SPACE SECURITY RESEARCH GROUP

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Towards a UK space surveillance policy

Protecting and growing UK equities in space

1. Executive summary

The space sector is expanding rapidly. This includes, space launch, the number and range of satellite operations and downstream applications supported by space capability. In recent years, advances in technology have driven the development of an increasingly competitive global space industry, fuelled by lower costs, entrepreneurial innovation, and investment. This growth is coupled to an increasing reliance on space systems for many states, presenting a critical security concern.

The UK has signalled its ambition to increase its involvement in the domain, and in July 2020 alone has invested £1bn in space-related equities and has committed funding to encourage space launch and initiating steps towards establishing regulatory frameworks and licencing regimes to attract space operators to the UK. These investments will compete in a global space market currently valued in the region of $400bn which is growing exponentially and undergoing discontinuous change.

These developments present the UK with a host of opportunities as well as significant challenges. An increasingly dynamic space industry represents a driver of technological development and a key site of growth for the UK economy in need of stimulation in the context of the UK's exit from the EU and the Covid-19 crisis. Space is also critical to military systems and security and acts as a focal point for improved international collaboration between allies and enhancing the UK's reputation and global influence. Yet, as the market becomes more dynamic, so the physical space environment becomes increasingly overcrowded, introducing new actors and unregulated orbits, an inevitable growth in orbital debris, all increasing the likelihood of damage to operational satellites and threatening UK security and its equities in space.

To investigate these points, this report has analysed the current state of space policy in the UK and engaged with key space stakeholders and experts from across all sectors. Their views have been synthesized by the authors to offer an unbiased, achievable space surveillance policy position for the UK to adopt and from which it could prosper.

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Policy recommendations

Investment in space surveillance capacity is key to seizing the commercial and diplomatic opportunities offered by space while defending UK economic and security interests. Furthermore, it would act as a foundational measure for greater cross-government coordination on space policy, key for managing the scope of civil, commercial and military requirements. Common to all however, is an interest in monitoring and securing the UK's space assets and investments.

The UK currently has little or no nationally assured space surveillance capability, despite possessing significant pockets of expertise. Yet for a modest investment, the UK would be able to acquire a space surveillance capability that, given a cross-sector approach, would be market leading, establish the UK as a principal voice in space regulations and sustainability, and set the conditions to attract space commerce and enable the UK-based space industry to safely grow and prosper.

Illuminating the key space surveillance opportunities available to the UK for the National Space Council to reflect on as it considers the pending UK National Space Strategy, this report focuses on 5 key areas: the UK's ambition in space, security and resilience, growth, the UK's international position and government structures. Specifically, the report recommends:

- For an estimated entry cost of less than £40m, a nationally assured UK space surveillance capability to understand the space domain should be established. The capability would comprise a cross-sector space surveillance operations centre to collate all existing UK sensor data with available global space surveillance data and to enhance this with a dedicated sensor for Low Earth Orbit (LEO) satellites.

- Amend existing structures to allow departments to aggregate budgets to fund a UK space surveillance capability and establish a cross-sector strategic space leadership to direct and manage the budget on the behalf of contributing departments and commercial partners.

2. Introduction

The space environment is communal, increasingly commercial and contested.[1] Commercial space activities have expanded in both volume and diversity, leveraging commoditised, off-the-shelf technology and taking advantage of lower barriers to market entry. This has led to a burgeoning space industry, driven by entrepreneurial investment and innovation, advanced technology, decreased costs and increased demand for space-based services.[2] The number of satellites in orbit will increase by an order of magnitude in the next five years as so-called mega constellations, comprising thousands of individual satellites, are launched. The size of satellites is reducing, making them more difficult to detect. Tracking satellites will become more difficult as new, more nomadic, satellites manoeuvre to conduct on-orbit servicing and on-orbit refuelling operations. Amid this increase in active satellites, the amount of orbital debris is increasing, further exacerbating the hazards created by six decades of unregulated space activity. Finally, increased human presence in space with the rise of space tourism will demand more stringent safety considerations. The need for space surveillance as the basis for understanding the increasingly complex and congested space environment and provide decision quality awareness is greater than ever.

As government departments seek to make key investment decisions in space-related capability, the scale and scope of those investments need to be judged against the UK's overall ambition in space. The areas requiring an overall ambition to finesse the scope include space launch, satellite regulation and licencing, satellite communications, Earth observation, Global Navigation Satellite Systems (GNSS), and space surveillance. Covering all of these areas in one policy would be an undertaking too ambitious for this report. However, one area that has particular relevance to all sectors of the space community and impacts all of the areas listed is space surveillance. Consequently, it is the space surveillance element of any UK space policy or strategy that this report will concern itself with. Additionally, as space surveillance is pertinent to all sectors, it can aid alignment of an otherwise fragmented group of stakeholders for future policy decisions. It can provide an important part of the infrastructure for space operations, as well as space policy.

