Article

How Has the UK Government Responded to the Commercialisation of Space Activity?

By Wing Commander Martin Williamson

Biography: Wing Commander Martin Williamson is a serving RAF officer with 20 year's experience. After serving as an Air Traffic Controller, in many locations globally, he completed numerous academic pathways. Following a Master's degree from Cranfield University he completed several command and staff tours. Subsequently he attended the University of Cambridge to read for an MPhil in Politics and International Studies. His research at Cambridge focussed on political responses to space exploration and technology in the UK, an area which he continues to research.

Abstract: This research paper examines the response of the UK government to the commercialization of space activity, from 2010 to the present, and aims to understand the nature of the UK space sector and its interaction with the government. The research unveils the intricate motivations driving the government's engagement with the newspace sector, and also reveals that interventions for political goals may yield unintended consequences. Notably, selective interventions such as financial support risk fostering a culture of dependence on state backing, potentially stifling innovation and undermining competitiveness.
Thus, underscoring the importance of a balanced approach to government involvement, ensuring long-term viability and preventing a state-dependent space industry. This study offers valuable insights into the UK's priorities, trajectory, and geopolitical aspirations in the realm of space exploration and utilization.

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Introduction

Space has been a key tenet of UK defence policy since the 1950s, but a recent surge in global commercial space activity has meant that the UK has had to swiftly adapt its approach to a changing paradigm. Inspired by SpaceX, Amazon Blue Origin and other flagship space enterprises the world has awoken to a new wave of possibilities and potential through space; the ability to launch technology into space on a commercial basis has catalysed the development of a new industrial sector known as newspace. Newspace is a global enterprise, appearing in a surprising array of countries. Yet academic discourse on the relationship between the state and the newspace sector is nascent, partly due to the rapid rise of the phenomenon. But the relationship is becoming an important factor to consider when examining the politics of a state; not only does space provide access to resources and data never before available to many countries beyond great powers, it is also a global issue in the way that it interacts with the politics of other non-adjacent states. Space technology has now become available to developing countries which are able to seek sovereign space capability. The potential of this progress is likely to change the global political dynamic; consider the commercial satellite operators contracted to examine the 2022 invasion of Ukraine by private actors,[1] or the way in which new Chinese missile silos were spotted using commercially available satellite imagery by an enthusiast.[2] Technology that was once only available to the military is now available to everyone with a computer, through newspace. The capabilities which will develop in the future are unknowable, as innovation in the sector is happening at pace. Accordingly, growth of the newspace economy is significant. This growth has caught the eye of governments due to its relevance to national defence, but so too has the potential utility of newspace to support other state requirements. Newspace therefore represents two worlds of possibility for a speculative state; a vibrant, innovative space sector which may yield significant economic growth, jobs and taxes, or a vibrant, innovative space sector which is able to provide a strategic edge for the country. Perhaps both are achievable.

This case study examines the relationship by answering the following question: 'How has the UK government responded to the commercialisation of space activity?' The UK was chosen for study for two reasons. Firstly, I was able to access senior individuals within the industry, government and the supporting scientific community in a way that would have been impossible in another country. Secondly, the changing political situation in the UK since 2010, combined with the presence of a burgeoning newspace sector meant that a study of this nature would provide a unique perspective on the relationship between the two. The research is important because the way in which a state interacts, nurtures and promotes its newspace sector has the potential to inform us of its priorities, direction of travel and even its geopolitical aspirations. In India, cautious development of a newspace sector within a framework of restrictive policy speaks to the need to use space as domestic infrastructure to support agriculture, rather than promoting international trade.[3] Luxembourg have undergone a process of deregulation and law-making such that newspace business is

attracted to the country, intending to boost the economy. In the US, the choice to use SpaceX and technology from other newspace companies by National Aeronautics and Space Administration (NASA) to develop a reusable personnel delivery system for the International Space Station signals a renewed intention for space flight and lunar exploration in a way that harnesses the innovative potential of business. Because of the nature of space and its global utility, a state's relationship with its commercial space sector potentially tells us far more about its geopolitics than examination of its relationship with other industrial sectors such as aerospace or finance.

To answer the question the study seeks to understand the nature of the UK space sector and explores governmental interaction with it from 2010 to the present. The study draws on a range of sources, including governmental and trade association publications, oral evidence from parliamentary committees, news articles and several original interviews with senior figures with experience of the industry. Interviews were conducted using a semi-structured format allowing pursuit of lines of interest, and full expression of views of the interviewees. Governmental interviewees include senior policy makers in the United Kingdom Space Agency (UKSA), Department for Business, Energy and Industrial Strategy (BEIS) and the Ministry of Defence (MOD). Beyond government sources, interviews were conducted with members of UK Research and Innovation, space clusters and senior figures within the newspace industry itself.[4] The thesis takes the broad findings of the case study and interprets them through the application of industrial policy theory.

The research finds that whilst one might expect UK government interaction with its space sector to be purely motivated by economic growth, the reality is multifaceted. Although pursuing economic growth is a political motivation, the UK has demonstrated that a range of political agendas may be pursued through interaction with the commercial space sector. Furthermore, an analysis of the case study findings using industrial policy theory highlights a worrying trend; the UK government is potentially damaging its space sector by using selective interventions to pursue political goals. Such interventions, usually financial, are developing a culture of reliance on state backing, which may stifle innovation. In such a highly competitive international market, a national newspace sector cannot afford to fall behind else it may lose its advantage and potential customer base. The thesis ends with an assessment of implications for national policy.

The thesis is divided into five parts as follows:

> Part 1 examines the literature surrounding newspace and how it differs from previous conceptions of the space industry. It discusses the sector's challenges, noting that the development of technology for use in space is more challenging than for terrestrial applications. The review examines the debate surrounding industrial policy, which has been rekindled since the financial crash of 2008. It highlights the tension in approaches between horizontal and selective policy and how the academic debate has developed.

It also discusses the challenge of regulation of space activity, as this is an element of UK strategy for space.

Part 2 examines the UK space industry, outlines the sector's size, and highlights examples of newspace businesses characteristic of the industry. The examination then discusses some government interventions which have shaped the sector; innovation catapults and a push to develop a sovereign launch capability. The section concludes with a study of an out-of-character government intervention to purchase a significant stake in the bankrupt satellite constellation OneWeb, to explore what the investment signifies in terms of government strategy.

Part 3 examines how the UK space sector is funded and finds a mixed picture. Whilst government provides funding primarily through direct grants, money is also routed through European Space Agency (ESA) and back to the UK. Private equity and venture capital are also an essential part of the picture but bear little relation to government funding patterns.

Part 4 investigates how the UK government's strategic response has developed since 2010 by examining policy documents, strategy and international aspirations. It finds that in policy, government focus pivoted away from developing economic growth to using space to achieve political goals since the UK voted to leave the European Union (EU).

Part 5 reintroduces the idea of industrial policy as a framework to examine the range and breadth of government intervention in the sector since 2010. The post-Brexit governmental pivot in priorities becomes apparent by dividing interventions into selective and horizontal and placing them into chronological order. The discussion derives three themes; the pre-2015 focus on the economic growth of the space sector, the post-2016 focus on political priorities, and the prevalence of grant funding as a means to achieve the political ends. Implications for national policy are discussed before the paper concludes by discerning potential problems with the government's approach and warns that, through government intervention, the UK may develop a space sector that cannot become self-sustaining; essentially a parasite of the state.

Part 1: Literature Review

The focus of this study is commercial space activity, and how political responses to it have changed in nature since 2010. Since 2010, the term newspace has become widely used in industry, academia and consultancy to conceptualise modern space activity. Sir Martin Sweeting defines newspace as 'the emergence of a different ethos for space where the established aerospace methods and business have been challenged by the more entrepreneurial private sector by adopting more agile approaches and exploiting the latest commercial off the shelf technologies' but acknowledged that the inference of an 'Oldspace' is unfair to the industry.[5] An alternative definition of newspace is 'A global industry of private

companies and entrepreneurs who primarily target commercial customers, are backed by risk capital seeking a return, and seek to profit from innovative products or services developed in or for space'.[6] The thematic link between these conceptions of newspace is the idea that there now exists a broader commercial market for space technology, than previously. Madry argues that newspace in the US has triggered a flood of investment in small fast-moving, Silicon Valley style businesses which will disrupt the established order of monolithic aerospace companies offering services in and from space. Further, it is argued that the emergence of newspace businesses is set to continue at pace, as access to space tech becomes cheaper and investment increases.[7] The development of reusable rockets, lowering launch costs and acceleration of time frames within which equipment may be launched into space has enabled the opening of a brand-new commercial market.[8]

The contrast between old and newspace is expounded by Davidian who compares the US Space Race in the 1960s to modern-day space tourism. Davidian argues that the primes who supported the space race should not be considered commercial as innovation was not required to stay ahead of the competition.[9] In this model, private firms working with NASA were largely insured against the enormous risks of investments in space through cost-plus contracts, but they had little ability to participate in the potential gains from a commercialised space market.[10] NASA were specific in their goal and their requirements, and industry contributed to the space programme by building components to order. Davidian contrasts this with newspace which contains a rapidly increasing number of private actors who generally do not produce to order,[11] making it difficult to say the type of products that may emerge. In the newspace era, private firms share in the enormous risks and (potential) returns of investments in space.[12]

Davidian's argument that unpredictability and non-linearity of newspace as a fundamental characteristic of the sector is supported by Madry who argues that newspace is characterised by small businesses that innovate quickly, mirroring a Silicon Valley approach.[13] But this argument forgets medium and large business who seek to operate on a more innovative footing in response to the change of paradigm. In terms of scale, newspace companies can operate with varying profiles; from start-ups and small to medium-sized enterprises that focus on lightweight technologies such as small satellites, to 'big players' who have engendered a start-up spirit, generally derived from the Silicon Valley sector.[14] Traditional prime contractors[15] have developed clear interests in the commercial space market and have also evolved to capitalise on it. NASA and ESA have departments dedicated to the search for disruptive innovation, though they have experienced limited success.[16] Meanwhile Airbus, have purchased small, innovative space companies to take advantage of the new markets.[17] Large companies should not be dismissed; they remain an important component of the modern space sector.

Accordingly, it is wrong to consider newspace as a typology of business, rather, it should be thought of as a market and an ideology. The established order of prime aerospace industry is being disrupted not because of the emergence of new innovative business in competition with primes, but because of the emergence of a commercial market for space-derived

products. The key difference between traditional and newspace business is the nature of the customer; primes target the state, whereas newspace target the commercial sector. Definitions of newspace however, are shrouded in ideas of profit, risk capital and innovation and take no notice of the role of state. Whilst it is accepted that space primes had a direct relationship with NASA for the development of technology to support their space programmes, the possibility of similar relationships are conveniently omitted from discussions over newspace. But the idea that newspace is self-supporting is incorrect. The public sector 'played a crucial role in the success of the first space ventures'[18] so too did Elon Musk's long-shot start-ups require vast backing from the US government[19]: …'they're not really examples of independent, innovative market capitalism. Rather, they're government contractors, dependent on taxpayer money to stay afloat'.[20] Indeed, the US National Space Policy states the necessity to 'support innovative entrepreneurial space companies through appropriate deregulatory actions'.[21] Summerer goes on to argue that space continues to be a predominately government-controlled domain which acts as a 'lead market' that creates downstream opportunities for smaller businesses.[22] Shammas and Holden argue that commercialisation means that in the future the space economy could become a post-state object,[23] which will operate in total isolation from state influence, but for now it is clear that a post-statist space economy is not a reality; there obviously remains a relationship between space and state. Shammas and Holden concede that in the meantime: 'For capitalism to survive in outer space, the state must … assemble outer space as a domain made accessible in legal, technical, and economic ways'.[24]

The Space Market

What does the commercial market for space products look like? There exists scepticism about the market for space technologies as space-innovation differs from other tech sectors for reasons related to the complexity of operating in outer space. Firstly, a high degree of risk-aversion exists in the space sector meaning that testing of space technology is difficult - there is little appetite for carriage of equipment into space which is not vital for mission success. Additional operational requirements restrict innovation in a way not experienced by terrestrial tech firms. Environmental factors include high-energy radiation, extreme temperatures, large and frequent temperature variations, micro-meteoroid and orbital debris impacts, the vacuum environment, high launch-related g-forces, microgravity and of course limited opportunities for repairs or adjustments after launch. Accordingly, very strict testing requirements, licensing, a need for redundancy and strict quality assurance processes are all required.[25] Compounding issues such as low volumes, high launch costs, and the effects of tight import and export controls all play a role in limiting innovation; the hostile environment of space[26] acts as a significant brake on innovation. Combine this with the fact that there is not yet a mass-market customer for space technologies, there is a clear need for state-backing at this early stage of market development.

