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Protect and defend: advancing a UK space architecture based on deterrence by denial

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About the Author

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Abstract

The United Kingdom has recently taken steps to elevate its status in space by creating the UK Space Command. It unveiled its Defence Space Strategy, addressing past criticism of inadequate involvement in this domain from a defence perspective. One of the emerging questions for the UK is how to ensure freedom of action in space considering the pivotal role satellites play in enabling multi-domain operations and serving as a force multiplier. Sub-threshold counterspace threats challenge this freedom of action, undermining deterrence by punishment. Fortunately, the UK's low number of space-based sunset capabilities offers an opportunity to design a resilient architecture subject to few path dependencies. This paper argues that the UK should strengthen its deterrence by denial posture and proposes various measures it derives from four denial strategies.

Deterrence-by-Denial: an opportunity for UK space strategy

In February 2022, after numerous delays, the United Kingdom (UK) published its first Defence Space Strategy. This was followed by other official space-dedicated documents, including the Joint Doctrine Publication 0-40 in September 2022, which represents the first doctrinal document exclusively on UK space power. Behind the occasional lofty rhetoric of "Global Britain becoming Galactic Britain",[1] there has been a reckoning in Whitehall that the UK should adopt a stronger defence focus on outer space. The creation of the UK Space Command in 2021 and the pledge to invest £1.4Bn over a period of ten years to develop sovereign military space capabilities further attest to the intensification of British efforts in this domain.

One of the major themes that has emerged from this renewed interest in outer space has been the necessity to "protect and defend" British military interests in space by bolstering the credibility of its deterrence posture. This posture has several components, including the ability to identify, attribute, and respond to threats against satellites in a proportionate manner. But there is also an emphasis on developing resilient in-orbit space architectures and space control capabilities.[2] In its first Capability Management Plan, the UK Space Command identifies space control as one of seven critical capabilities to be developed in the coming years. The core objective of space control is to create resilient systems that guarantee operational independence in space to support military operations on Earth.[3] Thus, to protect space-based assets, the ability to respond to an adversary's aggression should be accompanied by the ability to deny any benefits from such aggression. Put differently, deterrence by denial is an essential component of a credible deterrence posture in space.

This paper aims to evaluate the UK's current initiatives and actions associated with a deterrence-by-denial posture and offers policy recommendations to strengthen this posture further. Given the limited scope, this paper only investigates deterrence by denial strategies in the space segment. It does not investigate possible measures in the non-space segments. These segments deserve equal attention in future research.[4] Likewise, there are strategies not considered here that ensure satellite-enabled missions can be conducted by other platforms, including conventional aircraft, remotely piloted aircraft systems (RPAS), and high-altitude platform systems (HAPS).[5] Distributing missions across domains is another avenue to ensure that the UK armed forces can conduct multi-domain operations with limited degradation risks.

The paper's emphasis on protecting and defending UK space assets reflects the reality that the UK armed forces have increasingly relied on space-based capabilities to conduct their military operations, particularly since the 1991 Gulf War. Embedded in the multinational coalition led by the United States (US), the UK armed forces benefited from satellite communications, positioning, navigation, timing, and surveillance systems.[6] Meanwhile, the early 2000s witnessed the emergence of the British military transformation agenda in which space-based systems were expected to play an important role. The aspiration of the British theory of 'network-enabled capability' was to streamline the sensor-to-shooter loop via systems that could gather and disseminate information faster to achieve decision advantage in the battlefield.[7] The communication satellites developed under the British Skynet Series 5 constituted one of the key equipment programmes to deliver this ambition.[8] With the shifting operational dynamics and the emerging emphasis on out-of-area operations after the end of the Cold War, satellite communications became indispensable to the UK armed forces, ensuring command and control, transfer of Intelligence, Surveillance, and Reconnaissance (ISR) data, and communication with beyond-line-of-sight RPAS.[9]

The advent of strategic competition with Russia and China and their use of sub-threshold measures have persuaded the UK to adopt the multi-domain integration agenda. Space constitutes one of the five operational domains being integrated across all levels of war, representing a critical enabler to gain information advantage that can be used to exploit adversaries' vulnerabilities at the right time.[10] Russia's war on Ukraine has further stressed the critical role that satellite systems play in modern military operations.[11] Alex Chalk, then Minister for Defence Procurement, stated that the "war in Ukraine has served to reinforce the space domain's importance in securing information advantage and enhancing military operations".[12]

In addition to these operational realities, there is a capability-centric rationale to strengthen the deterrence by denial posture of the British military forces. Via a Private Finance Initiative (PFI), the Ministry of Defence (MoD) has priority access to the Skynet fleet, which currently consists of Skynet 4 and 5 satellites. The UK is planning to launch a low Earth orbit constellation soon under the Istari programme to acquire sovereign space-based intelligence, surveillance, and reconnaissance satellites. Another constellation, called Minerva, is expected to autonomously gather, process, and distribute data to the UK armed forces from national and allied satellites.[13] With a higher number of sovereign satellites collecting and disseminating data across the British military enterprise, protecting the British space architecture becomes even more important, not only from an operational perspective, but also to protect its assets.

The UK has been consistently accused of punching below its weight when investing on military-grade space capabilities. For instance, a 2022 report by the House of Commons' Defence Committee contended that the UK was a "tier three" space power, behind countries such as Japan, Italy, and France.[14] Whether this is true or not, it should be viewed as an opportunity: without many legacy systems that constrain defence planning and the design of the space architecture, there is room for manoeuvre to incorporate lessons learnt and novel ideas from other countries. Indeed, that is what the report alluded to when arguing that "as a relative latecomer to the defence space arena [the UK] has the advantage of capitalising on the experience of its peers and competitors".[15] This paper aims to capitalise on this opportunity and offer a few ideas to protect and defend the UK's space architecture from a deterrence by denial perspective.

To do so, the paper firstly draws on original research from MoD records at The National Archives to trace British space power's evolution in capability development, relationship with the United States, and the predominant military uses of space up until now. The following section argues that the dawn of the New Space age and the changing character of threats to space-based systems require the consolidation of a deterrence by denial strategy in space within an overall integrated approach to deterrence. The third section distinguishes among different strategies that can be pursued to strengthen a space deterrence by denial posture. The following sections apply these strategies to British space power, explaining what has been done so far and putting forward a few recommendations that the MoD could adopt to deny adversaries' ability to degrade the performance of satellites in support of British military operations. These recommendations have benefited from conversations with civil servants and military officers that the author has held over the previous year. Finally, the conclusion re-emphasises that deterrence by denial should be supplemented with other military and non-military deterrence strategies.

