Written evidence submitted by Dr Bleddyn Bowen

Space Defence Inquiry Written Evidence

This evidence is submitted by Dr Bleddyn Bowen, Lecturer in International Relations, University of Leicester.

The professional views and analysis below are my own and do not represent the views of any institution or organisation.

The reason for submission are: a) the subject matter of this call for evidence sits firmly within my area of expertise as an internationally-recognised academic researcher on military strategy and outer space, and UK space policy and security; b) I was kindly invited by Committee staff to do so based on my research and public engagement records, including previous oral testimony provided to the Select Committee on Exiting the EU and Defence Select Committee, and written evidence provided to the Cabinet Office, on related matters. The basis for much of the evidence below is derived from my following publications:

- *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh University Press, 2020) https://edinburghuniversitypress.com/book-war-in-space.html
- '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-the-integrated-review-web4.pdf
- 'A Familiar Frontier: British Defence Strategy and Spacepower', *Air and Space Power Review*, 2019, 22:2, https://www.raf.mod.uk/what-we-do/centre-for-air-and-space-power-studies/documents1/air-and-space-power-review-vol-22-no-2/
- 'British strategy and outer space: A missing link?', *British Journal of Politics and International Relations*, 2018, 20:2, https://doi.org/10.1177%2F1369148118758238

I would be happy to discuss these matters with the Select Committee in an oral evidence session if they wish.

Summary

The UK Government, as well as the MoD, has traditionally not been interested in the defence/security aspects of space policy and acquisitions throughout the Space Age, with the last 7 years of policy documents and activity being something of a (welcome) aberration. The recent Integrated Review and the accompanying Defence Command Paper rightly emphasises the importance of spacepower and space infrastructure to a degree not seen in non-space focused documents before. The UK Government has recognised the importance of space to defence, intelligence, and security in a way that it has not in decades past. This is to be welcomed. However,

clear and specific directions on any new investments were lacking, beyond renewing the Skynet system which had been previously announced, and mentioning a possible 'Intelligence, Surveillance, and Reconnaissance' (ISR) constellation which is too vague a capability category commit Government or MoD to anything specific. In the context of institutional changes at the MoD, Cabinet Office, and BEIS, what remains to be seen are concrete actions on: professional space education and training, specific capability acquisition programmes, and clear organisational responsibilities. These may yet be clarified in the forthcoming National Space Strategy (NSS) and Defence Space Strategy (DSS) later in 2021.

From the Integrated Review and Command Paper, investments in space, cyber, and artificial intelligence from the UK MoD will reach £6.6bn. £1.4bn will go towards:

- Setting up UK Space Command
- A space-based ISR constellation
- A National Space Operations Centre
- A Space Academy

In addition to that the Skynet 6 SATCOM programme has begun at a cost of around £5.2bn. Another headline figure is the modernisation of the Bowman tactical battlefield communications system (i.e. terrestrial peripherals for deployed forces) under the Morpheus programme, the cost of which is declared at £3.2bn.

Despite the release of the DSS 'pamphlet',[1] the MoD remains in the formative stages of spacepower development. It is only now setting up space-centric structures and engaging with external experts on ways forward.

The UK Government, and not only the MoD, needs to focus on these areas:

- Identify what space capabilities (either in space or terrestrial infrastructure/peripherals) are actually needed by UK Government users, in particular the MoD and the Security Services. Despite the recent Integrated Review, it is not clear what sort of war the MoD intends to fight in future. Without this, space investments will be harder to target and prioritise. Different space technologies are better suited for operations in different environments and enemy combat types.
- Identify the space-derived resources that are currently provided by trusted allies and partners which the UK *does not* need to replicate as their provision is likely to be uninterrupted and will meet demand. Global Navigation Satellite Systems (GNSS) such as the American Global Positioning System (GPS) is an example here.