Industrial Policy

And yet the newspace industry continues to grow. What does this mean for a government seeking to stimulate a space economy and attract newspace? The stakes are high. If, as Ruttan

argued space is a General-Purpose Technology (GPT) like nuclear technology, aerospace and telecommunications[27] then states must develop a stake in the industry for reasons of economy, prestige and security. Historically, GPTs required not only substantial government investment but vision, research and oversight of the commercialisation process. For any state seeking access to newspace, the historical argument is clear; government must play a role. But how best to achieve this? The answer lies in industrial policy.

Since the financial crash of 2008, there has been a resurgence of interest in industrial policy and how it may be used to stimulate entrepreneurship, innovation and growth to aid financial recovery. Pack and Saggi define industrial policy as: 'any type of selective intervention or government policy that attempts to alter the structure of production toward sectors that are expected to offer better prospects for economic growth than would occur in the absence of such intervention'[28] but there are many other definitions.[29] Common to all is a declared intention to alter the structure of certain sectors, markets or aspects of the economy.

Some argue that industrial policy distorts the market, as it means that private investment only follows after government lends its 'seal of approval'. This distortion relies on the premise that government has correctly 'picked a winner'[30] and so government approval becomes a prerequisite for funding by the private sector. This is problematic, as in some opinions, 'governments rarely evaluate the costs and benefits properly'.[31] Lerner argues that the implications of this can be severe as particularly in the early stages of sector maturity, it is easy for a government to 'overstep its bounds and squander its investments'. This is for two reasons. Firstly, government programs allocate funds and support incorrectly or counterproductively, although this is less of a problem in wealthy countries with well-established legal systems. Secondly, that in an environment where public subsidy is available, private and public entities often shape to capture these subsidies in a process known as regulatory capture.[32]

To avoid these issues, governments must be aware of both conceptual and implementation issues. A key argument is that government lack an accurate understanding of the sector and the market. This can lead to investment in industry when a market does not exist; a decision which may be driven by misguided political considerations or hubris.[33] In extremis, misdirected industrial policy can lead to an outcome like BioValley, a Malaysian government attempt to stimulate its biotech industry through a $160m infrastructure investment.[34] The project aimed to develop a research campus which would provide cheap rent and good communications to its residents but failed as there was no market for its research or products. Industrial policy can also fail if governments do not incentivise the development of technology appropriately; private investors pay keen attention to the issue through the use of industry experts.
As the BioValley saga informs us, the internationally connected nature of the market may be overlooked. The Malaysian government became too focussed on providing jobs for native Malay speakers, and disregarded the conventions and norms of the international market for scientific research.[35] This exemplifies the point that a domestic focus on business development can lead to divergence in economic relevance from the global market.

Other problems exist with too great a focus on an economic sector or selective policy. Governmental clamour to boost a sector may lead to a rush of start-ups, but some contend that such a rush may be counterproductive[36] and argue that policymakers should seek to promote higher quality start-ups to create economic growth by measures such as improving the qualifications of entrepreneurs, securing the availability of important inputs, and stimulating the innovativeness of regional entries. Governmental temptation to overengineer policy is also a problem; micromanagement can have a counterproductive effect.[37] Furthermore, which companies should attract focus? It has been argued that in order to promote economic development, policy makers should focus on high-growth firms instead of new – often very small – firms in general.[38] High-potential start-ups are very attractive to a government pursuing growth, as evidence suggests that it is fast growing firms which account for most new job creation.[39] Accordingly, the nurture of high-growth firms has become a key strand of entrepreneurship policy in the US.[40] This has important ramifications in the newspace sector, as it may be difficult to discern the difference between a micro-business and a high growth firm. A micro-business is sub-25 employees in size and does not dominate its field. Nor does it engage in innovation. In contrast, a high-growth venture is primarily focussed on profitability and growth through focus on innovation and unserved niches in the market.[41] Friar and Meyer argue that it is the high-growth companies which boost economies, however Mazzucato cautions against reifying such firms in an economy, and showering them with benefits and subsidies.[42] He argues that many of the high growth firms have existed for some time before reaching the take off stage and yielded fast bursts of innovation and employment creation. There are other significant issues with this focussed approach, such as substitution or deadweight effects where less viable start-ups are provided subsidies and remain in the market for an artificially enhanced period; so long as they can rely on that funding. Further, start-ups may survive and grow without any subsidy, meaning government funding is wasted.[43]

Another way in which selective industrial policy may inadvertently stifle industry is when the high rate of growth expected of high-tech industry stalls, as it has done in the Cambridgeshire bio-tech cluster. Stam et al demonstrated that the cluster was initially so successful in attracting Venture Capital funding that it distorted the natural market.[44] The influx of capital meant that house prices and the cost of living increased out of synch with the local labour market and wages. This had the effect of driving business elsewhere and abroad. This view of distortion was supported by Fritsch who argued that this phenomenon was an example of why governments should exercise caution with interventionist industrial policies.[45] The market must wherever possible operate on a survival of the fittest basis, and policy must aim to achieve an environment where survival of the fittest can occur. Specifically, policy which aims to develop an entrepreneurial sector should wherever possible avoid interfering with fair competition.[46]

To combat these problems, Lerner advocates several policy levers which government should utilise to enable growth and dynamism in a new sector. Firstly, to remember that

entrepreneurial activity does not exist in a vacuum. Specifically, entrepreneurs not only require capital, but legal and marketing support along with a range of other support functions. Secondly, to effectively leverage the local academic scientific and research base, by facilitating conversations between academic entrepreneurs and venture capitalists for example. The idea of technology transfer between academia and industry is important here, and without connection of both sectors an entrepreneurial sector is unlikely to develop. Thirdly, there exists a need to consider conformity with global standards and to understand the importance of global interconnection. A nation looking to enter a global market must consider the global standard carefully when developing its industry. In terms of newspace, this recommendation raises significant questions over global standards in space and the need for firmer regulation which is addressed below. Finally, Lerner advocates that government funding should follow the market, rather than vice versa. Market direction may be harnessed by allowing venture investors to show the way, using matching-funds[47] as the success of the New Zealand Venture Investment Fund[48] has demonstrated.[49]

The opposing view is that government policy should set broader conditions for development (horizontal approach) rather than focus on individual businesses or sectors (selective approach). The argument is neatly set out by Rodrik: 'We need to worry about how we design a setting in which private and public actors come together to solve problems in the productive sphere, each side learning about the opportunities and constraints faced by the other, and not about whether the right tool for industrial policy is, say, directed credit or R&D subsidies'.[50] Further, an expansion of an economy's scientific and technological capacity will not solve the problem unless there exists adequate demand for innovation in the business sector.[51] Therefore, Rodrik argues it is better to focus on developing the institutional setting rather than precise policy measures. Similarly, Bloom and Van Reenan argue that the best way to support small firms is via a broad governmental approach: 'ensure a level playing field by removing entry barriers to firms of all sizes, reducing barriers to growth, enforcing competition policy and strongly resisting the lobbying efforts of larger firms and their agents'.[52] This view is supported by Chang who showed that industrial policy in East Asia was successful not because of higher spending, but the establishment of better institutional networks which enabled information flow.[53] Chang argues that 'organisational design and institutional building is as, if not more, important in determining the success of industrial policy as the issue of designing incentive schemes'.[54] Herein lies the rub. The development of such institutional policy is more political in tone than delivery of funding and as Warrick notes 'the successful implementation of any industrial policy will likely depend on the nature of the political system and institutions in the country concerned' and that 'where the power of economic interest groups exerts undue influence through the political system, government support of an industry could be based more on political considerations than economic merits'.[55]

In summary, the arguments demonstrate that application of industrial policy to support a high potential sector is fraught with hazards. Too selective, and governments risk stifling innovation and preventing natural growth by distorting the market. Too broad, and the risk

is that frameworks of support become overly politicised and fail to address the economic potential of the sector it aims to support. This tension has direct relevance to industrial policy designed to support national newspace sectors as they are reliant on government support but in global competition with similar sectors for market share. How governments choose to support their newspace sectors now may have significant ramifications for their future success.

Regulation

A key political challenge for states who seek to develop a space sector is the establishment of a safe environment for the conduct of its operations. Currently, regulations for the safe and peaceful use of outer space fall under the remit of the Outer Space Treaty[56] (OST) which remains the only multilateral agreement on acceptable behaviour in space. Under the treaty, the launching state remains responsible for the flight and conduct of a mission, however long it may last. Ultimately, this includes liability for damage to other equipment and potentially terrestrial damage resulting from falling debris. The treaty has not been subject to update since its ratification, and as such presents the state with a significant regulatory challenge, especially those attempting to nurture a newspace sector. There have, however, been examples of national law being enacted relating to unapproved launches of equipment[57] where the US fined Swarm Technologies $900k for the unauthorised launch of four satellites.

But for a state seeking to exercise leadership or attract industry, a key issue is regulatory competition, where states compete to attract people, resources and entities into their jurisdictional authority.[58] The global nature of the newspace market means that businesses can locate wherever they perceive a regulatory advantage to be gained. As both Simon [59] and Linden outline, there are advocates and sceptics regarding international regulatory competition. Advocates view the competition as a method to produce the best regulation and laws, for both state and private entities (a race to the top). Sceptics view the only realistic outcome as a regulatory race to the bottom where stringent regulations deter businesses from joining the state to do business. A race to the bottom develops where governments are forced to lower standards to maintain a competitive regulatory environment. However, the layering of requirements for insurance and indemnification, Simon argues, ameliorates the tension as operations in well-regulated states will naturally attract lower insurance costs. At the macro-level concern exists that state-level legislation of space activity detracts from the utility of international treaties. As such international treaties are less likely to be observed, thereby destabilising the 'ecosystem'. Specific issues with international regulation are that due to its age, the OST lacks clarity relating to private industry and that there is a tension with sovereignty; the freedoms cited within the US constitution act in tension with the OST,[60] and Luxembourg's sovereign space mining laws also violate the OST.[61] For these reasons, Simon calls for parallel work to take place at international and national levels, to develop multi-lateral regulation. This will be difficult because, as Pekkanen argues, the newspace industry, is developing during an era of treaty decline and exit.[62] This tension makes the challenge of state response to the problems greater. Therefore, newspace activity is not only

a domestic industrial concern but a geopolitical one; a problem which must concern any responsible space-faring nation.