Space surveillance is the use of terrestrial and other sensors to observe the orbits occupied by satellites that support everyday services that society rely on and are integral to the UK's critical national infrastructure. These include global communications, location services, timing for banking transactions, Earth observation, meteorology and many others. Space surveillance detects and tracks the active satellites that support these services and also the many tens of thousands of pieces of debris that have accumulated over six decades of unregulated activity in space and pose a hazard to operational satellites.

The framework for undertaking space surveillance is undergoing significant change. Commercial companies offering space surveillance sensor data (radar and optical) are currently operating. The US is in the process of bringing a hugely capable military sensor on-line, the new Space Fence. This will detect and track tens of thousands of smaller pieces of debris that the space community have been aware of but blind to. Managing this flood of data will be a challenge. In addition, the US is transferring responsibility for the space catalogue from the US Air Force to the Department of Commerce. This all reflects a rise in space surveillance data and a shift of emphasis to

the civil and commercial sectors from the military. All sectors share a common interest in understanding the space domain.

There is a need for the development of a nationally assured UK space surveillance system, accessible by and contributed to by each of the defence and security, civil and commercial sectors.[3] The system would initially draw on the data available and process it to provide viable products and services for operators, regulators, insurers and for security. The picture of objects in Earth orbit gained by a space surveillance system will inform regulators and policy makers and allow for more informed action to meet the risks and threats to UK equities in space and the broader space environment that supports terrestrial critical national infrastructure.

To achieve this, a common UK space surveillance policy is required to inform the ambition of the National Space Council and act as a building block to the National Space Strategy. A space surveillance capability is fundamental to achieving the security and resilience of UK equities in space, to stimulate growth in the UK space economy, and give added credibility to the UK influence in the global debate on regulation and sustainability of the space environment. To achieve this, structures must be put in place to enable a common UK space surveillance capability to be created. This report will outline how and why this could be achieved.

Detail in the report is a distillation of discussion with key space stakeholders from across the military, civil, commercial, academic, legal and scientific community. From the generous access afforded, there was broad unanimity on the need for a UK space surveillance policy.

The report identifies two main themes that intersect and are mutually supporting – that of a need for cross governmental alignment, and the need for a space surveillance capability. The former is needed to generate a wider space policy, in which commercial, civilian and military needs are balanced in ways that differ from other domains such as air or maritime. The latter is a fundamental capability that is needed for virtually any other space activity. The space surveillance requirements of the different sectors overlap significantly, and there is considerable scope for inter-operability, lending itself to a cross-governmental approach. This will in turn engender structures and procedures that can generate better cooperation between the various sectors, producing more comprehensive policy in the future, while the space surveillance capability itself will provide a baseline for further activities.

There are five policy areas that will particularly intersect with a UK space surveillance capability. They comprise the ends, ways and means of achieving a UK space surveillance capability and include the following.

Ambition

A key component of the future of any UK space policy or strategy is to identify the scale of the UK's ambition in space. With this ambition set, it will then be possible to shape the scale and scope of subsequent enabling capabilities that is the responsibility of individual government departments, agencies and in the commercial sector. A fundamental enabling capability is the surveillance of space. This will provide the data necessary for the security and resilience of UK equities in space and in turn provide the

confidence for commercial growth and technological entrepreneurship that will deliver a return across the UK space industry and contribute to the UK bounce back from Covid-19. If enabled in the next two years, the UK will be a leading space nation in the increasingly important and relevant space sustainability debate.

Security and resilience

The UK has access to high quality space awareness, mainly through its relationship with the US. This space awareness is not nationally assured, nor is the UK at liberty to share the information it has access to. Being reliant on others for our space awareness comes at a cost. To replicate the space surveillance capability that the UK has access to would be unnecessarily expensive and duplicative, even if it did offer greater resilience. There are gaps in the global space surveillance network that the UK could profitably fill and, in the process, make a valuable contribution to greater international awareness and understanding of the space environment. This increased awareness would provide insight to the intent of other nations, monitor compliance of satellite operators licenced by the UK and offer surety for space launches from the UK. The effect would be an increased knowledge and confidence of the complex and congested environment the UK's space equities operate in. It would also provide a broader understanding and resilience of the space support that is so essential to the UK's critical national infrastructure.