[1] UK Ministry of Defence, 'Towards a Defence Space Strategy', 2018, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712376/MOD_Pocket_Tri-Fold_-_Defence_Space_Strategy_Headlines.pdf

- Identify the space-derived resources that are currently provided by trusted allies and partners which the UK *does* need to replicate due to possible bandwidth issues in a crisis, British tasking requests being deprioritised, or legal/classified data sharing issues. Communications and ISR platforms are possibilities here.
- Make decisions that focus scarce resources into improved, expanded, or 'new' capabilities that go beyond the small number of prototype/experimentation programmes that are currently in progress at Defence Science and Technology Laboratories (DSTL) and the RAF.
- UK Government should be able to develop a clear idea of which capability investments are desirable and needed without technological pilots. Many space technologies are not new and general principles and utilities are proven to meet specific terrestrial requirements. Allies, space experts, and the private sector can provide many 'lessons learned' here.
- Allocate the necessary, significant resources to achieve those decisions with a recognition of the opportunity costs such investments necessarily impose. Learning from European friends should be a priority here as France, Germany, and Italy face significant resources issues just like the British do.
- Many significant improvements in UK spacepower do not necessarily involve new satellite projects; whilst there is a case for some new satellite programmes, this should not distract from the fact that personnel recruitment and training, ground infrastructure hardening and expansion, and downstream analytical/service capabilities are all areas ripe for investment and capability development.
- The MoD needs to be ready to operate in a contested space environment which will have service impacts for MoD units on Earth. Service stops, degradation, must be anticipated and feasible 'backups' developed where possible/affordable. Terrestrial MoD units will also need to be ready to respond to space-enabled enemy forces.
- MoD should develop a cross-MoD, multi-service educational infrastructure on space, including the technical, policy, history, and strategic aspects of outer space. This should be a fixed feature in all services and staff colleges as all military personnel rely on or use spacepower in one way or another. The 'Space Academy' idea floated in the Defence Command Paper is encouraging in principle but concrete details remain to be seen. Spacepower education must be integrated throughout Professional Military Education (PME) provision and not left to a single service nor to only specific ranks of officers/levels of staff colleges. Spacepower is conceptually and intellectually on a par with seapower and airpower and should be treated as such. This is one area of MoD spacepower capacity that need not be 'outsourced' to the United States military.

How should the UK Government seek to further develop its strategic relationships and interoperability with allies?

1. The United States remains the UK's single-largest 'benefactor' in space and single-most important ally in this regard. The UK's spacepower is characterised by two forms of integration and dependencies: with the United States on military, security, and intelligence capabilities; and with Europe in the scientific, commercial, and industrial space sectors. The UK has enjoyed very high degrees of military and intelligence integration and dependency on the United States for critical space infrastructure since the 1960s. The UK's Skynet secure satellite communications (SATCOM) constellation, first deployed in the 1960s, is the exceptional sovereign space-based capability to the traditional British approach of relying on 'outsourced' space-based assets and services from allies and the commercial sector.[2]
2. The UK MoD currently enjoys a high degree of integration with the United States military with regard to space systems and infrastructure. RAF Fylingdales (ballistic missile early warning radar) and RAF High Wycombe (home of Space Operations Centre and now UK Space Command) provide Space Situational Awareness (SSA) data to the United States and receive and process composite data from the United States for UK users, respectively. Additionally, relatively small but persistent numbers of MoD personnel receive spacepower education and staff experience at US Professional Military Education institutions as well as military space units and Space Force Bases. Additionally, the UK's military personnel have long been participants in the United States' Schriever Space Wargames exercises which in the past ten years have taken on a more allied-inclusive approach.
3. Intelligence interoperability and cooperation can be assumed to be high given the historic Five Eyes linkages and GCHQ's institutionalised cooperation with the American National Security Agency (NSA) and National Reconnaissance Office (NRO) in the realms of cryptography, and signals intelligence (SIGINT) and imagery intelligence (IMINT), respectively. Any comprehensive discussion and perspective of UK Government, including those forming the forthcoming NSS and DSS, cannot ignore space intelligence cooperation and integration with NATO and Five Eyes partners, and the United States in particular.
4. The numbers of space-literate, and career-long space experts are small in the UK MoD compared to the United States, and arguably France, Germany, and Italy. France, Germany, and Italy operate sovereign or public-private secure SATCOMs and ISR space assets, and as such their defence ministries have a greater degree of 'in-house' expertise than the UK MoD.
5. France operates the Grand Réseau Adapté à la Veille Spatiale (GRAVES), a dedicated SSA radar, whereas the UK's Fylingdales radar is first and foremost a ballistic missile early warning and warhead detection/tracking radar, and SSA sensor is its secondary mission.
6. European 'operational experience' in how to fly and operate satellites day to day, as well as how to gather intelligence and data from space-based assets (not just use it), makes France, Germany,