Conclusion

The commercialisation of the space industry or newspace presents a conundrum for states seeking to establish a foothold in the global space market. Government support for a commercial space sector is essential, but the methods and degree to which this support is provided require consideration as the application of industrial policy is risky. The academic discourse surrounding industrial policy casts a new light on newspace, as the industry is young, and states have already diverged in their approaches. A further issue for states is the international regulatory environment which remains undeveloped. A state that seeks to operate in space and support a vibrant commercial space sector must walk a regulatory tightrope. With these issues in mind, the next part of this research explores the current shape of the UK space sector.

Part 2: UK Space

This section discusses the character of the UK space sector, using research drawn from government sources, the internet and research interviews. This examination provides the required foundation upon which to build an understanding of the way in which the government interacts with the sector. For context, interviewees from venture capital, government, commercial and academic sectors were asked (independently) of their opinion on how UK newspace could be characterised. The answers were surprising as they did not focus solely on the industry. Rather, they highlighted the interconnected nature of newspace between the sectors and the inter-reliance on each for the ecosystem to work.

A venture capital fund manager described why the UK in his opinion, was such a strong proposition for hosting a newspace sector: 'First of all, pools of capital. We've got the City of London one of the biggest pools of capital in the world for investment and debt, and the insurance market, one of the biggest in the world out of London. From a venture capitalist (VC) perspective we are the biggest pool in Europe, accounting for nearly half of all European ventures… the entrepreneurial psyche, much more entrepreneurial than other European countries but not as entrepreneurial as America. Then the talent pool, data scientists. The UK's also got a heritage in space - the UKs always been a leader in innovation in space, Surrey Satellites were doing it before anyone else'. A senior figure in the newspace industry working in launch technology highlighted the rate of change in the industry, as the cost of launch and size of satellites continued to diminish: 'what has happened is that satellites have been getting smaller and small satellites can now do what you needed a big one to do… one of the things was you need to make things cheaper and quicker. That coincided with the fact that technology allowed you to make things a little bit smaller and so you have the so-called tech-refresh, you can launch a satellite every three years every four years rather than twenty to always have the [most up to date] technology. But a tertiary perspective from the UK space research community viewed the rise of the private industry as being in

tension with the pace of government bureaucracy: 'The New Space sector requires fleetness of foot, and quick investments and Government bureaucracy are in terms of administration funding have evolved with a 1960's mindset…the whole bureaucracy in government is two orders of magnitude behind what is needed, so the government might talk about trying to support newspace but … where there is a real innovation that has been suggested in terms of organisation at very high levels of UK Space Government … [it] is now locked into a system within BEIS and now it has to go backwards and forwards. We have an old space way of addressing bureaucracy within government. We need to have a new space way of doing things when it comes down to managing and growing our Space sector.'

These viewpoints correlate. The strong foundations of the new sector support an industry which can focus on the challenge of keeping up with the requisite rate of technical change. The government realise that they too must keep up by supporting with investment and that strategic leverage has become available through the sector; support of the industry is now in the government's best interest. However, the opinion of the senior scientist shows frustration that the government is not configured for the challenge, as bureaucracy prevents the pace at which innovation may be seized upon. With this context in mind, a survey of the UK newspace sector is better informed.

Size of the Sector

The UK space sector is small in relation to the UK economy as reported by the UK Space Agency's Size and Health of the UK Space Industry Report.[63] The report provides an idea of the scale of contribution of the space sector to the British economy but does not enable a distinction between what might be considered newspace. However, forty-five per cent of the one hundred and seventy-one companies were considered micro or small in scale (one to forty-nine employees) while twenty-six per cent were medium (below two hundred and forty-nine employees) and the remainder large. The population of UK space businesses has grown from two hundred and twenty-seven in 2006, to one thousand two hundred and ninety-three in 2021, a rate of twenty-one per cent per annum; over the same period income from the industry more than doubled.[64] However, despite its small size, the UK space sector's income in 2019/20 was £16.5bn, which added £6.9bn of gross value to the economy through profits, salaries and taxes. Caution should be exercised here though, as government statistics on the space sector include data from the satellite TV industry, more formally known as 'Direct to Home' (DTH). In 2019/20 DTH accounted for approximately forty-five per cent of UK space sector revenue as it considers, for example, satellite TV subscriptions for sporting events etc. Absent DTH and the overall income from UK space was £9.1b in 2019/20. Employment in the sector in the period was forty-six thousand nine hundred and ninety-five, however, almost half of this figure is accounted for by DTH services.

In the same year, approximately a third of UK space sector income was derived from exports,[65] with Europe and the US serving as the main consumers (fifteen per cent and eight per cent respectively). Notably, those who work in the space sector are considerably more productive

than in other sectors. Labour productivity, which represents the value-added to the economy per employee is 2.6 times the average UK employee, potentially due to the high levels of educated workers.[66] Since 2006 the UK space sector has developed from a relatively minor industry to one of growing importance. An array of indicators such as employment, value-added to the economy, productivity and the sharply growing number of businesses show that the commercialisation of space is having a positive effect on the UK economy, with strong future prospects.

Newspace Business in the UK

Surprisingly, the UK is not new to the space industry, as it has a heritage of satellite manufacture. Established in 1985, Surrey Satellites Technology Limited (SSTL) was an anomalously early entrant to the UK commercial space market. Now subsumed into Airbus, a prime, the organisation's success has paved the way for similar companies to develop by enhancing the UK's international reputation through collaboration with ESA. Even now, as an arms-length organisation from Airbus the company operates in newspace terms, partnering with larger companies and universities to develop bespoke technologies in support of a variety of missions.[67]

Building on this heritage, the UK space sector has become populated with a growing number of start-ups and innovative space businesses. Space Forge, based in Cardiff began with an aspiration to manufacture materials in space which are too costly or difficult to produce on earth. By developing returnable satellites, Space Forge will launch satellites into orbit to allow on board robots to manufacture products, only returning to earth when complete.[68] This approach allows more complex material designs to be constructed whilst reducing CO2 emissions. Space Forge selected Cardiff for geographical reasons, proximity to universities with focus on advanced materials development and investment; the Business Development Bank of Wales provided initial funding. Notably, Space Forge is also supported by the Welsh government signalling that devolved administrations have recognised the potential benefits of the newspace industry to their economy.

Examples of start-up businesses that have received government support are numerous and include Skyrora[69] and Orbex.[70] Skyrora are a small, Edinburgh based business who seek to design and build small rockets which will act as a means by which manufacturers may launch small satellites into space. Through innovation, Skyrora's vision is 'to provide swift and cost-effective launch capabilities, which are able to rapidly respond to demand'.[71] Similarly, Orbex based in Forres, Scotland was founded in 2015 to provide low-cost orbital delivery systems for the small satellite market in the UK. Through innovation, they developed a low-carbon rocket fuel and have attracted $38m in funding from a range of public and private investors including ESA, the UK Space Agency and two venture capital firms.[72] Because of their innovative approach to the challenge of low-cost launch provision, Orbex was placed in the top ten UK disruptors to watch by the Sunday Times,[73] and won several start-up business awards in 2019. Despite early successes, neither Skyrora nor Orbex have yet been given permission to launch from the UK.

Although domestic start-ups are a key feature of the UK space sector, so too are newspace businesses from overseas such as Spire Global[74] and Astroscale.[75] Founded in 2012, the Californian company Spire Global established European HQ offices and manufacturing facilities in Glasgow in 2015. Spire uses a proprietary network of satellites to collect earth-observation data, draw it down through ground stations to sell it to end users.[76] As an expansion of an established space business with a constellation of small satellites already in operation, the business was drawn to Scotland through access to public funding, access to risk-capital and according to the CEO an 'eagerness to support innovative companies'.[77] Another example of a newspace business which has been attracted to the UK is Astroscale, a Japanese firm established in 2013 which aspires to develop a robotic satellite system able which is able to inspect, fuel and service other satellites and also remove space debris. Space debris is a well-recognised hazard for manned and unmanned spaceflight due to the destructive potential of uncontrolled material on orbit.[78] Astroscale was initially attracted to the UK by the prospect of a partnership with Surrey Satellites who were contracted to provide equipment for the project in 2017.[79] Soon after in 2018, Innovate UK and UK government granted Astroscale £4m to establish a satellite control centre at the Space Catapult in Harwell, UK.[80] Subsequently, Astroscale was selected by the UK Space Agency to conduct a study on the removal of satellites from orbit in 2021.[81]

The Satellite Applications Catapult

The Satellite Applications Catapult (SAC) is a significant feature of the UK newspace landscape. The Catapult concept was born from a report which indicated that the UK was not benefiting economically from its research base.[82] Highlighting the success of Technology and Innovation Centres (TIC) in Asia, it argued for government strategy to invest and develop centres for 'exploitation of new technologies, through an infrastructure which bridges the spectrum of activities between research and technology commercialisation'.[83] In response to the report UK Research and Innovation (UKRI) launched the SAC in 2013 through Innovate UK as an independent business: 'to drive economic growth through the commercialisation of research'. The Catapult sets out to act as 'a focal point where small and medium enterprises, large industry and end-users can work together with researchers to challenge barriers, explore and develop new ideas, and bring these to commercial reality'.[84] Through government funding the SAC supports start-ups through a range of initiatives including allowing access to high value equipment: 'so that they can have short-term or longer-term access to really high-cost, high-tech equipment, and they can have the business support that goes around that'.[85] Notably, the catapult has contributed to a wide range of innovative projects including Astroscale and the purchase of Oneweb.[86] However, the Space Applications Catapult is viewed with scepticism by some, as outlined by a senior scientist in the space research community: 'The catapult itself should be welcomed by the UK Space Industry, it is viewed by some companies well, by some with a degree of suspicion and I think that it has also become a space company in itself, competing with others, in some areas'. The scientist went on: 'I think they need to be far more collaborative in their approach with academia and with other companies than they have been. They have tended to want to go it alone, I have seen that

myself, rather than by genuinely harnessing more partnerships… I don't think it has been as affective at catalyzing partnerships, as it could have been'.

This perspective is notable as it highlights a problematic approach by the UK government to fund and develop innovation to grow the economy. Catapults are established as businesses, but ones which do not necessarily seek to make profit. Rather they must meet Key Performance Indicators (KPI) set by UKRI. The scientist argued that pursuit of KPIs had meant that catalysing growth in the sector had become a 'box ticking exercise' rather than one which actively developed innovation and business.

The Catapult is located at the UK Space Gateway in Harwell, Oxfordshire which acts as the UK focus for space technology and innovation. The UK Space Gateway in Harwell hosts the Satellite Applications Catatpult and 105 other space companies.[87] Here, business is surrounded by over 400 other research, government and associated tech businesses. The cluster has grown around RAL Space, the leading space institute in the UK which has a 60-year heritage of space programme experience. RAL space acts as a bridging function between industry and academia, as it provides open research facilities for both. Start-up support is also supplied at Harwell by the ESA Business Incubation Centre, situated in the vicinity of an ESA satellite communications hub.