Growth

The UK has interests in space launch, satellite communications, global navigation systems, has a world leading reputation for small satellite innovation and a desire to be the go-to nation for licensing. The UK space industry is poised to grow and prosper. To safely launch a satellite into orbit, a collision on launch assessment is required. Satellite communication systems and navigation systems are valuable equities and require an awareness of the space domain to be able to operate safely. A nationally assured UK space surveillance network will enable much of the space industry to grow and for the UK space regulatory framework to expand, confident in the knowledge that information on threats, hazards and dangerous actions in space are available. A civil space surveillance system is a necessary public good to create the conditions for growth. Monetising this investment is likely to occur as the products and services a space surveillance system offers meet the rising commercial demand of a global space industry estimated to be valued at around $400bn and growing.

International position

The US Defense Space Strategy calls for expanded information sharing relationships with capable allies and partners and to align on space policy.[4] To be in a position to achieve this, the UK must have space surveillance data to share and a policy to align. If the UK did establish a nationally assured space surveillance capability, contributed to from across all sectors, it would lead all other nations. Leveraging the knowledge, understanding and credibility this space surveillance capability would offer, the UK would be a leading regulator, and therefore a strong voice on establishing international norms and behaviours in space and be influential in the space traffic management debate.

Structures

The UK space sector is fragmented and poorly understood. Communicating policy, including structural changes should be accessible across all departments and commercial entities. One of the key structural changes necessary to integrate the public space sector will be the aggregation of departmental budgets to pursue cross-department projects, led and managed by a strategic leadership body.

It is to each of these five policy areas that this report will now turn. Providing the detail support to the argument for their implementation.

3. Space surveillance and ambition

Space policy in the UK has a fractured history. There have been a number of polices, often focusing on distinct sectors. The first, and last UK National Space Policy was published in 2015 with the aim of the UK becoming the European hub for commercial spaceflight and related technologies.[5] The space context has significantly changed since 2015 and so has the UK relationship with Europe. The recent UK acquisition of a controlling share in OneWeb significantly shifts the balance of requirements for the UK. To safely and successfully operate this constellation and burnish the UK reputation as a responsible actor in space, a space surveillance system would be the obvious next step. The space environment has become more congested and contested. The influence of space-based capabilities offered by this increased range of satellites and operators reaches all elements of the UK's critical national infrastructure. Space is key to modern defence and security capability, pivotal to the delivery of public goods and to the growth and prosperity of commercial companies that will be the engine of any economic bounce back from the Covid-19 pandemic. Any space policy or strategy should include a space surveillance policy as the foundation to safeguarding all of the capabilities mentioned.

As government departments seek to make key investment decisions in space-related capability, the scale and scope of those investments need to be judged against the UK's overall ambition in space. Of all the areas being considered, the one that is relevant to all sectors of the space community is space surveillance. Consequently, it is the space surveillance element of any UK space policy or strategy that this report will concern itself with.

The broad span of space across all sectors brings with it a varied understanding of what policy and strategy is. In this report, a space policy is seen as comprising the political objectives that provide the purpose for strategies. Strategy is the direction and use of means by chosen ways to achieve these desired objectives or ends.[6]

In space surveillance, the UK ambition should consider to what extent it is necessary to have a nationally assured capability. The increasing range of end users receiving the products and services from any space surveillance system include satellite operators and mission designers, launch providers, space tourism operators, debris removal and satellite servicing missions, insurers, defence and intelligence users, government regulators, civil contingency and academia.

To replicate the space surveillance capability that the UK has access to would be unnecessarily expensive and duplicative, even if it did offer greater resilience and the ability to share space surveillance data with other nations of the UK's choice. Complementing the space surveillance data the UK has access to and which fills gaps in the global surveillance network would be a viable and economically gainful ambition. The gaps the UK could fill with a nationally assured capability include:

- A cross-sector (civil, commercial and military) space surveillance operations centre that can exploit available sensor data and provide products and services to end users and innovate new products and services. This would be a world-leading enterprise and would also create unmatched expertise and experience. Depending on the scale of operations, a functioning centre would cost in the region of £10m, and could be expanded further depending on ambition.

- Sensors geographically located in British Overseas Territories that offer coverage of parts of the LEO orbital domain that are lacking. Locations for the sensors might include the Ascension Islands or the Falkland Islands.[7] This is anticipated to cost in the region of £30m per sensor and could be further scaled up depending on ambition, sensor types and orbits covered. This is anticipated to be capital costs only and does not include all through-life sustainability costs, connectivity, training and operation. These would vary depending on the model of procurement and operation adopted. Regardless of the variation, the costs are a small fraction of the value of UK equities in space (measured in the many billions of pounds) and an even smaller fraction of the value of the terrestrial capabilities they support (conservatively measured in the many 10s of billions of pounds).