A history of British space power

For the majority of its trajectory, British space power has been defined by its sovereign military satellite communication programme, called Skynet,[16] and its dependence on the United States for access to other space-based data, including intelligence, surveillance, and reconnaissance, meteorology, situational space awareness, and ballistic missile early-warning information.[17] The only caveat is that the UK also established a number of ground-based facilities for space situational awareness to contribute to the US space programme. In 1963, the Ballistic Missile Early Warning System (BMEWS) at RAF Fylingdales became operational.[18] The facility has been historically part of the US Space Surveillance Network (SSN) and offers the UK the ability to track satellites and other objects in space. During several decades, the Royal Aircraft Establishment Telemetry and Command Station hosted at RAF Oakhanger was also employed as a remote station for the US Air Force Satellite Control Facility. Part of the underlying rationale behind these facilities was to secure a quid pro quo with the US, whereby the latter would supply additional communication bandwidth from its military satellites to the UK.[19]

Satellite communications represented the successful story of British military space endeavours until now. In 1969, via a US satellite launcher, the UK deployed the world's first military communication satellite in geostationary orbit (Skynet 1A).[20] The primary mission of this satellite was to establish secure military-grade communications interlinks between the Royal Air Force (RAF) station at Oakhanger and fixed ground stations at British overseas military bases.[21] The successful deployment of Skynet 2B in 1974 was accompanied by the introduction of mobile terminals, particularly for shipborne use by the Royal Navy (RN).[22] The Skynet programme, however, suffered a few setbacks. After the British withdrawal from East of Suez, the MoD cancelled the Skynet 3 Series in 1974 as sovereign satellite communications ceased to be a priority given that Europe became the main theatre of operations. Instead, the MoD decided to lease bandwidth from US and North Atlantic Treaty Organisation (NATO) satellites for strategic communications.[23]

At the same time, however, studies investigated possible operational requirements for tactical level communication satellites. Following a joint Navy, Army, and Air Staff Requirement (NGASR 7123) in the early 1980s, the MoD decided to proceed with the Skynet 4 Series because there was an increasing demand for satellite communications for both strategic and tactical uses that exceeded current arrangements with the US and NATO.[24] Although the plan initially deployed two satellites, the Royal Navy advocated for the procurement of a third satellite (Skynet 4C) as the 1982 Falklands War had demonstrated an increasing requirement for tactical, "small dish" mobile terminals that could only be addressed with more data throughput.[25] Indeed, the Royal Navy was the champion of the Skynet programme, given its need to communicate globally.[26] The RAF, by comparison, earmarked less funding to the Skynet programme, yet was responsible for the operation and management of the Skynet satellites in orbit through its station at RAF Oakhanger.[27]

There were a few instances in which the MoD examined the benefits of establishing a national space programme beyond satellite communications. In 1984, the MoD Space Opportunities Report recommended follow-up studies to explore the creation of a national imaging satellite system for real-time targeting to support an independent long-range weapon development programme.[28] Ultimately, however, dependence on US satellite systems remained the cornerstone for British policy on space-based intelligence and surveillance.[29] The overarching reason is best summarised by the then Chief of Defence Staff: "recognising the immense costs of space programmes, [...] our approach should be one of minimum outlay ourselves, for maximum gain from the US".[30] In a nutshell, value for money was the guiding principle adopted by the MoD on space.

The 1991 Gulf War was a wake-up call for the British Army and the RAF as it showed the various missions that space-based systems could undertake to enhance military force on Earth.[31] Since then, the UK armed forces have been employing space-based assets, whether commercial, allied, or national, for their out-of-area operations in those theatres where they have been deployed.[32] First under concepts such as 'network-enabled capability' and later under the multi-domain integration agenda, outer space has become a critical enabler for the UK armed forces' operational performance. Skynet satellites and their ground terminals can extend the British Army's Bowman tactical communications system beyond the line of sight. Space-based ISR systems can be fused with other non-space-based sources to provide targeting data for RAF's aircraft. And space domain awareness (SDA) capabilities can detect when an adversary's ISR satellite is within the field of view of a naval system so that the Royal Navy can plan maritime operations accordingly.[33]

This dichotomy between sovereign satellite communications and exclusive reliance on US systems for ISR and other space-based information will erode in the upcoming years. On the one hand, the UK has continued to invest on its Skynet constellation. With the deployment of the four-satellite Skynet 5 fleet from 2007 onwards, and their procurement under a Private Finance Initiative, the RAF ceased to operate the Skynet programme.[34] More recently, the UK is upgrading its fleet with the Skynet 6 Enduring Capability, with the first satellite, Skynet 6A scheduled for 2025.[35] On the other hand, as the UK has announced large-sum investments for an independent ISR constellation, space control capabilities, and other systems, its dependence on the US will be reduced. With those investments, the UK cannot afford to delegate the protection and defence of space-based missions to other countries.

The following section argues that there should be a re-examination of space deterrence strategies considering four trends: the indispensable role that satellites are increasingly acquiring across all levels of warfare; the emergence of several spacefaring actors; sub-threshold threats to space systems; and new technological developments.

The rising importance of deterrence by denial in space

During the Cold War, the United States and the Soviet Union largely treated outer space as a sanctuary. Indeed, in that period space was inextricably linked to the strategic stability paradigm between members of the NATO alliance and the Warsaw Pact.[36] Satellites were critical for the US and the Soviet nuclear deterrence postures, enabling nuclear command, control, communication, and intelligence (C3I) capabilities. Likewise, satellites enabled monitoring compliance with strategic arms control agreements, establishing a "mutually assured surveillance regime" to enhance transparency and predictability.[37] This made the destruction of satellite systems a perceived overture to a nuclear strike. Thus, the US and the USSR reached a mutual understanding that outer space should remain a *sanctuary* in which satellites were not to be targeted.[38]