Leicester Space Park

Local Enterprise Partnerships (LEPs) were established in 2011 as private sector-led partnerships between businesses and local public sector bodies, to drive growth in local areas. Between 2015 and 2021 £12bn was committed by the government of which £9.1 bn had been allocated through negotiated Growth Deals.[88] The work of LEPs features heavily in the space sector. For example, the Leicester LEP, with support from the local university and government sought to capitalise on the industrial heritage of the midlands in their bid for the establishment of Leicester Space Park, a facility designed to bring industry and academia together to drive innovation and attract space focussed manufacturers.[89] Such moves by sub-state actors have been supported at the national government level, 'This is another example of how the Government is delivering for the Midlands with our modern industrial strategy, backing local businesses and building on local strengths.' - Rt Hon James Brokenshire.[90] Funded during the COVID pandemic, the facility allows universities to operate symbiotically with high-tech space business to enable the generation of cutting-edge technology. The idea behind the establishment works as it has drawn businesses such as Rolls Royce to benefit from working with Leicester University[91] on nuclear powered spacecraft propulsion. 'What has changed in the last five to ten years is the way in which universities are teaming with industry, not just the traditional big companies, … but with those key transformational smaller companies that are having a disruptive level of innovative transformation'.[92]

The Space Park also provides a means to attract foreign investment. By branding the establishment as a High Potential Opportunity as part of the 'Midlands Engine' concept

additional marketing support was provided to highlight the opportunities available to foreign investors.[93] Due to its location and timing of delivery, Leicester Space Park became a hallmark of wide-ranging government policies for including 'Levelling Up' and 'Building Back Better'. The premise of Levelling Up was that economic benefit of UK industry was unequally distributed and so government policy should redistribute wealth and prosperity across the country. The cross-government agenda sought to improve 'economic dynamism and innovation to drive growth across the whole country, unleashing the power of the private sector to unlock jobs and opportunity for all'.[94] Leicester Space Park appears to be a result of horizontal industrial policy which has enabled funding for partnerships which have been arranged at regional levels.

Launch

Another feature of the UK space landscape is the development of small launch facilities. The UK has never had a facility from which to launch vehicles into space, a particular problem for a state who wishes to develop a satellite manufacturing industry. UK equipment therefore typically rides on foreign spacecraft, including SpaceX (US), Arianne (ESA) and Soyuz (Russia), something which adds to overall cost and lead-in-time of launches. The ride-share principal also means less access for unique orbits which are in potentially high demand. A small launch provider, in contrast can place a satellite on the precise orbit it requires. An ability to launch small satellites then, becomes a facilitator to attract more industry and more investment. In a bid to capture this small-launch market the UKSA hosted Launch UK in 2017,[95] an initiative which sought to enable launch through discussion between potential spaceports, vehicle operators and other key space industry representatives. The government soon after announced funding of a vertical launch capability with Orbex and Lockheed Martin as providers.[96] In 2019, the UKSA announced that it would also provide £7.35m to Virgin Orbit UK for launch support equipment at Cornwall Airport, also known as Spaceport Cornwall[97]. The potential prestige of launching satellites through the use of Virgin Orbit's LauncherOne air-launch system also attracted funding from Cornwall Council of £10.3m. The reason for the government attention was captured by the UK Science Minister Chris Skidmore: 'We want the UK to be the first country in Europe to give its small satellite manufacturers a clear route from the factory to the spaceport'.[98] In interview, a senior member of Science and Technology Facilities Council (STFC) explained why this aspiration is important for UK industry: 'you need to have your small sats being designed here, built here, flight-qualified here, launched from here, operated from here, data analyzed from here. That's what makes the UK attractive'. In the government's direct intervention into this issue through the UKSA, the conditions were set to select and approve newspace businesses to operate as the first launch providers from UK territory. This selective policy intervention seeks to enable the business and economic infrastructure for future industrial development of the sector. The argument for direct intervention is clear; without UK launch, the newspace sector in the UK would be stifled and so this issue cannot be left to the market to resolve.

Regional Competition

Eagerness to attract launch providers to regions such as Cornwall and the north of Scotland

by sub-state actors is mirrored in the clamour to attract other elements of the space sector to other regions. LEPs across the UK have sought to gain foothold in the market by positioning their regions to become an attractive prospect for the sector. The New Anglia LEP were reported in local press to be in the early stages of such development because of the national government focus on the industry.[99] However, on interviewing a senior LEP representative it became clear that other motivating factors were at play. Regional industry such as agriculture and wind farms both demanded access to space technology, and government funding would favour economic plans which made clear the requirements:

'The government is putting a lot of money into the sector at the moment and we need to have something authentic to hook into it...the agri-tech scene is highly dependent on satellite applications but we've not been explicit in our economic strategy, so [we must] turn it on its head and say actually we have got a strong interest in space technology because of the application side'.[100]

The interviewee also noted that links were being explored with an existing telecommunications technology park, which could be used as the start point for a new science cluster, akin to Harwell. Further motivations were cited as the need to provide training and jobs for a relatively deprived region and established research at local universities. The interviewee made it clear that space could be viewed as a way to conjoin skills, regional industry and academia through support from the government, so long as the region could be sold as a viable proposition. However, the executive also noted the tension in the government's levelling up agenda, which in his view disadvantaged East Anglia as it was considered to be in the South East: 'it's a challenge for us as Norfolk and Suffolk, because we are in the East of England part of the whole levelling up agenda, we are seen or often perceived as part of the greater South East of England …the levelling up agenda actually risks overlooking some of our needs…because we are part of the south east and not needing that extra support I think our biggest risk in some ways is the levelling up agenda'.[101]

At the national level, competition to attract the industry is also prevalent. In early 2022 both Scotland and Wales announced the release of independent space strategies. The Welsh strategy highlights the potential benefits of space technology to the Welsh people, maps out existing space-related industry and highlights the emergence of new businesses such as Space Forge through investments from the Welsh Business Bank. Yet the strategy recognised that much would be required to attract more space industry to the country. In contrast, '*A Strategy for Space in Scotland*'[102] is more strident. It seeks to establish Scotland as a 'home for newspace'. The proposition is an economic one, which identifies a perceived gap in the market for a supportive environment within which to base newspace industry. This approach is clearly signalled in the Scottish governmental support provided to Orbex and Spire Global.

From the perspective of sub-state actors, the competition to acquire governmental funding is heavily influenced by geographical location. Scotland and Wales, with devolved

administrations, naturally have more autonomy to decide budget distributions, but for regions in the UK, the ease by which they attract funding is policy-driven. Here we see a different side of horizontal policy, as it negatively affects certain sub-state actors due to national political priorities.

OneWeb

A striking and unusual financial intervention by the UK government into the space sector was the 2020 purchase of a significant share of OneWeb, a satellite-constellation based broadband internet provider. OneWeb, established in 2012, may be viewed as a newspace business as it represents a privately funded initiative to provide satellite services to the wider market. However, the business had declared bankruptcy in March 2020 after failing to raise sufficient capital to pursue the launch of 430 of its initial fleet of 648 LEO satellites.[103]

In July 2020, as part of a deal to save the business, the UK Government and Bharti Global entered into a consortium to purchase a large share of the business, with the UK securing a golden share allowing control over future sales. Each partner invested £500m each which proved to be controversial within the government. The unusually swift decision to purchase the share caused consternation in the civil service, evidenced by the submission of a Request for Ministerial Direction to the Secretary of State (SoS) of BEIS.[104] In it, the Permanent Secretary highlights two key concerns. Firstly, that analysis had shown that OneWeb 'might' achieve a positive financial return, and compared the investment to that of the co-investor, who would be 'considering synergies with wider businesses', something which did not apply to the government's investment. The uncertainties and possible outcomes, he warned, meant that it was difficult to achieve confidence in the investment in such a short timescale. Other risks beyond the financial were also noted. An independent technical assessment of the network had been commissioned which highlighted that 'substantial technical and operational hurdles' would need to be overcome before it could 'become a viable and profitable business'. The chairman of the BEIS Committee expressed a view that 'using nearly half a billion pounds of taxpayer money to gamble on a 'commercial opportunity' whilst still failing to support manufacturing jobs with a sector deal is both troubling and concerning'. However, the concerns were overridden by Ministerial Direction[105] and the investment was subsequently approved.[106]

These events provide a clear indication of the priority afforded by the government leadership towards establishment of sovereign space capability. The arrival of the opportunity to buy into a newspace satellite constellation business led to the compression of procurement timescales and the public contradiction of policymakers, both highly unusual events. The letter submitted to SoS BEIS on the matter also provided insight into the leadership's thinking on the matter: 'I completely understand your, the Prime Minister's and the Chancellor's interest in wider benefits such as the potential long-term geo-political advantages for foreign policy and soft power that would come with sovereign ownership of a fleet of satellites. Moreover, I do not underestimate the potential opportunity that

this investment represents for UK interests globally'. Since the UK's purchase, OneWeb has succeeded in raising further capital reserves through subsequent funding rounds. Additionally, several launches have taken place which have increased the number of satellites in the constellation to 358 in October 2021.[107]

Insight into the OneWeb affair clearly demonstrates how the government senior leadership viewed as a necessity the establishment of a space capability. For the government to act in this unusually speculative venture capitalist manner, significant financial, technical and reputational risks were taken. But this purchase was not about making a profit, rather, what balanced the manifold risks was the prospective political gains to be made. The UK would become the first sovereign satellite constellation operator, with the potential to attract associated industry. The global signalling of UK ambition and independence, of Global Britain, could be achieved through the delivery of soft power, for example by UK sponsored provision of broadband services to the developing world. Taken into the political context of Brexit, the purchase also provided a potential solution to the ejection from the EU GPS programme as the Satellite Application Catapult was able to support the delivery of an alternative. In summary, the selective industrial policy to purchase OneWeb was motivated not by economics, but by the political aspirations of a newly independent UK.

Conclusion

This assessment of the UK space sector suggests that newspace is an industry which holds much economic promise for the UK and its regions. The sector is built on strong foundations and has the potential to be a source of economic growth, which requires a highly skilled workforce. The potential benefits of developing the UK industry appear to reach beyond economics as it touches a diverse range of other areas: academia, regional development and national prestige. UK newspace stands alongside the UK university research network; collaborations between academia and industry are common. Newspace business is able to nestle in clusters such as Leicester, Harwell or Glasgow which are all supported by government funding and academic institutions. The role of private finance and venture capital funding is key although start-ups are supported at a range of levels through ESA and UK government funding mechanisms. Foreign businesses have also been attracted by these schemes. That government views space as a feature of national infrastructure is highlighted by the purchase of OneWeb. The stimulus of the industry is primarily through financial means, but government strategy appears to play an important role in how this finance is delivered. This is exemplified by responses to the sector as seen with the establishment of the Leicester Space Park and a UK launch facility which demonstrate movement toward setting the conditions for industry development. Through the lens of industrial policy, a mixture of horizontal and selective policy is visible with a tendency towards the selective, yet horizontal policy has also had an influence by setting conditions for enterprises such as the Leicester Space Park. To expand on this observation, the following chapters take a closer look at how newspace is financially supported, and influenced, by the UK government and other actors.

Part 3: Funding the UK Space Sector

The development of space technology is highly capital intensive and whilst immature businesses such as Orbex, Skyrora and Space Forge operate at low technology readiness levels (TRLs) they are not able to attract custom, only capital investment. Established foreign businesses such as Spire Global require incentives to locate in the UK, and the purchase of infrastructure such as the OneWeb constellation requires direct investment. There are five key means by which funding is injected into the UK newspace ecosystem: government grants, research grants, direct investment, venture capital/private equity and through ESA.