With a focus for space surveillance sensor data, the varied and often specialised academic sensors would also be able to contribute. As a *quid pro quo*, it is anticipated that more general data could be shared with the academic community.[8] There are other gaps in the space surveillance sensor portfolio that could be filled, such as precision sensors (terrestrially based and on orbit sensors), Radio Frequency (RF) sensors to monitor the increasingly congested RF spectrum and Artificial Intelligence uses for data analysis. However, it is the space surveillance operations centre and geographically located LEO sensors that stand out as two clear examples and would offer the UK the greatest return in terms of resilience of UK space equities, growth potential and confidence in the UK space industry, as well as an enhanced reputational position of the UK in international space fora.

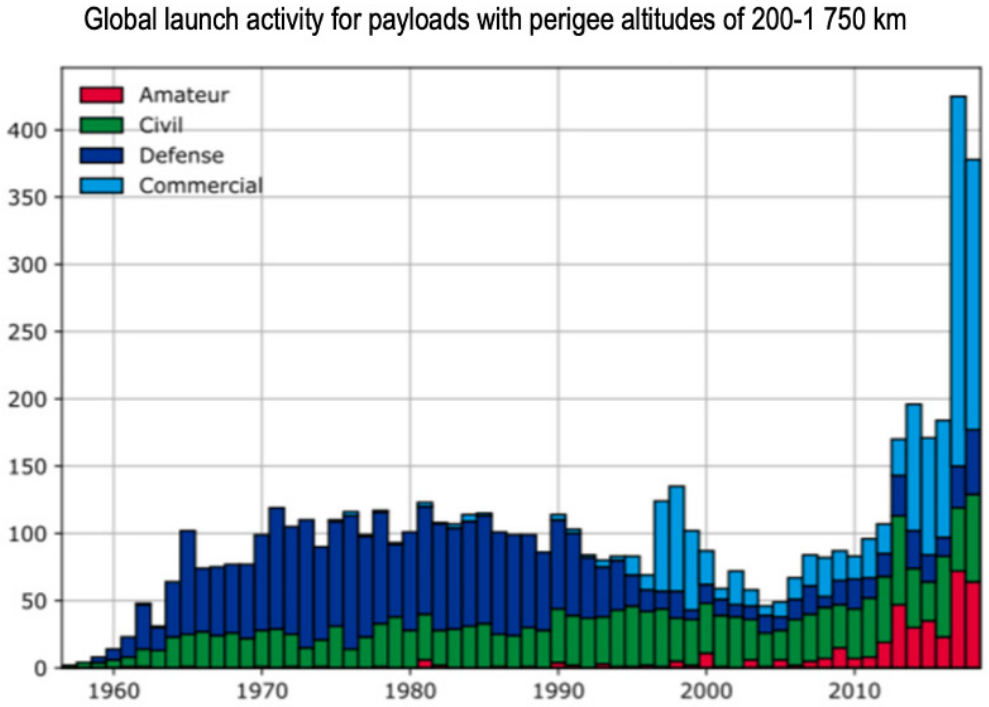
4. Space surveillance, for security and resilience

Space surveillance is integral to the resilience of UK equities in space and the terrestrial critical national infrastructure they enable. While space is inherently resilient to terrestrial events, operational satellites remain at risk from increasingly populated orbits and from orbital debris.

The number of active satellites in Earth orbit is 5,853.[9] This number will increase by an order of magnitude with the full deployment of one of the broadband mega-constellations. In 2018, the US Federal Communications Commission approved

SpaceX's plan for almost 12,000 satellites, and in 2019 the company submitted filings with the International Telecommunications Union for an additional 30,000 satellites.[10] The rapid rise in global launch activity for payloads in LEO illustrates this order of magnitude growth.

FIGURE 1: PAYLOAD LAUNCH TRAFFIC IN LEO[11]



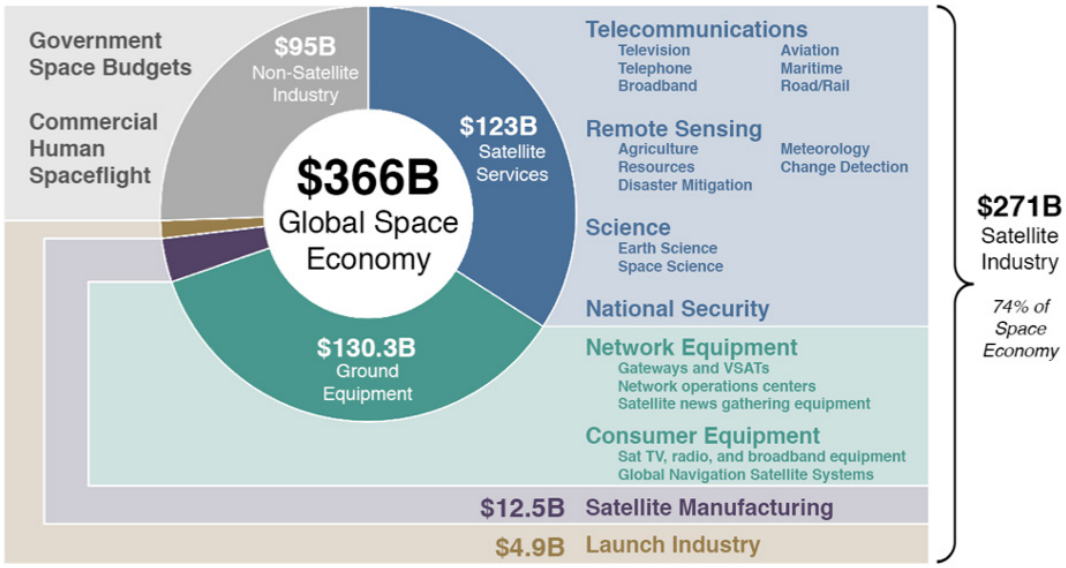
Add to this the existing orbital debris of one centimetre or larger, which varies between NASA's estimate of 500,000 and the ESA estimate of 900,000, and the issue of congestion and threat to the UK's equities in space is clear.[12]