As Finch and Steene put it, "the problem of space deterrence independent of nuclear stability was uninteresting at best".[39] Therefore, nuclear deterrence on Earth was the ultimate shield against attacks on satellite systems, extending the mutual assured destruction (MAD) paradigm into space.[40] Deterrence by punishment was the dominant strategy that spacefaring countries adopted to protect their satellites. The underlying logic of this type of deterrence is that adversaries will only refrain from malicious activity if they anticipate that the costs inflicted by the response of the target actor will outweigh the benefits accrued via an act of aggression.[41] In the Soviet Union's cost-benefit analysis, attacking a military satellite to degrade the US's capabilities triggered the *possibility* that the US would escalate by launching a nuclear counterforce campaign, and vice versa. Satellite systems then benefitted from general deterrence.[42]

Towards the late stages of the Cold War, however, space began to decouple from operating exclusively at the strategic level. Indeed, military forces started to capitalise on satellite systems for conventional military campaigns. The Soviet Radar Ocean Reconnaissance Satellites (RORSATs) deployed in the 1970s transmitted radio waves to track in near real time US naval platforms and be able to target them with stand-off missiles.[43] The United States also explored the tactical uses of satellite systems during that time. Funded by the Defense Advanced Research Projects Agency (DARPA) and the US Air Force, the Teal Ruby programme, with British participation, sought to demonstrate how advanced infrared sensors could detect and track tactical targets, including ships and aircraft, and provide surveillance over the battlefield.[44] Overall, the closer association between satellites and a tactical warfighting role further encouraged the two spacefaring superpowers into developing anti-satellite weapons.[45]

Key to a successful deterrence by punishment strategy is credibility. In particular, this depends on the adversary's perception that the target actor has the capacity to inflict damage and the will to follow through with the threatened consequences of an attack.[46] This deterrence by punishment strategy has eroded because space-based assets gained relevance beyond nuclear capabilities. Threatening a nuclear response to a kinetic attack against a satellite that performs a conventional mission appears disproportionate and, therefore, lacks credibility.[47] To be sure, satellites can still benefit from general deterrence. However, there is a risk that anti-satellite attacks are perceived as less escalatory because they do not inflict human casualties.

On its own, the *conventionalisation* of military satellites would not necessarily require a change in deterrence posture. However, two other developments are changing the way in which satellites should be protected. First, whilst the Soviet Union was the West's chief security threat during the Cold War, the UK now faces multiple actors that possess anti-satellite capabilities, namely Russia, China, Iran, and North Korea.[48] This complicates the cost-benefit calculus: by design, deterrence by punishment should not be a one-size-fits-all approach. The bottom line of this calculation ultimately lies in the eye of the beholder.[49] For instance, the degree to which an adversary relies on space-based systems for its military operations influences the risk it pins on losing its own force multipliers. States, therefore, must adapt their deterrence to every single adversary.

The second development is that several technological advancements expand the realm of possibilities in space. Small satellites and constellations, commercial off-the-shelf technology, the democratisation of satellite launchers, and decreased costs of entry to the space enterprise, just to name a few,[50] offer additional instruments to defend space-based assets beyond threatening retaliation. Spacefaring adversaries' investments in various offensive capabilities to deny the UK and its allies continued access to outer space accentuates this development. This further complicates a deterrence strategy based solely on retaliation.

Russia and China have explicitly communicated their possession of kinetic anti-satellite capabilities. In 2021 and 2007, respectively, these countries conducted debris-producing direct-ascent anti-satellite tests by intercepting two satellites in orbit.[51] While this type of counterspace capability may elicit a response in kind, non-kinetic systems are likely to have a leading role in the future. Both countries have acquired non-kinetic physical, electronic, and cyber counterspace capabilities. They are suspected of having ground-based high-powered laser systems that could blind or dazzle a satellite sensor to the point of degrading the performance of ISR payloads.[52] Leaked CIA documents cast light on China's investments in offensive cyber capabilities that could deceive enemy satellites by imitating the uplink signals from their ground stations and issuing self-sabotaging commands. This type of cyber capability could undermine a satellite's ability to transmit ISR data to the point of need or to convey commands to weapon systems in a warfighting context.[53]

The war in Ukraine has provided ample evidence of the contribution that non-kinetic counterspace capabilities are bound to make in modern conflicts. Just hours before its full-scale invasion started on 22 February 2022, Russia launched a cyber-attack against Viasat, a US commercial entity that provided satellite communications to the Ukrainian government and military institutions for command and control.[54] Russia has also made extensive use of electronic warfare (EW) capabilities. It has employed jamming systems to disrupt satellite signals used by Ukraine in support of the latter's military operations in the Southern and Eastern fronts.[55] Russian EW systems previously believed to be defensive, such as Tobol, have been identified as attempting to intercept Starlink's signals to the Ukrainian Armed Forces during the latter's counteroffensives in the Donetsk region.[56]

The UK Government identified sub-threshold operations as a serious threat. Official documents[57] have repeatedly acknowledged that adversaries are conducting sub-threshold activities to advance their strategic objectives in order to avoid a warfighting response. Because deterrence by punishment relies on internally clear thresholds above which force is employed, this strategy has less utility in these scenarios. Indeed, the UK Government has recently reemphasised the importance of bolstering resilience to ensure its ability to operate and warfight even in light of such threats.[58] Equally, the UK Defence Space Strategy notes the existence of various counterspace threats and establishes a three-pronged approach to protect and defend its satellite-based missions. This includes a resilient in-orbit infrastructure and commercial and international partnerships.[59] Therefore, whilst not mentioned by name, a deterrence by denial strategy will be a fundamental pillar to future UK space power.

Operationalising deterrence by denial in space

To ensure the UK armed forces' freedom of action in outer space and on Earth, it is imperative for the UK to adopt an integrated approach to deterrence. This means that the UK should protect and defend its space-based assets with complementary instruments in its deterrence toolbox, including both military and non-military ones. For example, the UK has been spearheading efforts at the United Nations to establish what constitutes responsible behaviour in outer space, and what activities should be deemed as threats to this domain.[60] This could constitute a deterrence through norms,[61] where the UK aims to delegitimise the use of anti-satellite weapons and as a result increase the political costs for an adversary considering such a course of action.