[2] Bleddyn Bowen, 'British strategy and outer space: A missing link?', *British Journal of Politics and International Relations*, 2018, 20:2, https://doi.org/10.1177%2F1369148118758238

and Italy more directly 'useful' to the Americans in space as the UK lacks its own assets here and instead relies on the same allies or commercial Western imagery companies. UK-based operational expertise mostly resides within the commercial sector (e.g. Airbus, Inmarsat).

7. For more UK involvement and integration with allies, more space-literate personnel across Government, not only Defence, is desirable (see below). Beyond personnel, allies value capability and contributions, and this involves space-based assets and supporting ground infrastructure (e.g. secure SATCOM bandwidth, IMINT/SIGINT assets/products, redundant ground stations). Beyond Skynet, the UK is lacking in hardware assets with space and many European states 'bring more to the table' in space for the NATO alliance. More participation with NATO allies – not only the United States – requires more qualified personnel as well as more capability to be taken seriously in space.

Where can the UK most effectively develop and deploy its own sovereign defence capabilities, with particular regard to:

Space Situational Awareness

8. The UK's current SSA data mostly originates from RAF Fylingdales' secondary mission. As such, there is no comparable radar system dedicated for SSA duties operated by the UK, whereas France operates the GRAVES system. Investment in SSA is potentially attractive for the UK as it is an area of existing UK space expertise both in the MoD and the private sector. It is also a relatively affordable capability investment with some estimates ranging only in the tens of millions,[3] compared to the £92m already spent on the UK GNSS (the Galileo like-for-like replacement) feasibility study in 2018-19 which led to the ambition being abandoned in 2020 due to its projected costs and limited capability added. There is an ever-expanding demand for SSA data and services, and American/allied SSA capabilities still only provide so much. Additional analytical capacity is another potential investment, and would expand the MoD's Space Operations Centre (SpOC) ability to process, analyse, and disseminate the raw SSA data that comes into the UK from allied and commercial sources and disseminate it effectively to UK users and decision-makers.
9. Recommendations here are:
   - Consider the feasibility and desirability of a dedicated SSA capability similar to France's GRAVES. This need not necessarily be a military capability. A civilian SSA capability is also possible and may produce data that is easier to share domestically and internationally than a military SSA system's.

[3] Mark Presley and Mark Hilborne, 'Towards a UK Space Surveillance Policy', August 2020, https://www.kcl.ac.uk/dsd/assets/towards-a-uk-space-surveillance-policy-final.pdf

- Invest in SSA analytical capacity and complement existing UK private sector strengths (e.g. NORSS, Astroscale UK). SSA provides terrestrial and personnel investment opportunities and capability returns that obviate the need for capital-intensive space-based assets/
- Deliberately include allied/commercial/civilian information sharing and provision into any increased UK SSA capability to provide greater UK 'buy-in' at allied/partner space mission capability discussions

PNT (Position, Navigation, Timing) services, in the context of the UK's exit from the EU's Galileo and EGNOS programmes