The impact of the loss of one satellite in Geosynchronous Earth Orbit (GEO) will have a significant impact on the capability it delivers. Satellites in GEO tend to be much more costly to build and launch to orbit, have longer operational spans and, therefore, have returns on investment often measured in decades. On 3 July, the UK committed an initial £500m (of the expected total cost of £6bn) to the next generation of UK GEO satellite communication Skynet 6A satellites.[13] LEO satellites are often more resilient because more satellites make up a constellation, they are smaller, have a shorter operational life span and are less costly to launch to orbit. On 19 July, the UK invested £500m in OneWeb, a LEO satellite operator.[14] Also in July, the US Department for Defense invested $15m in a commercial space surveillance sensor provider (LeoLabs – part of the investment portfolio of UK Seraphim Venture Capital and Airbus) to provide additional resilience to their coverage of this particularly congested orbit.[15] The scramble for pre-eminence in the broadband market in LEO is creating congestion which significantly increases the risk of collision. The great danger is one collision will create a debris cloud that will create multiple other collisions, causing a cascade of debris that would make the orbit unusable. This future scenario is called the Kessler syndrome and it is a potential modern-day tragedy of the commons. The exposure

of UK equities in both GEO and LEO orbits is significant. A UK space surveillance capability would be a small premium to pay to assure this investment and act as the foundation for greater resilience.

The global space industry is valued in the region of $366bn, although the Space Federation estimates this value to be in the region of $423bn.[16] There is no cross-sector, open and transparent space surveillance capability that is not controlled by the military. This may result in the sensors being tasked for uses other than space surveillance for civil and commercial interests. If the UK had a civil led, cross sector space surveillance capability (including commercial partners, the military and academia) it would be a world-first and it would be the market leader in offering space surveillance products and services to a fast-growing global space industry.

FIGURE 2: THE SATELLITE INDUSTRY IN CONTEXT



At the core of any security question for the UK's military requirement or resilience for the UK's equities in space is an understanding of what is happening in space, who is doing what, where and when. This must ultimately offer decision quality understanding of the domain. There will be no space traffic management without space surveillance. To what extent the UK requires a nationally assured space surveillance system has already been touched on. The common requirements for a UK space surveillance capability and associated operations centre might include:

- Awareness of risks (that include threats and hazards) to UK equities in space and an ability to act to avoid them or attribute actions detected
- Support UK launch licencing requirements
- Support UK de-orbit requirements
- Risk mitigation for UK economic interests in space
- Data exchange with other space surveillance entities and with commercial partners

- Act as a clearing house for UK sensor sharing and ingesting

- An understanding of space weather and an ability to predict and warn of events that may damage satellites.

To achieve a truly cross-sector space surveillance capability, openness must be the guiding philosophy. The majority of existing space surveillance sensors are behind military security walls and are often repurposed ballistic missile detection systems. Because of this, not all the space surveillance data they acquire is shared. The US Space Fence, the most capable space surveillance sensor yet, is another military asset and it is not clear whether all the data it collects will be available in the public domain. The UK has access to much of this US sourced data but is not at liberty to share it. Civil and commercial space surveillance sensors can serve the military requirement. A military space surveillance sensor has proven not to be able to prioritise support to the civil and commercial requirement. There is a growing market for independent, open and commercially available space surveillance sensor data. A UK sensor would not be able to observe all orbits or meet all the varied requirements for products and services. A strategically located radar sensor would detect objects in key sun-synchronous polar orbits, the preferred orbit for launches from the UK. Importantly, data from such a sensor would be a valuable commodity to exchange for other segmented sensor data available from other components of the global space surveillance network. This sensor would focus on LEO, telescopes and RF sensors could be added to provide more fidelity to the existing surveillance data on GEO. Added to this, there is an as yet unfulfilled market for the products and services distilled from the available sensor data across all orbits.