The military can employ deterrence by punishment and deterrence by denial in tandem. However, it is fundamental to re-emphasise deterrence by denial in space. Unlike deterrence by punishment, which ultimately cedes the initiative to the adversary, denial is a strategy of control with the objective to limit an adversary's strategic options. As Freedman argues, "with punishment, the target is left to decide how much more to take. With denial, the choice is removed".[62] The character of war in outer space strengthens the case for denial strategies. Attribution and predictability, two features embedded in any successful deterrence by punishment strategy, degrade in outer space. Yet, they are not prerequisites for a denial posture. Even if deterrence collapses, a capability and operational planning based on denial can lay the basis for a successful defence once the battle for space control has begun.[63]

Deterrence by denial can be broadly conceptualised as aiming to "deny, degrade, or delay the aggression in near real time" so that the aggressor, in anticipation of not achieving the intended results, is discouraged from launching an attack in the first place.[64] To that end, a resilient architecture that can withstand attacks and/or quickly reconstitute its plays a critical role.[65] Ultimately, the objective should be to ensure the operational soundness of the mission to which satellites are entrusted (e.g., providing communications to the UK armed forces with a certain degree of reliability in terms of quality and timing), rather than to protect a particular satellite as an end in itself. Whilst mission assurance encompasses a few approaches, the focus here is on denial strategies that can guarantee the continued performance of the mission from the space domain.[66]

The role of Starlink during Russia's war on Ukraine has offered ample evidence of the importance of a resilient architecture and of mission-centric, rather than capability-centric, approaches. The Starlink constellation has built-in characteristics that have generally prevented Russia from denying the Ukrainian Armed Forces access to satellite communications. These have included software upgrades to undermine cyber-attacks, and stronger electronic signals between the satellites and the ground stations that complicate a jamming or spoofing attack.[67] As a constellation, the mission is provided collectively so that critical vulnerabilities are not linked to individual capabilities.[68] Russia would have to kinetically target a significant number of Starlink satellites for the mission to be degraded.

To operationalise deterrence by denial in space, various overlapping taxonomies have been suggested in recent years.[69] The following sections examine how UK space power fares according to the following strategies: disaggregation, diversification or redundancy, proliferation, and reconstitution or responsive launches. These strategies can reinforce each other and should not be seen as mutually exclusive. A reconstitution strategy, or the ability to launch new satellites in orbit on demand, is slightly different from the rest of the strategies. In the former case, rather than reinforcing deterrence by denial by concentrating on a resilient architecture, it does so by promising the deployment of new assets to prevent the degradation of the mission in a timely manner.[70] In the process, the paper offers recommendations tailored to each strategy that the UK could adopt to strengthen its deterrence by denial posture in space.

A disaggregation-based approach involving the Skynet and OneWeb constellations

Disaggregation strategies intend to separate different missions across various platforms or payloads, located in different orbital regimes.[71] The idea is to prevent various missions from becoming concentrated into the same satellite constellation, becoming an easier target for adversarial anti-satellite systems. A disaggregated architecture can transfer some of the missions performed by exquisite satellites to fewer complex systems. In so doing, it can generate a higher number of satellites to perform certain missions, minimising critical points of failure and as a result strengthen overall mission assurance.[72] Applied to the UK's context, the Skynet programme consists of multi-mission defence satellites since they serve both strategic and tactical level ends. It is, in short, an aggregated architecture for military satellite communications.

In the future, the MoD should shift from aggregating different types of missions into the Skynet fleet towards a proliferated architecture that involves military satellite communications in geostationary orbit and low-Earth orbit. If it has not done so already, the MoD should draft a list of those military missions requiring space-based satellite communications, ranging from strategic-level missions such as enabling the command and control of the continuous-at-sea deterrent, to those serving the tactical level, including linking beyond-the-line of sight RPAS to their RAF operator. Subsequently, defence authorities should establish a spectrum that attributes a priority value for each military mission in terms of gaining access to the Skynet-enabled communications, and a threshold below which certain missions should be served by another, less costly constellation. Indeed, there are several missions that do not require the high degree of reliability and security offered by the Skynet fleet. Maintaining reliable and stable communications with the Vanguard-class submarines and transmitting real-time ISR data to an F-35 cockpit could be categorised as missions of high-importance. However, ensuring communications between an artillery unit and an RPAS for surveillance in the battlefield might be equally served by a low Earth orbit (LEO) satellite communications constellation.

Whilst the UK does not currently have a communications satellite constellation in LEO, OneWeb offers an efficient pathway to secure a disaggregated architecture. The UK government has a golden share in OneWeb that guarantees a series of national security rights, including setting security standards for the company's satellites and network and having priority access to its services on national security grounds.[73] The MoD should make use of this right and hold conversations with OneWeb to set specific security standards in tune with the UK armed forces' requirements for OneWeb's second-generation constellation, which is expected to be operational by 2028.[74] The upcoming constellation would then add another communications solution for the armed forces and create multiple targets for an adversary. It would also conclude the enduring dilemma that the UK government has faced regarding its investment in OneWeb: should it seek to maximise its economic return and abdicate its golden share to compete for EU contracts associated with the planned Infrastructure for Resilience Interconnectivity and Security by Satellite (IRIS^2) constellation, or should it retain its golden share to prioritise its national security rationale?[75] From a mission assurance perspective, the UK government should favour the latter option.

This disaggregation should be evaluated against the perceived utility of employing a deterrence through entanglement strategy.[76] In particular, aggregating tactical missions under a constellation that plays a major role in ensuring the credibility of British nuclear deterrence can discourage any anti-satellite attack. An adversary might fear that an attack motivated by a tactical/operational logic could be interpreted as an attack at the strategic level, increasing nuclear escalation risks. As explained below, however, disaggregating the missions undertaken by Skynet into other platforms and orbital regimes also come with other denial-based advantages, including unlocking a feasible reconstitution strategy given that the cost of production and launching satellites are lower.

Deterrence-by-denial strategies	Policies and activities in place	Suggested way forward
Disaggregation strategy	Skynet as a multi-mission constellation.	Proliferated GEO-LEO milsatcom architecture (Skynet and OneWeb). Classification of military missions according to priority use of Skynet. Maintain OneWeb's golden share.

Table 1: Summary of the policy recommendations and the current UK policies based on a disaggregation strategy.