10. The UK has, correctly in my view, abandoned its previous desires of pursuing an independent GNSS capability – a 'like for like' replacement of Galileo or the American GPS. Its costs may have exceeded the UK Government's current flagship space system, Skynet, and would only triplicate the services provided by both Galileo and GPS. As I have previously stated to Parliament,[4] it is important to note with Galileo and EGNOS:
    - The UK's exit from the EU resulted in the loss of opportunity for British-based companies to bid for major or security-sensitive contracts on EU-funded space projects, not necessarily loss of access to the services provided by EU space systems.
    - Brexit *does not* affect British industry's rights and opportunities to bid for major contracts in ESA-funded projects.
    - The UK will retain free access to the commercial/civilian signals of Galileo and EGNOS.
    - The UK has the option to negotiate user access to Galileo's Public Regulated Service (PRS) which is the sensitive, encrypted, military-grade navigation signal. This would duplicate what the UK has in terms of military-grade GPS signals access. This would be a major boon to PNT resiliency and redundancy for the UK's critical infrastructure and military capability. The United States and Norway have already signalled their desire to enter negotiations with the EU to establish PRS access. United States Space Policy Directive 7 explicitly states a desire to seek resiliency and redundancy by securing integration with friendly foreign PNT services – i.e. Galileo.[5] With non-EU NATO member states gaining access to Galileo's PRS it makes little sense for the UK not to pursue access.
11. Following the abandonment of a UK GNSS programme, the UK Space Agency is currently leading the Space-based Position, Navigation and Timing Programme (SBPP) study to look at alternative PNT technologies. Details are scant at present, but a number of technological possibilities are available but they are often tailored to specific needs or improve highly localised services, and cannot directly or easily replace GNSS services:

[4] Evidence to Exiting the EU Select Committee, 9th May 2018, https://www.parliamentlive.tv/Event/Index/2116b504-06be-4ba4-a6ec-5044dd16c1c9

[5] The White House, Space Policy Directive 7, 15 January 2021, https://trumpwhitehouse.archives.gov/presidential-actions/memorandum-space-policy-directive-7/

- Augmentation systems based in space (e.g. EU's EGNOS, Japan's QZSS). These systems rely on a GNSS (e.g. GPS) as a base or reference signal and then improve the PNT data's accuracy and signal strength for the user by broadcasting a secondary PNT broadcast. These often do not require major changes to existing GPS receivers or peripherals.
- Alternative systems based in space (e.g. Iridium's Satelles service). This uses a different type of PNT signal to GNSS with satellites in low-Earth orbit (LEO) as opposed to medium-Earth orbit (MEO). Such signals have trade-offs in terms of signal strength, coverage, persistence, and accuracy, and usually require new receivers or peripheral devices.
- Alternative systems based on Earth (e.g. eLORAN). These systems rely on local, terrestrial radio signals to provide PNT data and often require specialised, new receivers or peripherals. This requires fixed ground infrastructure and therefore is not feasible for expeditionary operations or an environment where ground infrastructure is likely to be destroyed.

12. Whether these systems provide enough resiliency for the setup costs required will be a difficult question for UK planners to grapple with, and will vary with each potential PNT service considered. A recent report in the United States claims that the potential alternatives to GNSS are not worth the costs they entail, do not directly replicate GNSS capabilities, and also undervalue the resiliency of GNSS systems themselves whilst overplaying the threats to a complete PNT breakdown.[6]
13. Recommendations for PNT:
    - Simply put, there is no cheap 'like for like' replacement for GNSS constellations which are highly integrated into everything a state does – military power, commercial technologies, and civil infrastructure. The emergence of a second strategically-trustworthy GNSS (i.e. Galileo) is to be welcomed as a boon for UK PNT resiliency.
    - The UK should pursue negotiations for Galileo PRS user access alongside the United States and Norway.
    - Allies and partners can already provide reliable space-based PNT services both for civilian infrastructure and military purposes.
    - Any space-based PNT project is likely to be capital-intensive and impose significant opportunity costs whilst there may be other, more affordable areas for capability development and contribution both for UK and allies. The costs are significant enough even for RAND to make this argument in the context of the USA's more profligate defence budget. Therefore any PNT investment should require a clear rationale for its need *relative to other possible investments*.
    - Terrestrial PNT 'backups' or enhancers/augmenters are worth considering for critical and domestic civilian infrastructure resilience

[6] RAND Corporation, 'Analyzing a More Resilient National Positioning, Navigation, and Timing Capability', 2021, https://www.rand.org/pubs/research_reports/RR2970.html

- Novel ideas and technologies are worth considering/exploring on paper. Terrestrial PNT services could have resilience/redundancy value in land-based defensive military campaigns (e.g. Baltic defence). But less so for expeditionary, 'out of area', or offensive campaigns.