There will be a need for the military to apply their own sourced intelligence to the data and that can be easily achieved. In addition, the space industry must be assured that commercially sensitive information is not revealed. Even with these qualifications, the previous veil of secrecy that was assumed for the vast majority of space surveillance information must be overcome if any UK space surveillance capability is to gain the confidence of all users and the products and services are to be trusted.

COVID-19 has highlighted the value of contingency planning. Core to any such planning is understanding. At the moment there is limited understanding of what is happening in space and so anticipating threats and hazards to the UK's space equities and their terrestrial links is left to chance. As a regulator and licencing nation, we have limited means of monitoring compliance or attributing accountability to the satellite operators that the UK regulates. To achieve any of this, the UK needs to understand what normal activity in space is in order to identify the abnormal and act.

5. Space surveillance for growth

The UK space industry generates £14.8bn, employs 41,900 people and represents 5.1% of the global space economy.[17] Following removal from the European Galileo project, the UK invested £92m to investigate a UK GNSS that is estimated to cost in the region of £3-5bn. The UK has recently invested £500m in OneWeb, a LEO commercial satellite operator providing broadband connectivity and offering the potential for other downstream services.[18] An initial £500m investment was also announced in July for the

next batch of UK Skynet 6A satellite communications constellation. The Government aims to establish commercial vertical and horizontal small satellite launch from UK spaceports and has already awarded grants totalling nearly £40 million. Bringing space launch to the UK is intended to be a catalyst for growth in the wider space industry. In that context, a modest investment of £40m is a small premium to pay for an entry-level dedicated UK space surveillance operations centre and space surveillance sensor. This combined capability would act as an exchange hub for global data sharing and creation of innovative new space surveillance products and services from the expertise of the operators it will develop. This will feed the growing market for space awareness products and for markets in space traffic management.

Launch operators require space surveillance data for a necessary collision on launch assessment. Satellite operators require space surveillance data to know of and avoid potential conjunctions with other satellites or debris. As a regulator, the UK needs an assured means of monitoring the activity of the satellites it licences for compliance. The proliferation of small satellites has increased the market for space surveillance data. There are no national space surveillance operations centres, other than the US Combined Space Operations Centre – which does not offer its services in the open market. Consequently, there is a market for space surveillance products and services and a gap that, if filled, would give the UK first mover advantage and with it, leadership in space surveillance globally.

As a regulator with access to space surveillance operations, it would draw space industry companies to locate in the UK. This is already evident in the choice of OneWeb, Virgin Orbit and a host of start-up companies that have moved to the UK. The City of London is seen as a global centre for finance because of its freedoms and its respected regulatory frameworks. In the same vein, the UK could also be seen as a global centre for space activity and the space surveillance necessary to support a trusted and valued regulatory framework would be the draw.

The UK space insurance market would benefit from the growing number of satellites, if the actuarial calculations were supplemented by trusted data to support the exposure. In 2018, approximately 93 satellites in LEO and 216 satellites in GEO, representing 6% and 43% of the active orbital populations respectively, had in orbit insurance. It is estimated that this represents some £4M and £22M in insured in-orbit exposure.[19]

Greater space surveillance capability is emerging with the US Space Fence becoming operational, marking a significant improvement in space surveillance capability – although whether all the data from this military sensor will be available is uncertain. As a balance to this limited availability of military sourced data, there is a growing market for space surveillance data from the arrival of commercial space surveillance companies such as LeoLabs and ExoAnalytic Solutions. There remains a gap in the market for expertise in the collation, analysis, creation and distribution of the available space surveillance data in the form of products and services required by all sectors of the space community. Initially this should be civil led as a public good. This would prime the establishment of the market and enable growth to deliver a likely return as demand for the products and services increased to monetise the investment.

A space surveillance system represents a clear and distinct contribution to global space sustainability the UK could make at modest cost and with little or no lead time. This would be a public good and contribute to the UK's soft power in terms of global leadership in space surveillance, space sustainability and space traffic management. In addition to filling this gap, the UK could viably supplement the available space surveillance sensor data with a sensor of its own located in valuable terrestrial locations that the UK is fortunate to have access to; namely the Ascension Islands or the Falkland Islands.