Collaborate-Access: Adding redundancies to the British space architecture

A diversification strategy ensures the continuity of the mission by employing various platforms, placing assets in different orbits, and/or capitalising on commercial capabilities or those of allied countries.[77] For instance, a European military organisation that wants to tap into space-based Positioning, Navigation, and Timing (PNT) signals could use interchangeably the US Global Positioning System (GPS) and the EU's Galileo Public Regulated Service (PRS), which transmits encrypted navigation signals for governmental authorities.[78] Likewise, the commercial space sector can offer back-up options if the primary source of satellite imagery or satellite communications used by a country is degraded or completely disrupted.[79] Similarly, partnerships with allied countries can provide redundant capabilities and augment national space power and, incidentally, contribute to a deterrence by punishment posture insofar as an adversary must factor in the possibility that more than one country responds to an anti-satellite attack.[80]

UK space power is allied by design

The importance of commercial capabilities and those generated by international partnerships has been captured by the own-collaborate-access framework first introduced in the 2021 Integrated Review and echoed in the UK Defence Space Strategy.[81] The UK has recently joined a series of initiatives with its closest allies. In 2019 it became the first country to join the US-led multinational Operation Olympic Defender with the objective to deter threats in space by improving, *inter alia*, the resilience of its space systems.[82] Most notably, ever since joining in 2014, the Combined Space Operations Initiative (CSpO) represents the primary space military alliance for the UK, comprised of the Five Eyes countries plus Germany and France. Their joint vision for the next decade prioritises mission assurance and the protection and defence of their space systems with an emphasis on resilience, interoperability, responsiveness, and collaboration.[83]

In addition to these collaborative efforts, the UK has a long pedigree of accessing space-based capabilities from allied countries. The UK armed forces largely resort to the US Government for space-based surveillance and reconnaissance.[84] On satellite communications, the UK is a member of a multinational consortium that has access to the US Advanced Extremely High Frequency (AEHF) System, a six-satellite constellation in geostationary orbit that provides partner countries with extremely high-frequency (EHF) and super high-frequency (SHF) communications for high-profile military operations, ensuring a high degree of survivability and protection against electronic warfare capabilities.[85] On SDA, the UK became the first country to have access to the US Space Force's Standardized Astrodynamics Algorithm Library (SAAL), improving its ability to predict the orbital trajectories of satellites and other objects in space.[86]

Deepening alliances beyond the special relationship

Access to US space-based assets will continue to be vital for UK space power. However, putting all the eggs in one basket is not a sensible approach: establishing stronger partnerships with other allied countries should be a priority for the years to come. The UK has recently concluded bilateral agreements with the Republic of Korea, Australia, and Japan to cooperate on information sharing, personnel exchange, and training.[87] But the ambition should extend beyond that and aim for joint capability planning and development, deepening cooperation with these like-minded countries. The most suitable candidate with which to collaborate more intensively is Australia, as there is a tradition of cooperation as part of the Five Eyes community. In the 2021 Integrated Review, the UK announced a "tilt to the Indo-Pacific", which it has since delivered according to the 2023 updated IR version. The British government has substantiated this commitment, notably with agreements on a nuclear submarine programme with Australia and the US and on a sixth-generation jet programme with Japan and Italy. The next step could be to take these efforts towards outer space, lending further credibility to the UK's involvement in the Indo-Pacific.

Australia recently announced the procurement of a sovereign military satellite communications project consisting at least of two satellites, with Lockheed Martin likely becoming the prime contractor.[88] Part of the project's rationale is to improve its self-reliance on space and decrease its dependence on the US and its Wideband Global Satcom (WGS) system.[89] In parallel, the UK is developing its Skynet 6 series programme, with the first satellite having been already awarded to Airbus Defence and Space. Fortunately, the development cycles of these programmes are closely aligned. Skynet 6A is expected to be launched by 2025, and new satellites to the Skynet constellation are scheduled for launch between 2028 and 2036.[90] Meanwhile, although negotiations between the Australian government and Lockheed Martin are continuing and a formal contract has not been awarded yet,[91] Canberra will want to accelerate the procurement of its first military satellite communication constellation as extant contracts with commercial entities to provide bandwidth are nearing their contractual or operational end.[92]

Considering these cycles, the UK MoD should explore the merits of integrating British communication payloads into the upcoming Australian military satellites. Australia could then undertake a similar process by hosting its own communication payloads into the upcoming Skynet satellites. Integrating different payloads into the same satellite bus comes with challenges. First, these payloads should be compatible at least in the intended area of coverage.[93] In this vein, Australia's upcoming military communication satellites are expected to cover Australia's mainland, the Indo-Pacific, and the Indian Ocean.[94] This aligns with the UK armed forces' geographical area of interest and with the current Skynet constellation which enjoys global coverage. Second, a possible partial shutdown of the satellite bus hosting multiple payloads would require a decision on which payload should continue in operation.[95] This can be solved with an *ex-ante* mutual agreement between the British and Australian governments whereby the British payload hosted on a Skynet bus would have priority over the Australian counterpart and, conversely, the Australian payload would be prioritised on its own satellite bus.

The UK and Australia have already cooperated bilaterally on space. In addition to the 'Space Bridge' partnership agreement signed in 2021,[96] both countries have previously signed a Memorandum of Understanding whereby the Australian Defence Forces could access services enabled by Skynet 4 and Skynet 5 satellites for beyond-line-of-sight communications in the Indian Ocean area.[97] By *exchanging* payloads on each other's sovereign capabilities, the UK would further strengthen its military alliance with Australia on space, diversifying away from its current dependence on the US. Framed in deterrence by denial terms, the UK would be investing in redundant capabilities if its Skynet fleet degrades to the point where it does not satisfy its operational requirements during a conflict. An adversary wanting to then target the British payload on an Australian satellite bus would have to consider the risk of dragging Australia into the conflict.

Another key ally, as enshrined in a recent bilateral defence agreement with the UK, is Japan.[98] After leaving the EU, the UK lost its access to Galileo's Public Regulated Service (PRS), the EU's PNT system. Although there have been voices within the British defence sector advocating for the UK to negotiate with the EU to regain access to Galileo's PRS,[99] this option seems increasingly unlikely. As it stands, therefore, the MoD relies on the US GPS constellation for secure access to this type of services. The UK has repeatedly acknowledged that strengthening the resilience of PNT services is a national priority,[100] and the UK Space Agency is currently leading a cross-government PNT office that includes representatives from the MoD.[101] Its main task is to devise a plan for a systems-of-systems approach that could include a space segment component as well as terrestrial assets and hence minimise single critical points of failure. Determining how to apply the Own-Collaborate-Access framework in this approach would remain a key issue.