Intelligence, Surveillance and Reconnaissance

14. At present the UK has no significant space-based ISR capability. Whilst the commercially owned and operated Disaster Monitoring Constellation (DMC) is UK-based with three satellites in orbit, it is not particularly geared towards defence requirements outside of humanitarian and disaster response. The UK relies on allies and the global commercial sector for intelligence and defence-relevant space-based intelligence and reconnaissance. Project Oberon (synthetic aperture radar [SAR]) and Project Artemis (live video from low-Earth orbit) are experimental prototypes testing out new techniques and systems. However ISR is a vast capability range, including multispectral imagery, many SIGINT types, as well as capabilities designed for 'national intelligence' versus 'battlefield reconnaissance' missions.
15. Recommendations:
    - Specific terrestrial ISR requirements need to be outlined. What current needs for ISR are not being met? How can space-based ISR meet these needs? Can such capabilities be developed with certain allies?
    - MoD's generally ambiguous definition of future warfare and geographically ambitious posture does not provide a clear focus for which space-based ISR UK forces or planners most desperately need.
    - The UK needs to move beyond experimentation and decide which kind of space-based ISR to invest in, if at all.
    - The UK should embrace the advances in small-satellite and commercial off the shelf technologies from UK science and commercial space sectors (e.g. Surrey Satellites' DMC satellites and the UK's stake in OneWeb) if they satisfy terrestrial defence/security needs. Defence space requirements should, if possible, complement and draw from what UK space industry and expertise can provide.
    - Clarity is needed on a fundamental point of ISR technology and needs orientation. ISR constellations can be designed to meet 'strategic' and 'national' needs, or for 'tactical' and 'battlefield' uses. The former will be of more interest to UK Government across the board, especially the Security Services, Cabinet Office, and other departments. The latter can be of direct use to MoD but will be monopolised in a time of conflict. These systems cannot be switched easily from a strategic role to a tactical role, especially in terms of information/data sharing infrastructures and procedures. This is evidenced US military's learning and implementation of tactical application of satellites since the 1980s.

Communications

16. Secure SATCOM is the only place where the UK enjoys any space capability that could be described as 'sovereign'. At present Skynet is a 6-satellite constellation, made up of two 4th generation and four 5th generation Skynet satellites. Work has begun on the first 6th generation satellites. Skynet is currently operated by Airbus personnel for the MoD. In addition, Inmarsat, headquartered in London, provides an important service for the UK's maritime communications requirements but is a commercial provider, not a dedicated UK government service.
17. There are some opportunities for SATCOM developments for defence and security:
    - Determine whether projected bandwidth requirements in a crisis are far in excess of what can be expected from Skynet and other SATCOM sources; then determine how much is required for secure services (such as Skynet) and how much is required for less secure services (such as those from commercial platforms).
    - Consider expanding Skynet 6 with more GEO platforms to increased secure communications bandwidth and increased resilience/redundancy from potential hostile anti-satellite activity.
    - Explore the opportunities provided by OneWeb constellation in LEO for MoD/UK Government communications services as the UK is now a major stakeholder in the company.

How vulnerable are our space assets to deliberate attack, both physical and otherwise, and what steps can be taken to improve their resilience (with regard both to defence capabilities and other critical national infrastructure)?

18. Space weapons and various 'counterspace' or anti-satellite techniques are proliferating, particularly in Russia, China, the United States, and India who have each demonstrated various 'hard kill' capabilities. However there are many forms of 'soft kill' counterspace activities such as electronic warfare (or jamming) and cyber warfare (or computer network intrusions) that are spreading to many actors and are harder to monitor.
19. The MoD needs to be ready to operate in a contested space environment which will have service impacts for MoD units on Earth. Service stops and degradations must be anticipated and feasible 'backups' developed where possible/affordable.
20. The UK has very few assets in orbit, and the Skynet system is already 'hardened' to withstand enhanced radiation levels and targeted electronic warfare effects. The main threats to space systems need to be considered in light of the UK's dependencies on *allied* space systems and threats to *them*, not the UK's 'own' assets, given the dearth of them.
21. The vulnerabilities of space systems to deliberate attack varies wildly based on:
    - Orbit locations