6. Space surveillance and the UK's international status

A robust space surveillance capability has the potential to bolster the position of the UK in the international space community in multiple ways. It would enable the UK to identify and characterise objects in space, which would strengthen the UK's position as a space regulator, which would in turn drive confidence in space companies operating or investing in the UK. A space surveillance capability would also reinforce the UK's influence within alliance networks and in international fora related to the space domain – not only would this provide the ability to identify malevolent activity in space, it would allow the UK to contribute directly to future discourse on the codes of conduct in space, and space sustainability. The demand for such regulation was evident in a recent survey of 21 companies.[20]

The requirement to manage space traffic is becoming critical. The best available current space surveillance sensors track some 20,000 debris objects greater than 10cm in LEO and greater than 30-50cm in GEO. This represents less than 0.02% of the total estimated debris population in Earth's orbits bigger than 1mm.[21] Between 2015 and 2017, more than 800 conjunctions were reported for one satellite mission, the European Sentinel 2A satellite.[22] Operators of mega constellations, such as Starlink, and the very large number of satellites in the OneWeb constellation, would be faced with potentially hundreds of thousands of avoidance manoeuvres. This will be unmanageable without better space surveillance sensors, more accurate conjunction warnings or a space surveillance system that can coordinate all sensor data, bring together available information innovatively to develop means of interrogating the data and producing new and more relevant space surveillance products and services. There is an opportunity for the UK to contribute to global space surveillance, and to become an important source of information and data, and to help establish regulatory administration.

The UK is currently home to the highest number of space start-ups of any country, after the US and China.[23] Creating the confidence that the operating environment is monitored will be attractive to prospective commercial enterprises. As a regulator with access to a space surveillance capability, the UK would be able to observe threats and hazards to space assets of UK-based companies and hence give them chance to respond. It could provide launch companies with the assurance that they are launching into a clear space. A space surveillance operations centre would act as a clearing house for sharing space surveillance data. It would contribute to the necessary increased safety requirements for space surveillance from the rising demand for space tourism. An operations centre would also be an accelerator for space surveillance knowledge and experience which would consequently be a source for new and innovative products and services, although this expertise would take time to develop, as a first-mover in creating

this cross-sector expertise, it would be world-leading. The combined output would reinforce the UK's position as a leader in space surveillance and build on its reputation as a hub for creativity and entrepreneurship.

A space surveillance capability comprising a federation of stakeholders from across all sectors has the opportunity to steal a march on the rest of the world and build the knowledge, skills and experience that is the prize of gaining first mover advantage. In business terms, this would typically allow the nation that did establish such a space surveillance capability to build 'brand recognition' and customer loyalty before competitors enter the market. The UK has an international reputation as a responsible regulator, well-established in the areas of finance and insurance. It is also home to a respected and innovative space industry that is at the forefront of technological entrepreneurship. The UK now has an opportunity to take a global leadership position in space surveillance too.

A space surveillance capability would also allow the UK to enhance its links with allies. The US Defense Space Strategy recognises the need for a greater global effort on space surveillance and calls for expanded information sharing relationships with capable allies and partners and to align on space policy. No nation has a space surveillance operations capability that is an equal partnership of civil, defence and commercial contributors that would be capable of sharing with the US in this way, including the UK.[24] However, the UK does have a defence and security capability that has a long tradition and deep expertise in space surveillance and enjoys a strong and well-established relationship with the US that would accelerate the development of expertise, the sharing of space surveillance data and enhance the UK space surveillance capability. The UK is in fact better placed than almost any other state to benefit and enhance ties with other allies in this domain.

The UK would obtain further leverage with other established space nations. It would also offer leverage with emergent space nations such as Japan and the United Arab Emirates as well as influential commercial actors.

A UK space surveillance policy and associated capability would help the nation be vigilant to purposeful interference with UK and allied satellites. Recent incidents indicate growing capabilities and boldness of certain states in space. In February 2020, the US accused Russia of shadowing a sensitive US satellite operated by the National Reconnaissance Office.[25] In April 2020, Russia conducted an ASAT test – one that was not announced, but identified independently by US space surveillance systems.[26] While the announcements from the US marked a new transparency in identifying activities that previously were considered classified, the UK had no forewarning, and were thus diplomatically at a disadvantage. A nationally assured space surveillance capability would enable tighter integration in how these activities are dealt with. Without space surveillance awareness, we should be deaf, dumb, and blind in the space domain, and left needlessly vulnerable.[27]

The UK has a central position in international discourse on issues of security, and it is a prominent member of every key international institution. Notably, regarding space, it held the presidency of the UN's Conference of Disarmament (CD) in 2019, and amongst its accomplishments was the establishment of working structures to focus the

organisation's work along the four lines of its core work, one of which is outer space.[28] On 26 August, the UK tabled a draft UN Resolution on responsible behaviours in space. As greater regulation becomes increasingly urgent in the space environment, discourse and negotiations will ensue on a number of issues. Alongside its international reputation as a responsible regulator, the UK would benefit from a space surveillance capability, particularly one that is composed of civilian, commercial as well as military sectors, as this would aid transparency and confidence. This diplomatic dividend could be an important source of soft-power.