Research Grants

UK Research and Innovation (UKRI) is a non-departmental public body under BEIS and in turn, the Department for Trade and Industry. UKRI comprises nine councils, including the Science and Technology Facilities Council which deals with the space sector. It is funded through the government's Industrial Strategy which commits a percentage of Gross Domestic Product (GDP) to research and innovation.[108] STFC uses a variety of funds to promote scientific research and innovation using a network of 50 universities, through a system of UKRI-led grants. Funds include the Global Challenge Fund which supports international collaboration, Strategic Priorities Fund, the Strength in Places Fund (for regional development) and a Fund for International Development.[109] Funding for successful applicants is by means of grants, which has the effect of minimising interaction with government downstream.

National Space and Technology Programme (NSTP)

The establishment of the National Space Technology Programme NSTP was a response to industry calls for the establishment of a UK space programme. Allocated £10m in 2011, the programme aimed to supply the required seed-corn funding for businesses to push their technology along the TRL ladder, from one to four. Objectives of the NSTP were threefold; to encourage strategic partnerships between industry and academia, to de-risk projects and to effectively utilise government funding.[110] This government funding aimed to make investees more attractive to investment from private sources, the EU and ESA, by de-risking the technology thereby increasing the chances of commercial success. The nature of NSTP means that it may be used for situations where the UK wishes to keep hold of the intellectual property of a technology whilst assisting its preparation for market.

Now under the remit of the UK Space Agency, NSTP offers funding for industry and academia, including start-ups to support the development of new technology. Funding profiles range in scale from small grants for exploratory ideas at £15k over three months, rising in scale of ambition to flagship work which could attract up to £1m over 24 months. The type of funding made available is typically related to the technologies' position progress along the TRL scale.[111]

A 2014 independent review found the NSTP an effective way to develop innovation in the UK, raising the TRL of supported technologies by up to four levels. Notably no funding lines had been developed for TRL1 technologies, meaning there was insufficient support for fledgling

business and university spin-offs,[112] but this is the remit of STFC funding. Use of the NSTP was shown to have attracted further investment from other partners. However, the review highlighted that whilst the NSTP had spread funding across a diverse portfolio of activity it was unable to fully capitalise on it[113] as it fell short in supporting the transition from mid-TRL validation to higher-TRL live demonstrations. This shortfall appeared to have affected the ability to reach readiness for commercial sales. The review contrasted the novel technologies which had been supported by the programme with those that had received support from ESA or NASA. ESA and NASA backed projects were funded to include flight testing and other demonstration costs, whereas flight testing proved a significant challenge for NSTP backed projects.[114] NSTP funding was found to be successful at lower TRLs, but lacked efficacy as TRL increased meaning that sovereign technology was subject to a potential barrier to the realisation of full viability.

National Space Innovation Programme (NSIP)

In 2020 the UK government announced the NSIP, a scheme which aimed to promote the development of innovation within the space sector. The programme sought to issue grant funding to UK teams with ideas for innovation but who required seed-corn funding.[115] As a condition of application in 2020/21 the ideas must have fallen within two themes; earth observation to tackle climate change and ubiquitous communications.

The announcement of NSIP highlighted the relationship between space and other strategic goals of other elements of the UK government. In November 2021, the country was due to host the 26th UN Climate Change Conference of Parties (COP26) in Cornwall, a major event attracting a large number of world leaders including the US president. The goals of the NSIP, which aimed to promote the generation of new instruments and tools, seemed to be tailored to signal to partner nations a resolve to tackle climate change through technology. Simultaneously, the government signalled to the space sector the direction for travel, and potentially what type of technologies would be most likely to receive funding both through NSIP but also NSTP. The NSIP also seems to address the identified gap with the NSTP of very low TRL technologies (Level 1) which require seed-corn funding. The second theme for innovation of ubiquitous communications for enterprise, consumers and government focuses on providing sovereign satellite connectivity to support the UK digital economy, and emergent technology such as 5G and Artificial Intelligence (AI). Whilst the call for interest notice invited a focus on solutions to support societal change, it is possible to view the aspiration of NSIP to develop novel ideas to enable the best use of the newly acquired OneWeb constellation. Through the encouragement of innovation through seed-corn funding, the UK government sought to leverage the commercial space sector to pursue strategic objectives and make the best use of its newly purchased infrastructure. The funding was also used to support cutting-edge university research in pursuit of UK-owned IP. Similarly, STFC grant funding is targeted at governmental strategic objectives through the establishment of purposed funds. Regional and international development feature strongly, as do general 'strategic priorities'. Assessment of government funding lines through UKSA and UKRI provides

the clearest indication that government funding for newspace is targeted towards its own strategic objectives, rather than the growth of business for economic gain.

European Funding

Although Brexit meant that access to EU funding ended,[116] funding routes through ESA remain a vital part of the financial picture for UK space. Over the past 10 years UK engagement with ESA increased steadily with contributions increasing from £220m in 2010 to £300m in 2015. In 2016 a five-year investment of over €1.4bn was announced making the UK the fourth largest contributor after France, Germany and Italy.[117] In 2016/17 contributions to ESA accounted for eighty per cent of the UKSA budget. This imbalance has meant that UK investment into its own space sector has remained small, estimated to be fourteen per cent of overall income into the sector in 2018.[118] There exist systemic issues with attraction of investment from ESA. Firstly, ESA does not focus on the eventual commercialisation of technologies.[119] Secondly, there exists a view from the private sector that the ESA funding process is too complicated to access, and therefore the pace of newspace is too rapid for it to be of any use.

Government or Private Support?

The problems with this system of funding from disparate sources, which operate at different rates of provision were well captured by the perspectives of interviewees. The Venture Capitalist's perspective was that: 'the pace that they [newspace companies] do things is faster than they can get these [ESA] grants, so they're not bothering to go and get them. The companies which end up spending the time and years to access the funding are often like the also runs, that can't get the money in any other way'. He argued that because newspace move too quickly for ESA funding, they turn to national government funding for assistance and so: 'They build businesses on what government handouts are available from one year to the next… and so their horizon… is built on accessing the next government grant' accordingly, 'there is a real distortion in the market of the funding provided by governments'. The Venture Capitalist's summary of the system was that: 'There is too much of an approach to give a small amount to everybody, than build success in a particular area of the market which is really what's required to build big businesses which will pay large amounts of tax, and hire lots of people… I don't believe it is government money well spent'. He continued: 'Government grant funding barely moves the needle on technology like this'.

The point was echoed by the senior scientist from STFC: 'the funding is what facilities everything. We've got a multi-track funding system delivered through the research councils, delivered through the [UK] space agency, covering everything that in principle should be able to unlock and bring together all of the technological capability that we have in the UK, not just in academia, but in industry meaning Primes and those newspace companies. But it's not working well enough, and it's not working at speed'.

From the perspective of the senior newspace business executive, grant funding is 'crucial… they allow you to run the company they way you want…they let you get on with business,

they see that there is progress, they monitor the progress and check the milestones but they don't interfere or require board membership or anything like that.' In the interview, the executive confirmed the importance of government grants by highlighting that for his business was funded 50:50 between private and government grants.

From the perspective of newspace businesses operating within the UK, both funding from government and private investment is vital for sustainment and development. As new products are innovated and developed, uncertainty exists as to who the consumer will be and how long-term revenue will be generated. Here, worry is evident, along with a co-dependency on government investment in such a way that newspace business would not be able to innovate and develop without these funding lines. The relationship is symbiotic; government funding is required to de-risk speculative private investments whereas newspace businesses require both to remain viable.

Government grant funding is also used for attracting business to a region, as in the case of Spire Global where the Scottish Development Initiative played a key role in stimulating interest in locating in the region.[120] Leicester Space Park received government grant funding as part of the Build Back Better campaign, which in turn focussed industry attention on the area. Cornwall received grant funding from UKSA and local government to provide the requisite infrastructure for a portfolio of activity.

Critics of the grant system hold the view that wide dispersal of small amounts of government funding is insufficient to ensure the realisation of newspace business aims. When asked whether government did enough to support newspace business the CEO of the Satellite Applications Catapult Lucy Edge argued that a gap existed between initial capital investment into technology and innovation from government and subsequent private equity investment into the business surrounding the technology. 'There is still quite a big gap in the middle, which is that high-risk space'[121]. With this in mind, the UK government faces a dilemma; invest heavily in singular high potential newspace business with the aim of generating high tax revenue, or invest seedcorn funding across a range of businesses based on other priorities. Evidence suggests that the latter is typically chosen, which indicates that priorities other than economic growth are at play.

The UK government's preferred grant approach to funding indicates that money is not spent in the hope of realising full technological readiness of a product; this is left to private investment. If the purpose of government investment in the space sector was to build large successful businesses, then greater amounts of funding would be targeted towards individual businesses which had been professionally assessed to hold the most potential in the same way as VC investment. Investment would be sustained until such a point as the product was marketable or the business could be bought. However, the model used by government for space technology has been to thinly spread investment over a large number of businesses, through a variety of mechanisms. This seedcorn funding is typically not enough

to sufficiently advance the product along the TRL ladder, and so businesses become reliant on government handouts.

The tension between ESA funding commitments and the ability to use space funding to pursue sovereign objectives is clearly demonstrated in the international space. One of the key frustrations for BEIS has been that the UK's responsibility toward ESA has meant that the generation of sovereign business has become more challenging. Post-Brexit, the commitment to ESA did not wane but the Global Britain ideology demanded greater focus on developing international trade and leadership. This meant that while the majority of government space investment was funnelled towards ESA, only a relatively small amount was left to direct to UK businesses or to forge alliances with other states beyond diplomatic agreements, partnerships and MOUs. The tension between these two approaches is clear; whilst financial contributions to ESA pay dividends to the UK in terms of support, knowledge and guaranteed customer base, the ability to develop sovereign business strategy suffers. A senior strategist in BEIS commented on other European states who have leveraged their ESA contributions to develop a sovereign space program in parallel: 'for example, the French leverage what they consider to be the best part of [the ESA] program for their initial programmatic work for their national programs and then at a certain point they come out of that and bring it into a national program that allows them then to strategically partner with countries such as the United Arab Emirates (UAE), Saudi Arabia or wherever', and opined that this is a strategy the UK could also pursue: 'so perhaps there is an issue there about building and developing that strong bilateral funding program, that allows us the opportunity to engage with the likes of US, Canada, India, when you look at the Indo-Pacific tilt, you know that will be one for a strategic relationship as well. So, space is one part of that'. This opinion reflects the idea that too great an amount of money is directed to ESA from the UK space budget, which prevents the proper development of sovereign activity.

However, the development of international soft power support to states has been possible through sovereign grant funding. Using small direct grants to the space sector, the UK government has sought to enhance the image of the UK abroad. The investment of capital into international projects via NSIP has led to the development of research and technology for the investigation into space sustainability for the UN, flood forecasting in India, and international collaboration projects such as the Nancy Grace Roman Space Telescope to name a few.[122] The International Partnership Programme provides[123] another example of how the UK seeks to exert influence on the global stage, through the means of targeting grant funding at UK businesses with space-based projects that have the aim of improving the lives of those in developing states. The programme is a five-year programme with a total budget of £152m and is coordinated by the UK Space Agency . Whereas development aid would usually be the remit of the Foreign, Commonwealth and Development Office (FCDO), the IPP routes money through UKSA and into UK business who are at the innovation and R&D stages. By setting a context of using space as a tool for development, the government has sought to incentivise British business through problem setting and seed-corn funding.

Problems such as deforestation, agriculture and disaster resilience have been targeted with the funding. Through this strategy of issuing small grants to firms, the UK seeks to achieve two goals; support for the development of UK based space technologies which may have a future export market, whilst signalling assistance for issues in developing nations, using newspace as the medium.