  - LEO and MEO satellites are easier for ground-based direct-ascent kill vehicles to reach, but harder to acquire as targets and schedule for unpredictable attacks due to the timing needed to intercept 'moving' targets.
  - GEO satellites are easier to acquire as targets, but harder and more cumbersome for kill vehicles to reach with any element of surprise due to the predictable or 'fixed' locations of 'everyday' or background traffic in GEO.
- Counterspace weapon basing location
  - Counterspace weapons can be based on Earth or in space. LEO targets can be efficiently reached by weapons based on any terrestrial environment.
  - Space-based weapons do not provide unparalleled advantages in mobility. Much depends on their orbit and weapons types, as well as the orbits of their targets.
  - Placing weapons of any kind in space is expensive. Cheaper terrestrial alternatives may exist.
  - It is sometimes easier to conceal anti-satellite weapons on Earth than in space.
  - Space-based weapons cannot be regularly maintained once in orbit. Weapons require maintenance and credibility – if a weapon in deployed in space for 5 years without maintenance checks, can it be expected to function flawlessly when called upon to do so?
  - Some states have been developing close-orbit inspection and loitering technologies in GEO, which have anti-satellite use potential. However such behaviour is often difficult to conceal and relatively easy to attribute with adequate SSA capabilities, and there are no dedicated constellations of anti-satellite platforms deployed by any space power as yet, though flight testing of certain technological capabilities with weapons potential have been conducted by the United States, Russia, and China.
- Attack types:[7]
  - Kinetic-kill vehicles can destroy a satellite by blowing it up, but will generate clouds of debris that may indiscriminately destroy other satellites, with severe environmental and political consequences. Both Chinese and Indian hard-kill ASAT tests (2007 and 2019, respectively) generated debris that continue to orbit Earth today. Such activities can be more easily detected, monitored, and attributed compared to 'soft kill' anti-satellite or counterspace methods below. Hard-kill weapons are not highly proliferated, with the US, China, Russia, and India having demonstrated kinetic counterspace capabilities. Among these, Russia remains the only one to have not conducted an intercept test since 1991, instead, it has conducted flight tests only.

[7] Accessible overviews of counterspace weapons developments: Brian Weeden and Victoria Samson, 'Global Counterspace Capabilities', April 2021, https://swfound.org/counterspace/; Todd Harrison, Kaitlyn Johnson, Makena Young, 'Defense Against the Dark Arts in Space', February 2021, https://www.csis.org/analysis/defense-against-dark-arts-space-protecting-space-systems-counterspace-weapons

Kinetic actions are ‘permanent’ and are more desirable if greater confidence in neutralising a space system is required than ‘soft kill’ such as electronic warfare and cyber intrusions – both of which have greater defensive countermeasures to overcome and can be reversed.

  - Electronic warfare aims to neutralise space systems by disrupting or ‘jamming’ their radio communications links; their ability to ‘listen’ and ‘speak’ with users on the ground, ground terminals, or each other. This is a very sensitive technological area therefore specific details are hard to come by. These capabilities can be general, blunt, unsophisticated and highly proliferated with low barriers to entry, whilst others can be highly targeted and sophisticated and open to only the most dedicated and best-funded electronic warfare units. Electronic warfare is a dynamic activity with many defensive and adaptive options open to the victim based on technical capability of the platform and the skills of the operators. Some platforms are more susceptible to jamming than others, such as commercial communications. Successful electronic warfare may not generate debris, but its effects can be undone or reversed.
  - Cyber attacks are similar to electronic warfare in that they refer to a diversity of methods of attack and defensive measures, often shrouded in secrecy. Satellites are totally reliant on computer networks for their operation because these are simply machines and ‘robots’ in orbit. Therefore the potential for network intrusions are ever-present. Barriers to entry can be low and relaxed cybersecurity standards invite opportunistic attacks not only from state actors but from non-state actors. Secure and essential satellite systems require the highest levels of cybersecurity possible.