From a 'Collaborate' perspective, a space-based solution that could ensure access to PNT services against a degraded GPS constellation would be to rely on regional PNT systems. This is one of the areas where Japan can be a valuable partner. Initially intended to augment GPS signals around Japan's area of interest with a four-satellite constellation in orbit since 2018, the Quasi-Zenith Satellite System (QZSS) is expanding into a seven-satellite constellation by 2024, with plans already announced to deploy eleven satellites in total.[102] With seven operational satellites, the Japanese system will become a back-up capability as it will be able to function independently from GPS.[103] To demonstrate the ability to seamlessly operate in a GPS-degraded environment, the UK could begin by employing the QZSS in a military exercise. For example, as the UK deploys its Carrier Strike Group to the Indo-Pacific in 2025,[104] the Royal Navy could perform some of its duties enabled by the QZSS rather than the GPS. In so doing, the MoD would be sending a message to adversaries that attacking its primary PNT system might only yield limited effects.

Accessing commercial assets

At the same time, commercial entities play a key role in enhancing space resilience. The UK has experience in accessing commercial capabilities and cooperating with private entities. In the framework of the Skynet 5 programme, the MoD has an ongoing contractual partnership with Airbus Defence and Space where the latter provides commercial and military communications services to the UK armed forces. Thus, the MoD defines the requirements (e.g., frequency bands, bandwidth) and Airbus guarantees access to beyond-line-of-sight communications through a combination of the military-grade Skynet fleet and long-term leases with commercial providers. At the time of its creation, this partnership was a European innovation in how a government could engage with industry for the provision of military space services.[105]

The UK National Space Operations Centre (SpOC) stood up a Commercial Integration Cell to deepen partnerships and harness expertise located in the commercial sector.[106] In the initial stages of this Cell, it was seemingly geared towards exchanging best practices and reaching a cross-understanding between the commercial and the defence sectors on how to protect and defend space assets,[107] rather than on supporting military operations on Earth. More recently, the UK Space Command has established a space domain awareness commercial cell called Joint Task Force-Space Defence Commercial Operations Cell (JCO-UK). Part of a US programme, its objective is to enhance the UK's understanding of orbital activities by complementing sovereign capabilities with commercial sensors and analytical tools.[108] This has been followed by the joint MoD-UK Space Agency publication of SDA requirements so that industrial actors can develop appropriate sensors that can be ultimately exploited to improve the space surveillance and tracking ability of the UK.[109]

For space based ISR services, meanwhile, RAF Wyton hosts the UK's National Centre for Geospatial Intelligence, which delivers intelligence support to the UK armed forces deployed in international operational theatres. Under the PICASSO programme, led by Defence Intelligence (UK Strategic Command), the UK armed forces receive geospatial intelligence products to improve their situational awareness when fulfilling their missions.[110] Indeed, it is UK Strategic Command, as the organisation supporting joint military capabilities and operations, which is responsible for supplying data to the armed forces. Therefore, even if UK Space Command is to negotiate commercial agreements for the provision of ISR, there is a high chance that the organisation holding the tasking rights was UK Strategic Command.

These recent efforts are a clear step in the right direction and consistent with a diversification strategy. And although institutional investment on space capabilities has been underwhelming when compared to similar countries, the story is different in the private sphere. The UK's industrial base has received a significant share of the overall increase in global private space investments over the past few years, partly given investments in start-ups, making it a very dynamic sector.[111] The MoD should capitalise on this dynamism and the dual-use nature of many space-based technologies and ensure that both the traditional prime contractors as well as SMEs and start-ups are integrated into the National Space Operations Centre's Commercial Integration Cell. In turn, this Cell should tilt towards a greater emphasis on ISR data and analytics. In so doing, UK Space Command could establish a structured platform wherein, on one hand, it acquires a better grasp of the ISR ecosystem and novel technologies in the UK, and on the other hand, companies can better understand the MoD's needs and operational requirements for ISR. Such a platform would signal to commercial vendors that the MoD is taking steps to act as a larger anchor customer for space-based services. This wider integration could be complemented with periodical exercises where commercial actors demonstrate their innovative sensors or analytical products in a realistic operational environment.

This improved awareness of the commercial ISR sector and a more mature relationship with commercial vendors should lay the foundation for the procurement of services contracts. These should secure priority access for tasking satellites upon request in a short timeframe. That would avoid requesting satellite data in an ad hoc manner, which might not guarantee the provision of ISR data if other actors are competing for the same systems during a conflict. UK Space Command should work closely with UK Strategic Command in the process because the latter is likely to maintain the tasking rights for systems that provide support to military operations. These contracts should aim to plug the capability gap until the Istari constellation reaches full operational capability. In the long term, the UK could replicate the services-based approach of the Skynet programme for ISR capabilities. In particular, a private company could operate the Istari constellation, providing of commercial data upon request by the UK armed forces via long-lease commercial agreements.

Deterrence-by-denial strategies	Policies and activities in place	Suggested way forward
Diversification strategy	*Alliances* UK is allied by design: Operation Olympic Defender, Combined Space Operations Initiative, bilateral relationship with the US, bilateral partnerships with Australia, ROK, and Japan. *Accessing commercial assets* Skynet's PFI with Airbus Defence and Space. UK Space Command's Joint Task Force-Space Defence Commercial Operations Cell (JCO-UK). Commercial Integration Cell embedded in the UK SpOC. UK Strategic Command's PICASSO programme.	*Deepening non-US alliances* Joint capability planning: Hosted payloads on Australia's new milsatcom constellation. Integrate Japan's regional PNT system into a military exercise. *Improving the commercial output* Add both prime contractors and SMEs and start-ups into the Commercial Integration Cell. Greater emphasis on ISR data and analytics within this Cell. Long-term contracts with commercial companies for ISR. The Istari constellation could replicate Skynet's PFI approach.

Table 2: Summary of the policy recommendations and the current UK policies based on a diversification strategy.

Investing on in-space SDA capabilities as a proliferation strategy

A proliferation strategy can be defined as the deployment of "larger number of the same platforms, payloads or systems of the same types to perform the same missions".[112] The major difference between a proliferation and a diversification strategy, therefore, is that the former implies the use of additional payloads or systems that are not owned by commercial entities or allied partners. A historical British example is the development of the Skynet 4 Series. Initially, the joint Services' operational requirement envisaged two Skynet satellites to ensure that the programme could enable secure and reliable communications for defence users with 95% probability of full availability. Eventually, the Directorate of Naval Plans successfully campaigned for the addition of Skynet 4C to restore the operational availability with the same level of confidence as it was perceived to have become degraded since the approval of Skynet 4's initial requirement.[113] The procurement of Skynet 4C hence constituted a small-scale form of a proliferated architecture.