Analysis of the way UK funding is distributed has demonstrated that grants are used heavily to support domestic and foreign policy. The reason for the issuance of relatively small amounts through grants may be related to the significant investment in ESA to support European wide programmes. Such vast investment leaves only limited amounts to spend, and so where it is possible to support newspace technology, it makes sense to support government intent. In this way, commitment to ESA may be considered a limiting factor in the way the UK develops its own sector. Views from the senior strategist at BEIS reflects the idea, but highlights that it need not be this way as other European countries leverage ESA spending for their own economic as well as technological development. The use of grants in schemes like the International Partnership Programme represents further evidence for the argument that in influencing the UK commercial space sector, politics plays a significant role. In this respect, the UK newspace sector may be viewed as an instrument through which government aims to achieve its political aspirations rather than economic growth which could be made possible through more selective, sustained investments as advocated by venture capitalist professionals.

Part 4: UK Strategic Responses

This section demonstrates that UK policy responses to the emergent space sector since 2010 have been shaped by the need to address broader political crises; climate change, Brexit and COVID. As discussed, at an international level, motivation for national responses to the new commercial space paradigm varies between countries due to a number of factors including appetite for risk, geopolitics, domestic requirements and the prospect of economic gain. This chapter argues that UK policy demonstrates a direct connection between domestic and international political crises and the UK government's space strategies.

UK Space Agency

In the wake of the 2008 global financial crash, and following criticisms that the UK's approach to space lacked direction[124] the UK government made significant structural alterations to pivot towards space. The first such move was the establishment of the UK Space Agency in 2010, which aimed to improve: 'coordination of UK efforts in fields such as Earth science, telecoms and space exploration'[125] and the Space Leadership Council (SLC).[126] The Space Leadership Council comprised the head of the UK space trade association and SoS for Business Innovation and Skills. Prior to the Agency, British space policy and budgets had been handled by a partnership of government departments and science funding councils. The agency drew together previously disparate government responsibilities for space matters, whilst the SLC aimed to provide strategic leadership of the sector. The SLC comprised a range of senior civil,

military and industry figures.[127] It was established to: 'assist ministers with responsibility for space in developing their strategic policy and supporting actions by providing expert inputs to set alongside advice from officials'. According to Lord Drayson at the Space Agency's launch, both frameworks would: 'make the decision-making by government in all aspects of space policy much more joined up, better co-ordinated - a single point within government which has responsibility for making sure that we get everything in alignment such that the space research we do, the space industry that we're building, fulfils its true potential'.[128] The first centralised policy released by the Agency was the Space, Innovation and Growth Strategy (SIGS).

Space Innovation and Growth Strategy 2010

The SIGS, released in 2010 represented the first formal recognition that business and government would be required to work together to achieve collective ambition. It begins with an acknowledgement that the space sector in the UK was already somewhat developed, exhibiting growth of nine per cent per year between 1999 and 2007. The resilience of the sector was associated with a perceived continuous demand for products from space in the digital age, and a diverse customer base. Strong satellite manufacturing credentials from businesses such as SSTL also contributed to the foundation.[129] The SIGS sought to capitalise on this rapidly growing industry, acknowledging the predictions for global sector growth. The strategy recognised that government support was critical in developing the sector further[130]. The headline ambition of the strategy was the economic goal of capturing ten per cent of the global space market by 2030 through the development of new high-growth markets, growth of exports and increasing returns from Europe.[131]

A key premise of the SIGS was that the UK was at risk of falling behind other states in terms of spending, skills and technological relevance. For example, it was recognised that spending on space in Italy, France and Germany was directed at ESA, but also at their own national space programmes.[132] In contrast, the UK did not have a space programme, and therefore the majority of funding was directed towards ESA. The subtext of the argument was that should the UK fall behind on relative national spending, and in turn technological relevance, then the UK could slip into international irrelevance. The report also recognised that with a quickly growing sector, another way for the UK to fall behind would be with a lack of appropriately skilled workers. Therefore, it called for training at school, college apprenticeships and at university level to be bolstered with industry support and development of curricula that supported the goals.[133]

The relative lack of UK investment in space, it argued, could be countered by encouraging joint activity between industry, academia and government(s). Further, a better-defined space technology programme would attract greater funding from ESA to enable a higher rate of technology development in the UK. Whilst extolling the potential benefits of a strong space sector, the strategy recognised that state leadership in pursuing joint action was essential and argued that the extant Civil Space Policy was insufficient to achieve the required

coordination. Critically, the strategy determined that there was no cross-government policy which conjoined civil, defence and security components and that this fragmentation led to a wasteful, disjointed approach to space spending in the public sector. Accordingly, the strategy called for the development of a National Space Policy to align cross-government approaches to space.

By 2014, significant changes had occurred throughout the government, both within policy and structure. The Space Leadership Council and the UK Space Agency had been established and an increase of 33 per cent further funding had been directed at ESA. Additionally, the Satellite Applications Catapult had been established at Harwell in Oxford.[134] It was also reported by the government that due to funding recommendations made in SIGS, the international reputation of the UK in space had improved significantly. The SIGS action plan cited a number of industrial successes which were championed as proof that government focus and intervention had had a positive effect on the UK space sector. Examples include British satellite company Avanti raising private finance to launch its fleet after receiving ESA funding of £25m, British success in the EU Galileo programme as satellites had become ready for launch, and the award of Chinese-led contracts for development of earth observation and climate satellites to Surrey Satellites. Whilst the government's conclusion that renewed focus and funding since 2010 had triggered this success is questionable, it is notable that trade and partnerships from ESA had provided the UK with a market and a route to space for UK based business. Also notable was the way in which contracts had been won on the basis of climate and earth monitoring technology to the global market.

National Space Security Policy (NSSP) 2013

Released in 2013, the NSSP represented the first time that space was recognised as a critical function in the protection of National Security; the policy formed a late addendum to the Civil Space Strategy. The strategy indicates that policymakers had realised that national dependence on satellite services was growing in line with the commercialisation of space. 'Without satellites, distribution and transport systems would be slower… which would damage our national economy'[135] . This represents the first recognition in policy that the role of space was fundamental not only to the economy, but also to the UK's international reputation: 'Our ability to monitor, warn of, or react to threats as diverse as international humanitarian crises, volcanic eruptions, severe weather events, terrorist attacks, breaches of arms control agreements or expanding drug cultivation in remote and hostile areas would be seriously curtailed'.[136] This formal recognition was vitally important because it spoke to the newly intrinsic relationship between commercial space and government. No longer was space an activity which could be viewed solely in economic terms, but one which had to be viewed in terms of national security. However, co-signed by four ministers, Ministers for Universities and Science, Defence Equipment, Europe and NATO, and Immigration and Security the policy highlighted a degree of departmental isolation. It indicated that there was no single authority who could enact the policy, rather that it would be up to separate government departments to interpret and respond how they saw fit. It appears as though the acceleration in governmental focus

and activity, and the rapidly developing global space economy since 2010 meant that the UK government was on the back foot.

National Space Policy

The National Space Policy was delivered by the Department for Business, Innovation and Skills in 2015 and focussed on setting the conditions for businesses to invest in the sector.[137] As justification it noted the growing number of satellite launches year on year, and the significant economic growth and job creation of the UK sector. Despite the establishment of the UK Space Agency, the policy indicated the growing complexity in government in supporting and benefitting from space activity. Twenty two other departments were cited with an interest in the policy. For example, the Ministry of Justice used space for offender location management, the Department for Energy and Climate Change required data from space for climate modelling and the Department of Health used medium-range weather forecasting to develop public health information. Four policy categories were introduced: recognition of the strategic importance of space, preservation of the security of space, supporting growth of the commercial space sector and collaboration on international regulation. The response to the commercial space sector here is key as the government committed to long term targeted intervention to enable the establishment of an environment where industry can thrive and manage risk. Significantly, this policy was the first to recognise 'newspace' by committing to invest in 'disruptive space techniques, data and technology with market applications'[138]. Recognition of the challenge of the sector was visible, stating that the government would provide the environment necessary to 'generate large scale innovation in areas where there are higher risks'. Interestingly, the policy argues that industry was best positioned to grow itself within a government strategic environment. Pointing to the Space Growth Action Plan[139] essentially conferred responsibility for the management of sector growth to the industry itself. Therefore, the policy prescribes the government with a strategic role; the government affirmed its responsibility for setting the conditions within which the industry could develop. Accordingly, there were several roles adopted by government within the policy, amongst them:

- **Government adoption**. Government would commit to providing a customer base for the sector by driving in-government adoption of space derived solutions.

- **Supporting Finance**. By supporting the Satellite Applications Catapult, the government sought to bring industry and academia together to de-risk ventures, thus making them less risky and more investable. Also, a commitment was made to a range of funding programmes to support technologies at different stages of development.

- **Private Finance**. By facilitating access to markets, promoting availability of investment capital and developing a regulatory structure for the industry to operate within, the government would enable response to the global market.

- **Industrial/Academic Interaction**. A commitment was made to support the development of new 'clusters' like that at Harwell, and that support would be spread nationally and to developed administrations.

This role adoption clearly signals the recognition of the critical role of government within the commercial space paradigm to grow the sector. In order to develop a newspace industry which capitalises not only on custom from the supra-national and benevolent ESA, but on the more challenging global market, it was viewed that aggressive state action was required. Essentially this policy aimed for economic growth, whilst secondarily noting the potential utility in supporting other aims such as climate change. However, the motivation behind government interaction was set to change when the British public elected to leave the European Union.

Integrated Review of Security Defence, Development and Foreign Policy

The 2021 Integrated Review of Security Defence, Development and Foreign Policy marked a vitally important change of approach to space.[140] By setting out a post-Brexit vision of a Global Britain it sought to re-establish the UK as an independent, powerful state on the international stage, and to address future perceived challenges to the security of the UK. As part of this vision, the review recognised the new domains of both cyber and space and the role of rapid technology development with those domains. It therefore committed the UK government to equipping its armed forces accordingly. Specifically, the Review committed to the idea of the UK becoming a 'meaningful actor in space' which demanded an integrated space strategy. This aim sought to resolve the disparity between the parallel civil and defence space policies, and to finally bring together government focus on the domain. The Integrated Review also recognised the paradoxical role of the commercial space sector in the development of products which would increase the contestation of space, but that would also allow the state to protect its national interests.[141] Whereas previously it had been the aim of UK strategy to develop space for the economic benefit to the UK, the Review recognised the commercial space sector as a vital element of the national security architecture for the first time. Importantly it also promoted recognition that government departments could and should benefit from the domain. The Review had essentially recommended that governmental departments leverage space and associated activity for their political goals.

The Integrated Review precipitated the formation of a National and Defence Space Strategy as it committed to the development of an integrated military/civil policy. Due to the prospect of new technologies increasing competition in the military domain of space, and the risk to strategic stability if compromised, a new military 'Space Command' was announced. To pursue strategic autonomy, a goal to launch British Satellites from the UK by 2022 was set to use the commercial sector to achieve it[142]. Part of such intervention would require an ability to achieve progression of space technology up the TRL ladder, and so the Review committed to promoting 'whole of life' approach to the industry, from initial R&D, finance, operations, launch to end of life services. The ability to access space without recourse to partner nations

was only possible through a commercial space sector, and so the Review provides a realisation that the achievement of autonomous activity in space necessitated government intervention.

National Space Strategy

Released in 2021, the National Space Strategy developed the ideas voiced in the IR. The strategy represented the first time in the UK that space was considered a joint civil and defence enterprise, and one which was underpinned by government action. Analysis of the document reveals a number of key themes which reflect the sentiments behind the Review and the political context of the time.

