TIME FOR LAUNCH

HOW GOVERNMENT CAN TAKE ADVANTAGE OF THE SPACE AND SATELLITES OPPORTUNITY

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Foreword by Jo Johnson, Minister for Universities, Science, Research and Innovation
TIME FOR LAUNCH
THOUGH THE SPACE SECTOR HAS TRADITIONALLY BEEN THE PRESERVE OF NATIONAL GOVERNMENTS AND AGENCIES, THE EMERGENCE OF THE ‘NEW SPACE’ INDUSTRY HAS PROVIDED INCREASINGLY MORE AFFORDABLE ACCESS TO SPACE AND SATELLITE TECHNOLOGIES, LEADING TO A GROWTH OF SPACE SERVICES AND APPLICATIONS IN THE PRIVATE SECTOR
With the cost of access to space reducing, Britain is ready to thrive in the new commercial space age. The latest figures indicate a sector now worth in excess of £14.8 billion, with Britain holding over 5% of the global market and employing over 41,000 people.

The UK Government is ready to ensure that success continues by kick-starting small satellite launch and sub-orbital flight from UK spaceports. Most recently in June this year we announced our work with Cornwall Council to support horizontal launch from Spaceport Cornwall. This new access to space is being underpinned by space legislation and regulation through the dedicated Space Industry Act 2018.

In addition to being home to some of the world’s largest aerospace and satellite companies, the UK has built an emerging ecosystem of hugely exciting space technology start-ups and scale-ups. There has never been a better time to start and grow a space business in the UK, with support networks, funding opportunities and advice available across the country.
To support growing businesses and start-ups, we are developing world-class facilities, including the National Space Propulsion Facility in Westcott and the National Satellite Test Facility in Harwell, as well as developing a network of space-focused business incubators across Britain. Technology derived from space is fundamental to modern life, from weather forecasting and satnavs, to communications and monitoring climate change. And as this report outlines, there is a significant opportunity to use space and satellites across the public sector.

We are already delivering on our ambitions to make space technologies more accessible, while supporting further growth. In March we made free access to more than 1,000 high-resolution satellite images of Britain available for anyone working in the UK public sector through the ‘Space for Smarter Government Programme’, which will benefit areas such as planning and development and environmental monitoring. And in April we supported a number of exciting medical projects derived from space technology for the NHS’s 70th birthday, including the development of a 3D X-ray machine based on star-gazing technology and real-time diagnosis of bowel cancer thanks to the application of high-speed satellite data connections.

As well as strengthening capabilities for the public sector through space technology, these programmes should also break down barriers to start-ups and small businesses entering the sector and create opportunities for new collaborations with public sector bodies.

As we look to the future, I want the public sector to continue to grasp the benefits presented by space. An important part of this will be the coordination of a new National Space Council in the coming months, which will provide leadership on the UK’s space strategy, investment and use of space through a new National Space Framework.

Establishing a National Space Council will help to put space at the heart of government policy and support sector growth. And as we approach the European Space Agency’s (ESA) Council of Ministers in November, the UK will reaffirm our founding membership with an ambitious new investment. This will cement our leading role in the institution and help us to deliver a more global and outward-facing space industry. Every penny that the UK invests in ESA returns to the UK in access to industrial contracts and world-leading science.

The Government and the UK space sector have bold ambitions to lead the new space age, ensuring we can exploit long-term strategic and commercial benefits for the UK.

Jo Johnson
Minister of State for Universities, Science, Research and Innovation
EXECUTIVE SUMMARY

Space and satellite technologies underpin many of the services that we rely on every day. Though the space sector has traditionally been the preserve of national governments and agencies, the emergence of the ‘new space’ industry has provided increasingly more affordable access to space and satellite technologies, leading to a growth of space services and applications in the private sector.

However, the public sector lags behind the private sector in taking advantage of the applications of satellite data and space technologies. Within government, space has traditionally been treated as a niche industry, with solutions often viewed as too complex, technical, or expensive for widespread application to public sector problems.