Other than the current Skynet constellation in orbit, comprised of Skynet 4 and Skynet 5 satellites, the UK does not have any other proliferated architecture at the moment. This will change with the development of the Istari constellation, a multi-satellite programme for intelligence, surveillance and reconnaissance that is likely to incorporate electro-optical as well as synthetic aperture radar sensors. Interestingly, one of its core objectives is to reinforce bilateral and multilateral relations with the Five Eyes community, particularly with the US.[114] This is in line with the Minerva programme, which aims to lay the groundwork for the Istari programme by enhancing interoperability with allies and sharing data with them.[115]

Considering budgetary constraints and the roadmap established by UK Space Command, it is unlikely that HM Government will invest on additional constellations any time soon. But that is not the only means by which the UK can strengthen space resilience via a proliferation strategy. According to the 2022 Defence Space Strategy, the UK is considering opportunities to integrate secondary payloads into the upcoming Skynet 6 fleet. This idea is not new. In a 1974 report titled "Military Applications of Space", the Defence Research Committee explored the possibility of incorporating an infra-red sensor into the Skynet 3 platform to detect nuclear explosions on Earth.[116] This appetite for secondary payloads, which represents a cheaper alternative to procuring both the satellite bus and its payloads, can be harnessed for adopting a proliferation strategy. The question remains, then, what type of secondary payloads would add the greatest value to UK space power?

In-orbit space domain awareness is a strong candidate. *Collaboration* with allies, and *access* to commercial capabilities will furnish the British approach to understanding the space domain and identifying and tracking threats and aggressive behaviour from adversaries. *Owning* SDA-related capabilities would not reflect the ambition of securing a comprehensive and detailed picture of what is going on in outer space. That would entail a level of investment that cannot be met by the UK. This does not mean, however, that the UK should forego sovereign SDA capabilities altogether. The chief purpose of investing on sovereign SDA capabilities should be to improve its bargaining position vis-à-vis the US and become a valuable partner, rather than a valued customer, which can offer something in return for the various space-related data that the US shares with the UK.[117]

To that end, the UK should procure niche capabilities to plug gaps that the US has in surveying and understanding the space domain and characterising its impending threats. Indeed, the US has expressed its interest in capitalising on allied and commercial capabilities to feed into its space surveillance network.[118] As outer space becomes more congested and China and Russia are increasingly conducting suspicious manoeuvres in space, the current US network will require higher resolution data and quicker revisit times, a demand that has been emphasised repeatedly by the US Space Command.[119] In addition, there are current SDA capability limitations in other areas that the UK could contribute to, including surveillance in geostationary orbit,[120] tracking LEO satellites orbiting over the Southern hemisphere,[121] and tracking satellites during daytime.[122]

Currently, the UK's most important sovereign SDA capability is the Ballistic Missile Early Warning System stationed at RAF Fylingdales. While this radar array can be re-tasked to provide space surveillance and tracking information, it is a collateral rather than a dedicated sensor, for its primary mission is not to detect, track and characterise satellites in orbit.[123] To add capabilities, the UK could invest on in-orbit space domain awareness via secondary payloads. These payloads could be hosted on Skynet 6 satellites or on the upcoming Istari constellation. The choice would also depend on where the UK wants to augment surveillance capabilities to maximise its utility for the US Space Command: hosting an SDA payload on a Skynet 6 satellite would entail a focus on geostationary orbit, whilst the Istari constellation will operate in low-Earth orbit.

Deterrence-by-denial strategies	Policies and activities in place	Suggested way forward
Proliferation strategy	Skynet 4 and 5 series as a small-scale proliferated architecture. Upcoming Istari as a multi-satellite constellation.	Secondary payloads on Skynet/Istari constellations for in-space SDA. Chief aim of investing on SDA capabilities is to improve bargaining position with the US.

Table 3: Summary of the policy recommendations and the current UK policies based on a proliferation strategy.

There are a few advantages to investing on in-orbit payloads in comparison to ground-based alternatives. Operating in orbit allows these sensors to detect smaller objects more effectively as they are closer to their targets. Without any atmospheric obstacles, these sensors are unaffected by day/night cycles.[124] Furthermore, they can eliminate terrestrial coverage gaps such as the scarcity of optical and radar sensors in the Southern Hemisphere. Yet, as a secondary payload, they would receive a fraction of the overall power and processing budget of the satellite bus.[125]

This approach underscores how deterrence by denial strategies in space can mutually support each other. In this case, a proliferation strategy working towards securing leverage towards the US via additional payloads on existing and planned British satellites can bolster the prospects for a successful diversification strategy. Indeed, offering valuable space-based data to its closest ally can *guarantee* that the UK will continue to be in the position to exploit US satellite systems and derived data for its military missions.

The UK's space architecture will determine the convenience of responsive space launch

Having the ability to launch satellites on demand to quickly replace degraded or disrupted assets in space is yet another pathway to reinforce a deterrence by denial posture: if the adversary anticipates that the UK can deploy additional satellites in a short timeline to continue supplying bandwidth to the UK armed forces for communications, for example, the strategic or tactical value of targeting British satellites diminishes. The idea of replenishing damaged satellites in orbit rapidly is not new.[126] With the democratisation of satellite launchers and the proliferation of commercial spaceports, there are renewed efforts in various countries to acquire this capability. By 2026, the US Space Force aims to launch satellites in orbit upon request, ideally within a day, in what it calls tactically responsive space capability.[127] Smaller countries are also embarking on this path. Norwegian aerospace company Andøya Space is currently building a spaceport in the northern part of the country with the objective of having a responsive capability to launch small satellites on demand.[128]

The UK has recently experienced the shortcomings of not having accessible space launch capabilities. Shortly after launching the war on Ukraine, Russia halted the launch and seized a batch of OneWeb satellites aboard the Soyuz spacecraft, delaying the completion of the OneWeb constellation in orbit. As the CEO of the company noted, the problem emerging from that was not so much manufacturing additional satellites, but rather securing new launching agreements with other providers.[129] In the 2026-2030 timeframe, the UK Space Command is aiming to secure "partnerships and freedom of action to safeguard assured launch of assets into orbit at a moment's notice".[130] This has been also emphasised by commercial launch service providers. Virgin Orbit, once the operator of Spaceport Cornwall which has since filed for bankruptcy, repeatedly noted that its horizontal launch capability was extremely valuable to strengthen the MoD's space resiliency via responsive launch.[131]