In part one of the strategy, the economic argument for the development of the space sector is restated, citing the opportunities for growth, the higher than average Gross Value Added of the industry and the rapidly increasing demand for space services. The notion of newspace was again noted as an opportunity for the UK as the global space sector was projected to grow significantly in value, reiterating that the UK had underspent and was falling behind. Accordingly, the strategy resolved that 'The government will act to put the UK space sector in a position to fully capitalise and lead in the new space markets of the future, as well as the established and growing space markets of today'.[143]

Building the argument for UK space industrialism, the strategy highlighted a foundation of UK strengths such as in science and technology, an established space sector, and a 'strong talent pipeline'. It moved to argue that whilst there existed a role for government, it was simply to 'help identify the opportunities the UK is best positioned to pursue and then to empower the sector to thrive. It should provide support only where it is needed and where only government can intervene'.[144] The argument of the strategy signals a shift from pure economic focus to one which sought to leverage the industry to pursue other political goals; government intervention in the sector would promote growth, which in turn would allow a range of other goals to be achieved. This rationale is clearly captured in the goals to 'guide government focus':

1. Grow and level up our space economy
2. Promote the values of Global Britain
3. Lead pioneering scientific discovery and inspire the nation
4. Protect and defend our national interests in and through space
5. Use space to deliver for UK citizens and the world

Here it can be seen that the political goals of the IR are fully represented in the National Space Strategy. The fundamental principles espoused in the IR, predicated on the need for the UK to move into a post-Brexit era are woven together using space as the medium. Goal 2, for example, seeks to use space as a subject upon which to engage internationally. The discussions surrounding regulation, safety, security and sustainability represent an opportunity to act as a global leader. However, this aspect of the strategy does not require

the development of a UK space economy. Rather, it is work which may occur independently from the UK space sector, at government level. Goal 3 seeks to use the space sector as an inspiration 'for the next generations of space scientists, engineers, and entrepreneurs' in order to build and sustain a strategic advantage in science and technology. Here, the space sector is again used as a medium through which to derive political rather than economic strength. Arguably, if the space sector were not to grow, but remain working steadily to provide mission equipment for ESA, this goal could still be achieved. British astronauts working with ESA would continue to inspire the next generation. Therefore, economic growth is not a requirement to achieve this goal. Pursuit of Goal 5 seeks to develop further utility at domestic and international levels; 'to tackle global challenges, including climate change and biodiversity loss, and deliver better services to the public such as modernising our transport system, supporting our NHS, and protecting our borders'.[145] This goal recognises a government role to support businesses and enable clearer lines of procurement. Whilst this may be viewed as a means by which the UK develops a sustainable customer base for the sector, it is not totally introspective. The goal represents a need to develop technology which may be deployed to raise the profile of the UK abroad, for example in monitoring biodiversity loss, climate or space weather. Achievement of the goal requires innovation, and a ready customer base. In the NSS, the government commits to support both.

International Strategy

The use of space as a political environment through which to develop reputation and influence is perhaps best exemplified by the UKs desire to develop international leadership. Recognition that the UK is unable to support a sovereign space program, and post-Brexit isolation may be explanations for the desire within the Integrated Review to increase international influence using the domain. The NSS sought to develop UK soft power through regulatory diplomacy and the development of partnerships; a less financially demanding approach than a national space programme, but potentially as effective in developing a positive image of the UK. Beyond ESA, the UK's principal partner, further relationships have been developed. The US Artemis Accords,[146] Combined Space Operations (CSpO),[147] and UK/Australia 'Space Bridge'[148] are three examples of such relationship building. The Artemis Accords are a US led initiative to which the UK has become a signatory, which seek to establish a common set of principles, building on the UN Outer Space Treaty for the conduct of civil space missions to the moon, Mars and other extra-terrestrial bodies. The agreement paves the way for NASA's successor to the Apollo programme, by seeking to garner support amongst supporting western states such as the UK, Japan, UAE and Luxembourg among others. In contrast to this US-led agreement, the UK developed the Combined Space Operations for which the Memorandum of Understanding was signed by Australia, Canada, France, Germany, New Zealand, and the US which seeks to establish a set of norms which determine the safe use of outer space and agree that space should be a domain free from illegal interference. The agreement of 2021 signals an attempt by the UK at space diplomacy, leveraging its newly formed military Space Command as a bastion of soft power. Lastly, the 2021 UK/Australia Space Bridge represents a civil agreement through

which the UK has sought international influence. The Space Bridge is a formal four-way agreement between the UK Space Agency, UK Department for International Trade, Australian Trade and Investment Commission, and the Australian Space Agency which seeks to enable collaboration and encourage foreign investment and extend UK influence into the Indo-Pacific Region. Here, the burgeoning newspace sectors of both countries have enabled dialogue and partnership; without the aspirations of each to develop a commercial space sector, such an agreement would not be in either's interest. The three agreements represent clear examples of how the growing prestige of the UK space sector is being utilised as an instrument to enable the development of diplomatic and geopolitical power, boost international trade and demonstrate a degree of leadership in the safe use of outer space.

Regulatory Diplomacy

As the innovation of new space technology develops, it is difficult to foresee how threats to safe operations, and therefore the critical infrastructure of states may advance. For example, debris removal technology such as the systems in development by Space Forge, may be viewed by some as a means to enact hostile measures.[149] Through the IR, the UK seized the challenge of regulation as an opportunity to extend global influence through an ambition to 'shape the open international order of the future, by using international influence to convene partners'.[150] Part of this commitment was to establish behavioural norms in space, arguably a response to the new cavalier approach taken by other states and corporations in relation to safety in space (e.g. ASAT testing). The UK subsequently declared in the *National Space Strategy* that the principal challenge in space was the 'development of an international common acceptance of a set of rules and norms, a framework within which all states may operate safely'.[151]

In turn, the definition of such norms and regulatory frameworks has become a national priority. But significant challenges are presented to states seeking to reach a common agreement. Influence in a collaborative environment is certainly required. The developing congested nature of space also places specific demands on responsible space-faring nations, particularly those that seek to place more objects in space for their own use. Furthermore, international collaboration would be essential: `We will have to negotiate that with other countries, and we will have to somehow find a way to do it, but we will not do it on our own. We cannot manage space traffic when we are a single nation'.[152] The recent UK strategies sought to capitalise on the perceived gap in the regulatory market, by committing to the pursuit of regulatory diplomacy: 'bringing together governments, standards bodies and industry to influence rules, norms and standards – particularly in rapidly evolving areas such as space…'[153]

This goal highlights a degree of political opportunism. As space technology develops and presents regulatory challenges, the UK aspires to take a leading role in promoting its safe use. Professional views indicate that the UK is well-positioned for the role: 'The UK is in a very

strong position to be able to influence the world in that respect'.[154] Whilst the congestion of space represents a growing problem because of newspace proliferation, it also provides an opportunity for states seeking to define themselves as international leaders in the domain. In line with the Global Britain ideology, the leverage of the commercialisation of space for the development of soft power is quite evident here.

Conclusion

The progression of policy and strategy from 2010 represents an evolution in approach by the UK government. From the early recognition in the Hauser report that the UK needed to do more to bring academia and industry together in clusters, as had occurred in East Asia, the UK set out on a path to promote the economic growth of the sector. The establishment of the Satellite Applications Catapult was a direct result of this realisation. The horizontal policy of the Space Innovation and Growth Strategy led to the selective intervention of the Catapult. As policy evolved, it was clear that the cross-government approach was leading to a complicated way of using space technology. The establishment of the UK Space Agency and the Space Leadership Council was a structural step to address that issue, bringing the national strategy under a defined structure. This enabled more cogent policy approaches in the National Space Security Policy and the National Space Policy. The National Space Policy remained clear that the government had a clear role to play in developing the conditions for economic growth of the sector. However, government policy evolved again after 2016 with the introduction of the idea of Global Britain, possibly as a direct response to the UK vote to leave the EU.

Through the release of the Integrated Review and the subsequent *National Space Strategy* international priorities become tied to the space sector. Specifically, the nature of the Integrated Review suggested a pivot towards the international. Whilst it recognises that space is a vital technology for defence, it also sought to use it as a means through which to project global influence. The international nature of space means that many political opportunities are presented for diplomacy and regulation as evidenced by the signing of the Artemis Accords. Evidence suggests that the UK yearns for international engagement by investing in space technology which has utility for developing states, forging international alliances and demonstrating leadership in regulation. Each of these aspects of international engagement are written into UK strategy, and interview evidence demonstrates the degree to which it is a priority for the government. Faced with difficult political situations, space became the answer to a number of strategic problems for the UK including Brexit, Levelling Up, international development and maintenance of its international position. The progression of strategy from 2010, culminating in the Integrated Review and the *National Space Strategy* demonstrates that the commercial space sector developed to become a means through which to pursue political rather than economic goals. The change in policy coincides with the proliferation of newspace since 2010. The development of UK aspirations to engage internationally at different levels in this sector may be seen as a direct result of the modern commercialisation of space.

Part 5: Discussion

Since 2010 the UK government has intervened extensively in the UK space industry. This case study has examined the array of measures it has employed across the young and diverse newspace sector and shown how these interventions have been received throughout the sector. Through analysis of the means by which the UK government has intervened, we are able to draw conclusions about its motivation. In this section, I seek to draw the findings together and develop the argument that all interventions witnessed have been political in nature. I then apply the theoretical framework of industrial policy to examine the interventions in terms of horizontal and selective approaches. I argue that although there has been a range of structural changes made to the political domain (horizontal), selective interventions usually reserved for triggering economic growth have been co-opted to develop political capital. I finish by considering the implications for theories surrounding politics and the commercialisation of space and for the UK space sector as it continues to develop.

Using Warwick's typology of industrial policy we are able to divide UK government activity into horizontal (setting framework conditions) and selective (strategic interventions). To classify policy interventions in this way is to make sense of a dizzying array of steps taken by the government in the sector. To recap, horizontal policies include those that set the wider context for businesses to successfully operate; consider skills and education policies, Entrepreneurship and Innovation policy and favourable corporate tax conditions. Selective policies include promotion of business through state aids, sector-specific trade policy and enterprise zones.[155]

Drawing from the case study of the UK space sector, it is possible to draw a non-exhaustive cross-section of government interventions. Using Warwick's typology of horizontal and selective approaches, the industrial policy interventions are divided in chronological order as follows:

Examples of selective intervention include:

2013 Satellite Applications Catapult
2015 Grants to foreign businesses (Astroscale/Spire Global) to establish presence in UK
2014 Space Growth Action Plan
2017 Launch UK
2018 Grant to Astroscale to establish satellite control centre at at Harwell
2019 Grants to Virgin Orbit and vertical launch providers
2020 Purchase of Oneweb
2021 UKSA selection of Astroscale to conduct satellite removal study
2021 Leicester Space Park

Examples of horizontal intervention include:

2010 Establishment of the Space Leadership Council
2010 Space Innovation Growth Strategy
2011 Establishment of the UK Space Agency
2011 Local Enterprise Partnerships

2013 National Space Security Policy
2014 Space Innovation Growth Strategy Action Plan (Highlights lack of skilled workers)
2015 National Space Policy
2017 DIT Industrial Strategy
2017 Midlands Engine
2018 Global Britain
2019 UK Space Directorate drive towards Regulation
2021 Build Back Better: our plan for growth
2021 Integrated Review of Security Defence Development and Foreign Policy
2021 UK/Australia space bridge
2021 National Space Strategy
2022 Scotland and Wales space strategies
2022 Combined Space Operations Vision 2031
2022 Levelling Up Agenda

Observation of the split between horizontal and selective industrial policy interventions allows a clearer view of the development of space-related UK policy. Three key themes emerge; the pre-2015 focus on economic growth, the post-2016 flurry of space-related industrial policy and finally the use of selective policy including grant funding as a means to implement horizontal policy.

