latest Japanese defence budget has seen a hike of over 7% to \$59bn USD, within which new satellite capabilities will be fielded for the Japanese Defense Forces’ ‘counterstrike capabilities’ which refer to the ability to attack mainland Chinese targets with Japan-only capabilities.¹⁶ This necessitates a large deployment of new ISR satellites for the Japanese MoD, including optical and radar imagery satellites, as well as signals intelligence capabilities, coupled with a more expansive communications network.

Similarly, South Korea has announced a major space and defence plan. The Fourth Space Development Promotion plan, 2023-2027 sees a doubling of spending on space (civil and military) between 2021 and 2027, towards \$1bn USD in 2027. This is a notable plan because it explicitly includes the military and security dimensions of space, specifically for reconnaissance and communications on the Korean peninsula.¹⁷ This would still necessitate dozens of such satellites for a

[the-integrated-review-web4.pdf](#)

¹³ Bleddyn E. Bowen, *Original Sin: Power, Technology and War in Outer Space* (Hurst, 2022) pp. 137-138

¹⁴ Bleddyn E. Bowen, “British strategy and outer space: A missing link?”, *British Journal of Politics and International Relations*, 2018, 20:2, <https://doi.org/10.1177/136914811875823>

¹⁵ Japanese Cabinet Office (2023) ‘Space Security Initiative’, June, https://www8.cao.go.jp/space/english/anpo/kaitei_fy05/enganpo_fy05.pdf; Paul Kallender and Christopher W. Hughes (2019) ‘Hiding in Plain Sight? Japan’s Militarization of Space and Challenges to the Yoshida Doctrine’, *Asian Security*, 15:2

¹⁶ Colin Clark, “‘New era of crisis’ prompts Japan’ biggest defense budget ever: \$59B for 2025” *Breaking Defense*, 05/09/2024, <https://breakingdefense.com/2024/09/new-era-of-crisis-prompts-japan-biggest-defense-budget-ever-59b-for-2025/>

¹⁷ Lee Jung-Ho, “Fourth Space Development Promotion Plan: Unmanned Landing on the Moon in 2032, on

credible sovereign capability. Both Seoul and Tokyo have begun fielding the first military satellites for their respective constellations. India too has recently announced a plan to deploy over 50 military ISR satellites.¹⁸

Japan, India, and South Korea's military space investments are far beyond the scale and ambition of the UK MoD's ISTARI ISR satellite programme which remains a Research and Development programme focused on 5-6 separate satellites, each testing different kinds of capabilities (e.g. optical imagery, radar imagery, optical communications). These investments by Japan, India, and South Korea in their military and space industries show the scale of effort needed to take one's own defence seriously when allied space service provision is either insufficient or not as forthcoming as one would like.

In addition, Japan, India, and South Korea have invested in space-based PNT services. Japan's QZSS, India's GAGAN, and Korea's KASS enhance GPS services in their regions. Whilst they are not critical sovereign defence capabilities, they are essential stepping stones for possible GNSS or other more advanced and military-grade PNT services, as the European Union and India demonstrated with GPS augmentation technologies being the first step to their own sovereign GNSS or regional PNT systems. Building GNSS remains extremely expensive and challenging, therefore long-term investments in these areas remain the purview of only a select number of states and specialist space technology companies. India has also developed its own regional navigation system which operates independently of GPS – the NAVIC system – and is a crucial stepping stone should India wish to develop its own GNSS in future.

Developing such ambitious national defence space capability programmes with long-standing publicly funded rocketry programmes, Britain will have to accept in the short to medium term that there will be several other “middle powers” in space that are far more sovereign in their space capabilities than Britain – specifically France, India, Japan, and South Korea. In some ways this is an opportunity for Britain to partner with or contract from newer sources, but it can also be a challenge in that British technical advantages will remain only in very niche areas and UK dependencies on other states will only grow in space. What these other middle powers' historic and recent history shows that significantly increased industrial and scientific capacities in space grow only from increased investment in a national programme which includes defence which in turn provides further opportunities and credibility in developing

Mars in 2045”, *Kyungyang Shinmun*, 22/12/2022,
https://english.khan.co.kr/khan_art_view.html?artid=202212221752047

¹⁸ Abinhav Singh, “The latest in Indian defence? ISRO to build military satellites for surveillance and intelligence”, *The Week*, 10 April 2025, <https://www.theweek.in/news/defence/2025/04/10/the-latest-in-indian-defence-isro-to-build-military-satellites-for-surveillance-and-intelligence.html>

cooperative projects. This should not and can not be a replacement to existing international efforts – such as UK participation in ESA which is fundamental to UK space research and industry – but rather as a powerful force multiplier and signal of serious commitments to space technologies and infrastructure to our international partners.

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