This ambition should be understood in the context of LaunchUK, the UK's Spaceflight programme under the auspices of the UK Space Agency.[132] In addition to Spaceport Cornwall, this programme has funded the development of two commercial spaceports for vertical launches that will soon become operational in Scotland, namely the Saxavord and Sutherland spaceports. Both have secured agreements with commercial launch service providers for orbital and suborbital launches.[133] However, the emphasis of these spaceports in British soil is on the launch of small satellites, as the UK aims to become the "leading provider of commercial small satellites launches in Europe by 2030".[134] Indeed, none of the spaceports can offer a payload capacity beyond 1000kg and they are all equipped to place satellites in sun-synchronous and polar orbits, which limits the manoeuvrability of the MoD in terms of replenishing damaged satellites to other orbital locations.[135] For comparison, each Skynet 5 satellite weighs around 5000kg and operates from geo-stationary orbit.[136] These spaceports would not offer a launching option for this constellation.

Furthermore, the UK Space Command already operates with a budgetary straitjacket, so having expensive capabilities such as Skynet satellites sitting idly by somewhere in a storage facility awaiting launch to replace another satellite seems improbable. If a Skynet satellite were to be permanently damaged during a conflict, what seems more likely is that the UK, as an interim solution, would rely on communication satellites from the US or other allies. Another alternative could be to manoeuvre a second Skynet satellite into an orbital position that covers the geographical area of interest previously under the responsibility of the defunct asset. Yet, this would come at a cost for the satellite as it would expend valuable fuel that could shorten its overall operational life.[137]

The design of a responsive space launch strategy will be contingent on the space architecture pursued by the MoD. How the MoD decides to implement its deterrence-by-denial strategies will inform the value and direction of this one. If the MoD chose to have a proliferated architecture on satellite communications by relying both on the Skynet constellation and the second-generation OneWeb satellite fleet in GEO and LEO, respectively, then it would be more valuable to have a reconstitution strategy in place for the latter constellation: satellites in large LEO constellations are lighter, cheaper to launch, and because there is a higher turnover rate, the production learning curve suggests that over time LEO satellites become even cheaper to manufacture.[138] A similar argument could be made with the upcoming Istari constellation as soon as the operational concept demonstrators lead the way for its final architecture. In both cases, having redundant satellites for launch on demand can be easily justified on two grounds: it is not significantly expensive, and in any case these satellites can be launched as soon as the life cycle of satellites in orbit ends.

In the short term, because the capabilities suitable for a reconstitution strategy do not yet exist, the MoD's Space Policy Team alongside UK Space Command could conduct feasibility studies in consultation with space launch industrial stakeholders. They could review various scenarios in terms of future British space architecture and how each one of them would have strategic implications for adopting a reconstitution approach. For example, these studies could ascertain the security implications of having OneWeb's main production facility located in Florida, US, and whether any manufacturing should be transferred to British soil.[139] More broadly, they could examine the costs and benefits of establishing spaceports in British overseas bases, including in RAF Ascension Island and RAF Mount Pleasant in the Falkland Islands. And they could reflect on the specific arrangements with commercial entities: would the MoD prefer a government-owned, company-operated arrangement, an end-to-end sovereign structure, or a purely commercial approach? In the long term, if the studies yield positive results, the MoD could sign launch-on-demand agreements with commercial spaceports and launch providers and issue contracts to undertake demonstration missions wherein the UK Space Command requests a provider to launch a satellite at short notice. This would enable a better understanding of the immediate challenges that the MoD would encounter in the event of replacing a satellite during a conflict.

Deterrence-by-denial strategies	Policies and activities in place	Suggested way forward
Reconstitution strategy	LaunchUK programme to invest on commercial spaceports for small satellite launches. UK Space Command's ambition to secure a responsive space launch capability by 2030.	The eventual UK's space architecture will determine the value of responsive space launches. Short term: Feasibility studies to review the impact of different architectures for a reconstitution strategy. Longer term: If applicable, demonstration missions to launch on demand.

Table 4: Summary of the policy recommendations and the current UK policies based on a reconstitution strategy.

Charting the way forward in the deterrence by denial space

UK space power has been historically characterised by its sovereign military communication constellation and its dependence on the US for other space-based data. The increasing role that satellites are playing across all levels of warfare and as a force multiplier across other military domains, combined with a higher degree of contestation in outer space and upcoming investments on sovereign platforms put a premium on the UK to protect and defend its space-based missions. Although emphasised in the 2022 Defence Space Strategy, it is not clear how protecting and defending British interests in space is to work in practice. Given that the UK does not have many sunset capabilities in space that generate path dependencies, it has an excellent opportunity to design a cutting-edge architecture that undercuts the effectiveness of adversarial attacks.

Sub-threshold counterspace threats such as electronic warfare and cyber-attacks exploit the inherent limitations of deterrence by punishment strategies. For this reason, this paper has argued that strategies that strengthen a deterrence by denial posture should be emphasised. In particular, the MoD should embrace policies that can be framed as disaggregation, diversification, proliferation, and reconstitution strategies. The proposals laid out should not be seen as an exhaustive list. Rather, they merely offer a way of thinking about deterrence by denial in space to bolster resilience and mission assurance. Other policies could be envisaged that follow a similar logic. For instance, the UK could reach agreements with allies to have a responsive space launch capability, a policy that would fit in both a reconstitution and a diversification strategy.

More importantly, these strategies represent one component of a multifaceted approach to deterrence that the MoD should strive for. Indeed, the scope has been confined into enhancing resilience and mission assurance in the space segment. This should be supplemented by an equal emphasis on the ground and the cross-link segments that comprise space activities. Likewise, because the approach should be mission- rather than platform-centric, it is important to examine how redundancies can be achieved by distributing space-based missions across other domains. Deterrence by punishment should not be left outside the deterrence equation either: developing offensive space control capabilities and constructing a credible response posture constitute the other pillar of military-based deterrence. At the broadest level, deterrence should be pursued beyond the military sector as a whole-of-government approach to maximise synergies, by co-opting the diplomatic and economic tools of statecraft, establishing a normative framework at the international level to regulate what safe and sustainable behaviour in space looks like, and bolstering the industrial and skills base of the UK.

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