7. Surveillance policy – structures

There are many challenges to establishing a common UK space surveillance policy and its resulting capability. From the interviews conducted for this report, one barrier repeatedly mentioned is the siloed approach and the bureaucratic government structures that prevent departments aggregating budgets to achieve common aims.

The creation of the National Space Council (NSC) is a very positive step and will generate a much more cohesive approach for the UK's ambition in space. The addition of a body that can manage and align space budgets and requirements on behalf of contributing departments and commercial contributors as well as provide strategic direction and leadership on behalf of the NSC would be an asset. A space strategic leadership team could achieve this detailed implementation on behalf of the NSC, and it is recommended one be formed.

The cost of a national space surveillance capability is modest but the returns could be great. These returns would include improving compliance behaviour among satellite operators as an indispensable step to contribute to the future sustainability of the space environment. In achieving this, a range of policy solutions and lessons learned from other domains and sectors may prove instructional. One relevant avenue for exploration is strengthening space situational awareness systems and data reporting structures and standards to build common architectures. This implies close coordination between public and private actors across the defence and security, civil and commercial sectors. Faced with an order of magnitude increase in the number of active satellites in LEO, it will become critical to strengthen current space surveillance data processing and management capabilities.[29]

Another challenge for space is to create an informed understanding across government and galvanise the public. With a space surveillance operations centre as a focus, the UK would have a tangible hub from which to communicate space surveillance issues in the relatively close Earth orbits populated by the satellites that are so essential to the UK's critical national infrastructure.

A common UK space surveillance capability federated across the civil, commercial, defence and security sectors would be a world first. A change to existing structures to enable aggregated funding, create a focus for space and in turn position the UK as a global lead in the debate on the sustainability of space. This structural revision would also position the UK as the desired location for space activity and generate growth and prosperity in the space industry and beyond.

8. Conclusion

The population of satellites in orbit, particularly LEO, is set to increase by an order of magnitude in the next five years. Improving space surveillance sensors available in the next two years will start to track smaller objects, increasing the catalogue of known debris by several orders of magnitude. Space-based capability is already serving and supporting every part of society and is key to the UK's critical national infrastructure. Into this congested and contested space market, the UK is investing in renewing its satellite communications capability, in broadband provision from space and a potential GNSS capability. The UK has ambition to be a destination for horizontal and vertical space launch, and to be a regulator of choice and preferred nation for the space industry to locate. The UK is aiming to achieve all of this without a space surveillance policy that considers all sectors of the space community.

This report sets out what such a space surveillance policy should consider. It concludes that it should start with a clear statement of the UK's ambition in space to set the scale and scope of any subsequent infrastructure investment. Any space surveillance capability will enhance the security and resilience of UK equities in space and add to the appeal of the UK as a destination for licencing satellite operators. With this foundation, existing UK space industry will flourish and draw in international companies wishing to locate in a country with space ambition, clear policy, a space surveillance capability and clear, even-handed regulation. If the UK were to deliver a space surveillance operational capability in the next two years, it is anticipated that it would be a world leader and would gain first mover competitive advantages. This would rapidly enhance the UK reputation and leverage its voice in the key space debates on sustainability and space traffic management. First, the bureaucratic structures must be put in place to allow the aggregation of budgets across departments to fulfil the ambition.

The National Space Council has an opportunity to act. Under the Chairmanship of the Chancellor of the Exchequer, and as a Cabinet Level Committee, it will be setting a National Space Strategy and space surveillance must be a key component of that strategy. Elements of any space surveillance capability should include, but certainly not be limited to, the following:

- A clear statement of the UK ambition in space
- A cross-sector (civil, commercial, defence and security), nationally assured space surveillance capability that would contribute to the global space surveillance data by:
    - Establishing a space surveillance operations centre, drawing on civil, commercial and military contributions, to focus and develop UK knowledge, expertise and innovation and share space surveillance data, products and services with allies and international partners.
    - Locating a space surveillance radar sensor in either the Ascension Islands or Falkland Islands to contribute data in support of UK space launch and as a contribution to a gap in global space surveillance coverage.

- Enable departments and the commercial sector to aggregate budgets to invest in the necessary infrastructure to establish a common UK space surveillance capability and create a strategic leadership body to oversee the budget and manage space surveillance operations.

In July 2020, the UK invested in the region of £1bn in space-related equities and is set to invest much more. Safeguarding this investment and setting the conditions for the UK-based space industry to safely grow and prosper requires a common space surveillance policy and subsequent capability. For a relatively modest investment the UK can acquire the space surveillance awareness necessary to providing the resilience to its space equities. A basic LEO capability could be achieved for less than £40m, though further investment could expand this to provide wider products and services and surveillance of other orbits. In the process this would encourage growth and enhance the UK's reputation as an innovative and leading space power.

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