- Constellation size and alternatives
  - With electronic warfare and kinetic attacks on satellites themselves, a higher number of platforms can provide a greater measure of resiliency and redundancy.
  - A successful cyber attack could try to take the entire system down, regardless of constellation size.
  - A successful weapons strike or electronic warfare campaign against a limited number of control terminals on Earth could have a similar systemic effect against a satellite constellation.
  - Therefore terrestrial infrastructure must consider redundancies, not only satellite constellations. As space weapons proliferate space systems operating at ‘peacetime’ capacities cannot be taken for granted in a time of serious crisis or open warfare.
  - Some space capabilities could have diverse backups and alternatives in a crisis, e.g. SATCOMs and trusted commercial providers, commercial IMINT and SIGINT.
- Terrestrial infrastructure vulnerability

- Attacks may not be against the satellites themselves. Any attack method listed above can apply to terrestrial sites as well as the space-based platforms. Ground stations could be the focus of a missile barrage or electronic warfare campaign, or a computer network intrusions. Against a determined foe, the UK must be prepared for such possibilities.
- Fortunately, hardening ground infrastructure should be more affordable than developing a greater number of space-based platforms.
- 'Hardening' ground infrastructure, user terminals, and satellite platforms must take the risks of electronic warfare and cybersecurity in to account. Whilst these may be more common on military satellites, the commercial sector is usually less secure on this front.

22. Not only are potential hostile counterspace possessors proliferating, but so are the potentials of space-enabled hostile military forces. For example, modernised Russian forces make use of extensive space-based infrastructure in their own command and control and precision warfare capabilities, or proxies, clients, or allies of large space powers may gain access to precision warfare technologies. Terrestrial MoD units will also need to be ready to respond to space-enabled enemy forces and cannot take their security for granted. The kind of 'networked' and precise warfare NATO states have enjoyed for 30 years does not belong to NATO alone today.
23. Increased traffic in space, as well as the proliferation of potentially hostile satellites as well as counterspace weapons are increasing the salience of greater SSA capabilities, both in terms of sensors and analytical capability. Having multiple centres of data and analysis can help build reliable, robust NATO and wider allied attribution of irresponsible of threatening behaviour in space, which is preferable to the currently US-dependent position of SSA.
24. The MoD and UK Government should consider whether offensive counterspace capabilities are desirable. Whilst direct-ascent kinetic weapons is beyond the UK at present thanks to non-existent ballistic missile programme beyond the Trident programme and small air defence missiles. Therefore UK options here are in electronic warfare and cyber attacks. GCHQ's offensive cyber capabilities have been declared, but whether there is a dedicated anti-satellite cyber attack capability is unknown at this time. Similarly, electronic warfare in the UK is not something that is discussed in public, therefore it is not known whether there is a dedicated anti-satellite jamming capability in the UK. For example, the US Space Force operates the Counter Communications System, a squadron which deploys in-theatre dedicated to enemy satellite jamming missions. Any such discussion should be mindful of the UK's current sponsorship of the UN General Assembly Resolution on Responsible Behaviours in Outer Space.

How can defence industrial policy ensure that investment and innovation in in the private space sector is harnessed to align with the UK's defence requirements?

25. The UK Government must outline clear requirements for defence and security needs that the private sector can then target solutions towards. 'ISR' is simply too vague a label, and the UK Government must make systemic decisions on whether it requires national/strategic level ISR or 'tactical' level ISR. The forthcoming NSS and DSS may provide clear directions in this regard.
26. UK spacepower in part relies on an aggressive involvement in ESA's affairs to ensure UK based companies and Universities get the most return on investments. Current estimates show that the UK economy receives £10 back for every £1 invested in ESA.[8]
27. UK space industry also relies on healthy and attractive universities, and permissive work environments and visa regimes for a highly mobile and desirable workforce.
28. Technological innovation from UK universities and industrial partnerships occurs beyond the 'Golden Triangle' and the Russell Group universities, and the fate of STEM innovations in space relies on the general health and world-recognised excellence of the *entire* UK Higher Education sector, including social sciences, arts, and humanities.
29. A state's spacepower requires political, social, and strategic understanding, leadership, and direction, not only STEM expertise in space. This is highly evident in the UK's diplomatic efforts at the United Nations General Assembly with the resolution on Responsible Behaviours, as well as a recent G7 announcement on the need for global space debris mitigation and space traffic management governance/rules.

Have recent machinery of government changes ensured a joined-up and coherent approach to defence space policy both across Whitehall and within the MoD? What further improvements could be made?