Theme 1: Pre-2015 Focus on Economic Growth

The case study has shown that between 2010 and 2015, UK industrial policy was primarily focused on harnessing the developing sector to yield economic growth. This is evident from the outset, as the title of the Space Innovation Growth Strategy suggests. The Space Leadership Council was established to support the strategy with senior figures from the government (UKSA and MOD), trade bodies and the research community. Guests on the council were typically industry CEOs. Here for the first time, trade organisations were able to advise the government at a high level on what was required for the success of the industry. Key warnings in the strategy were that government spending could fall behind international competitors and that growth of the sector could outstrip the labour market, as too few had appropriate skills to work in the sector. Recommendations for increased spending and governmental support of STEM in schools and universities were made; clear examples of classic horizontal industrial policy. A year later, Local Enterprise Partnerships were implemented, meaning that a conduit for regional focus on economic growth had been opened.
This framework went on to play a key role in the development of space clusters and remains a means through which sub-state actors seek to attract the space sector. The establishment of the Satellite Application Catapult is also indicative of a strategy to drive growth through sector collaboration. In 2014, the Growth Action Plan attempted to re-focus government thinking on how to grow the sector by setting out further recommendations as it argued that focus had slipped due to the cross-government approach taken up to that point. This approach was highlighted by the cross-governmental nature of the 2013 National Security Policy.

Theme 2: Post 2016 Change to Political Focus

After 2016, there appeared to be a significant change of tack by the UK government. Although horizontal policy such as the 2017 Industrial Strategy provided a broad focus with the aim of 'boost[ing] productivity by backing businesses to create good jobs and increase the earning power of people throughout the UK with investment in skills, industries and infrastructure',[156] other more selective interventions had become focussed on areas other than growth. The Global Britain ideology was first detailed in a memorandum from the Foreign Office in 2017,[157] and later formed the premise for the Integrated Review. Promoted as a response to the forthcoming secession from the EU, the idea maintained that through effective foreign policy, the UK could be: 'a Britain with global presence, active in every region; global interests, working with our allies and partners to deliver the global security and prosperity that ensures our own; and global perspectives, engaging with the world in every area, influencing and being influenced'. These political aims rapidly became translated into policy surrounding space; the Space Directorate began to work on regulation in space with international partners, the National Space Strategy was released and international partnerships began to be developed such as CSpO and the UK/Aus space bridge. Furthermore, the purchase of a stake in OneWeb, was a clear statement of intent through which to establish a sovereign presence in space and pursue the Global Britain agenda.

Theme 3: Prevalence of the Use of Grants

After 2016 there were a number of selective interventions which sought to boost development of the UK space sector. The Launch UK initiative may be viewed as a classic example along with funding of the Leicester Space Park. These and other initiatives were chiefly funded through the issuance of grants which appears to be the UK government's preferred method of supporting and shaping the industry, outside of ESA. This is evident in the development of launch capability in Cornwall and in Scotland, but also in the attraction of foreign business investment to the UK. The establishment of Spire Global (US) in Glasgow, and Astroscale (Japan) at Harwell shows that the power of grant funding has been an important and useful strategy in building the UK newspace sector. The allocation of grant funding from the Cornwall Council to reinforce national government spending is also indicative of the strength of the policy; it appears that investment attracts investment. The use of grants has become a favoured lever to influence the UK space sector, and has been used for pursuit of other political goals such as the UK's green and international development agenda through the funding of newspace technologies.

Issues/Problems for the UK Space Sector

Whereas from 2010 to 2016 there was a distinct focus on setting the conditions for economic growth in the UK space sector, the focus waned from 2016 onwards. The switch is understandable as the range of political issues required to be dealt with by the UK government increased substantially, not least the decision to leave the EU. Focus on regainingstatus as Global Britain and the policy measures to achieve that set out in the

Integrated Review meant that the UK had to rapidly switch gear, and this was felt in the space sector. The UK space budget which remained after contributing to ESA was used through grant funding to support national priorities. Coincident with the shift from economic to political focus, industrial policy has shifted from horizontal to a more selective approach. This interventionist style of industrial policy has caused some problems.

Primarily, as evidenced by interviewees from the newspace industry the sector relies on government grants and ESA funding to maintain business viability. As the venture capitalist pointed out, this has bred a sector which has become reliant on the government through a mechanism which distorts the market. Potential exists for companies to become deadweight actors that would not survive in a pure market. This effect is worsened by the liberal dispersion of grant funding through separate institutions; ESA, UKRI and the UKSA are all able to issue grants which are aligned to their own purposes. Newspace businesses are therefore less able to innovate as they must bid for grants according to the agencies' political or technological aspirations. Because of this, private equity and venture capital may become less inclined to invest as the will to innovate new, potentially high-value products is eroded. The UK industry is therefore at risk of becoming artificially sustained, and one which may lose out on the newspace race.

The problem of selective rather than horizontal industrial policy is exemplified in the national workforce. The artificial stimulation of the newspace sector through the injection of seed-corn funding for start-up businesses presents a problem with requirements for a skilled workforce. In Japan, a source of high-tech industry for decades, a workforce familiar with the science and technology industry is readily available to take advantage of the newspace sector.[158] Similarly, the presence of a decades-long national space programme in India has meant that a skilled workforce is available for employment.[159] In contrast, the UK has a limited talent pool from which to draw high-tech skills. Combined with Brexit-induced difficulties of attracting talent from overseas, and the 'great-resignation' the UK faces significant challenges in developing a talent pool at a rate which matches the growth of the global sector. In contrast, an industry which was supported with cogent, wide ranging horizontal industrial policy would make use of the framework supported by the government, including a well-educated talent pool. A second problem is the selective approach of developing the Satellite Applications Catapult whilst there remained little government attention focussed on the attraction of other industrial sectors to benefit space utility. Contrast this with Japan, where the S-series of events actively seeks to inform and cross-pollinate businesses with the newspace sector.[160] UK strategy misses the opportunities which would be presented by an informed customer base for its own technologies.

Policy Implications

The research conducted for this thesis provides a unique perspective on the UK space sector and its relationship with government. The use of industrial policy as a theoretical lens

highlights issues which could be resolved through different political approaches. Accordingly, as a post-script to this research I provide areas for consideration which may strengthen the UK newspace sector:

1. Consideration should be given to better ways to support this nascent industry beyond small grant funding. Methods could include a commitment to act as a customer for technologies it recognises will have utility in defence, development or any other appropriate area of government. This commitment would provide a target for newspace actors, who could develop technology in line with government priorities and potentially establish a steady-state revenue stream. Alternatively, strategies such as investment matching as used in New Zealand would take advantage of the expertise in the private equity world, and somewhat safeguard government investment. Additionally, this approach would prevent artificiality in the sector that grant funding can produce.

2. In turn, the UK government should seek to refocus efforts on the provision of a healthy framework within which the space sector can thrive. Development of a skilled workforce, an appropriately relaxed regulatory system and a business culture aware of the economic potential to be found from interaction with the newspace sector are a few examples of what could be achieved through less selective industrial policy.

3. A consistent request from trade bodies in the sector is the development of a national space programme.[161] Citing advanced manufacturing, clean energy, aerospace, health and genomics, the CEO of SpaceUK called for 'government action to ensure that the space sector can achieve its growth potential' specifically, through the development of a plan to develop a sovereign GPS system, a method to tackle space debris and a national earth observation system. As in France and Italy, sovereign space capability could be developed in parallel with work commissioned by ESA, a step which would attract industry, create jobs and increase the potential for trade. Such a programme could be supported by governmental commitments to act as a customer for innovative solutions, a move which would engender much needed certainty in the sector.

Given the phenomenal growth of the newspace industry and the prospects for innovative technology to change the way we live, the relationship between state and space will become increasingly important. Further research would be useful to develop understanding of how the industrial policies of other states influence, positively or negatively the development of the sector. Further, it would be useful to understand how countries with laissez-faire economic and regulatory policies differ from those which have more constrained and restrictive view on such matters. Quantitative comparison and analysis have not been a tool within this thesis, but again, this would be an informative approach. This thesis could be built upon by comparing the industrial policy of a range of states, with sectoral growth statistics. Furthermore, it would be interesting to develop an idea of how different political systems, from democratic to autocratic affect the industry. The examination of newspace and industrial

policy is a useful step towards developing understanding of politics in the 21st Century, and should be pursued.

Conclusion

The nature of government interaction and excitement around newspace in the UK masks a risk that the sector may never become a fully self-sustaining industry. The opportunities in the market are significant, as UK Space argued: 'the UK space sector could better aid the economic recovery by boosting jobs in the space sector and also sectors which derive capability from space. Without such ambition, the UK may fall behind other nations and will become a dependent state in space, required to rely on other states for national infrastructure'. [162] As technology in the space sector becomes cheaper and more widely accessible to terrestrial businesses, investments into the sector will surge. Only those states which have prepared adequately will be able to fully capitalise on the potential on offer. The imperative for the UK to prepare and nurture its newspace sector is quite clear. However, the recent pivot to the pursuit of political aims rather than a purely economic approach through industrial policy has meant that the UK space sector may be ill-equipped to capitalise on and keep up with newspace advances seen in other parts of the world. As I have demonstrated, the approach to newspace has pivoted since 2016 from a clear aspiration to promote economic growth in the sector to a strategy of extraction of political utility. Whilst venture capitalists argue that the only way to truly realise the potential of a newspace sector is through selective funding of high potential technologies, it is evident that the government has taken a different approach of providing small funding packets to support the development of early TRL technologies. By intervening to utilise the newspace sector as a political response to an array of wider issues, the government has changed the character of UK newspace in such a way that it has become potentially unsustainable as a self-supporting sector. Consequently, the reliance on funding from state and ESA that has developed may stifle the real innovation the newspace sector requires to keep pace with the rest of the world.

Notes

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[4] Owing to the seniority of interviewees and sensitivities surrounding their opinions, contributors have been anonymised.
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[6] Weinzierl and Acocella, 'Blue Origin, NASA, and New Space (A)', 1.
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[25] Jan van der Veen et al., 'Disruptive Space Technologies', 31.
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[29] Warwick, Ken, 2:15.
[30] Baum and Silverman, 'Picking Winners or Building Them?'.
[31] 'Picking Winners, Saving Losers'.
[32] Lerner, 'The Boulevard of Broken Dreams', 66.
[33] Lerner, 'The Future of Public Efforts to Boost Entrepreneurship and Venture Capital', 259.
[34] Cyranoski, 'The Valley of Ghosts'.
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[38] Friar and Meyer, 'Entrepreneurship and Start-Ups in the Boston Region'.
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[46] Michael Fritsch, 13.
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[51] Rodrik, 4.
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[61] Feichtner, 'Mining for Humanity in the Deep Sea and Outer Space', 257.
[62] Pekkanen, 'Governing the New Space Race', 95.
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[76] 'Nanosatellite & Data Company Spire Choose Glasgow for European HQ'.
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[85] Question 29 Edge, Ojha, and Southwood, Oral evidence: UK Space Strategy And UK Satellite Infrastructure, HC 98.
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