30. The machinery is going through a process of change therefore it is difficult to tell what impacts have been achieved as yet. Early 2020 saw the MoD's Director of Space role begin, and April 2021 saw the renaming of Joint Forces Command as UK Space Command. 2019 also saw the setup of the National Space Council (NSpC), but there has been remarkably little evidence of activity, decision-making, or outputs from that body to date. It is difficult to tell what meetings, if any have been held, and what decisions have come as a result of convening the NSpC.
31. In light of point 32 below, greater clarity over the roles and relationships between the various space-responsible parts of the MoD would be a welcome move. Between various press statements and public speaking events the areas of responsibility for space in the MoD are not particularly clear.

What should be the priorities of the new Space Command, and how will its structures facilitate integration across all military domains and co-operation with commercial space operations?

[8] UK Space Agency, 'Annual Report and Accounts 2019-20', 16 July 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901360/HC606_UK_Space_Agency_Annual_Report_2019-20.pdf

32. At present it is unclear where the responsibilities for space operations, capability development, and training lie between UK Space Command, UK Strategic Command, the RAF, and DSTL. Clearly delineating who is responsible for what in space on both operational and development fronts needs to be improved. I confess to being confused by MoD statements and Gov.uk web pages on this topic over the past 24 months. The official web page for Space Command states that Space Command is responsible for space operations and capability development.[9] Yet Strategic Command, according to the Defence in a Competitive Age paper, is responsible for Skynet, Space ISR, the Defence Academy and the Defence Concepts and Doctrine Centre (DCDC).[10] The latter point on the Defence Academy and DCDC raises questions regarding the relationship with Space Command's proposed Space Academy. SSA and Ballistic Missile Defence are RAF missions. Additionally, DSTL plays an important role in space capability development. Clarity on the responsibilities and relationships, or at least common terms of reference, is needed as current explanations leave a lot of overlap in space duties between RAF, Space Command, Strategic Command and DSTL.
33. Develop a credible programme of PME on spacepower for MoD and UK Government personnel. The current provision of spacepower education is minimal, and in particular on the strategy and policy sectors. The only avenue where UK officers can gain PME opportunities on space is in the United States. There are ample opportunities for space-centric PME in all staff colleges in the UK, but especially at the Joint Services Command and Staff College at the UK Defence Academy. However, as shown in the 'Defence in a Competitive Age' paper, this is a Strategic Command responsibility, not Space Command.
34. UK MoD should develop a joint multi-service and non-combat centric military space culture. Spacepower is mostly about support services and logistics, not combat. Therefore, military personnel must be in tune with these realities and not allow combat-centric doctrines and thought to unduly marginalise the logistical and international nature of the space services UK Government and MoD rely upon. The current RAF domination of space in the Ministry of Defence should not be seen as 'natural', but rather should be continually justified on expertise, experience, and merit. Additionally, space-centric careers should be desirable and prestigious across the MoD if it wishes defence personnel to take space seriously and develop their expertise in it across the length of a career.

How can the Ministry of Defence ensure that it attracts, develops and retains high calibre space specialists in both policy and operational roles?

[9] UK Government, 'Space Command', https://www.gov.uk/guidance/uk-space-command (accessed 14/06/2021)
[10] UK Government, 'Defence in A Competitive Age', 22 March 2021, p. 43
https://www.gov.uk/government/publications/defence-in-a-competitive-age

35. Integrated space-centric PME from junior levels onwards can help entrench in the minds of personnel that spacepower is a legitimate area of activity and progression within Defence.
36. Space needs to be promoted and treated as a serious career path within the MoD with attractive salaries that matches equivalent levels of expertise in the private sector.
37. Spacepower's influence and impact on military power and strategy needs to be inclusively represented and communicated to members of all services and the Security Services to avoid developing an image of UK spacepower as something that only the RAF does or should do, or rather something that can always be 'outsourced' to allies. Institutionalising high level Army, Navy, and Security Service roles, representations, or secondments in space activities should be considered as a way to enshrine a pan-MoD space culture.

END

Dr Bleddyn Bowen

Leicester

14 June 2021