This report challenges this narrative through surveying examples of space-enabled GovTech in the health, environment, transport, energy, and security sectors, arguing that government needs to do more to take full advantage of the opportunities and solutions which space presents. In particular, this report explains how space technologies can be better integrated into the following policy areas:

**HEALTH:** Satellite applications are instrumental in enabling new models of healthcare for the NHS and local authorities, especially for remote and preventative healthcare applications.

**THE ENVIRONMENT:** Earth observation and satellite remote sensing enable better monitoring of natural resources and environmental assets. This facilitates the targeting of public resources where they are needed most, reducing waste, thereby improving living conditions and environmental outcomes.

**TRANSPORT:** Satellite data will be key to the future of transportation planning, underpinning the rollout of electric vehicles and infrastructure, as well as enhancing efficiency in vehicle, freight and infrastructure monitoring and maintenance.
ENERGY: Space technologies can make energy networks more robust, predictable, and secure, with real-time monitoring facilitating smart energy distribution. Satellite-enabled weather forecasting increases the reliability of clean energy sources, decreasing fossil fuel dependence.

SECURITY: Public safety and security is enhanced through satellite-based services such as offender tagging, better navigation services for emergency response, and the use of satellite and GPS data as evidence in criminal cases.

The UK now boasts a world-leading ecosystem of innovative space startups developing cutting-edge technology solutions and platforms. We argue that these startups are crucial for delivering greater innovation in public sector outcomes, and that supporting the continued growth of this sector should be a key strategic priority for government. Although government is supportive of the new space industry, it could be doing more to support the development and scaling of startups. In particular, much more needs to be done to help these companies to work with public sector customers.

We interviewed 50 leading space technology startups to understand the barriers to entry in providing products and services to government. We also engaged with government representatives and key policy officials to gauge the biggest challenges for incorporating space technologies in public sector services. On the basis of these consultations, we have made ten recommendations for government:

1. Review whether grant funding streams should have a stronger focus on commercialisation.
2. Establish a dedicated vehicle to transfer space innovation in the military sector to the wider civilian community.
3. Review how to stimulate greater VC investment into space and satellites startups.
4. Undertake an audit of current government spend with a focus on identifying unnecessary spending duplication.
5. Publish guidelines for how government agencies can procure space and satellite services.
6. Scale up the use of challenge-based funding initiatives and increase the use of innovative procurement procedures.
7. Establish common standards to facilitate satellite data being used for different public sector purposes.
8. Implement a new framework for working with space bodies in Europe.
9. Introduce new training initiatives to build up expertise in using space-related products and services.
10. Explore how space data can be used in key future government projects.
Few of us are aware of just how reliant we have become on space-enabled services as we go about our everyday lives. Yet, the majority of us living in the UK use services such as satellite navigation, telecommunications, and television broadcasting services every single day.

87% of the UK adult population have smartphones, each equipped with a chip-sized receiver picking up signals from hundreds of satellites 20,000 km above that orbit around the Earth at several kilometers per second. Over 90% of context-aware smartphone applications now rely on Global Navigation Satellite Systems (GNSS).

These satellites enable time to be measured with an accuracy within billionths of a second, and location to be identified to within a few metres. Computer networks, telephone networks, television broadcasters, DAB radio stations, ATM machines, stock exchanges, railways, electricity grids, internet search engines, and mobile gaming apps all rely on satellites for timing, location, and synchronisation purposes. New satellite-enabled applications are being launched all the time, such as flood monitoring, insurance risk assessment, supply chain and logistics management, and precision agriculture, to name just a few.

**Space In The Public Sector**

The public sector, too, has come to rely on space for mission-critical services such as weather forecasting, air traffic control, automated road user charging, traffic management, maritime systems, and offender tagging.

Indeed, emergency services – such as ambulance, police, fire, and search and rescue - already use GNSS and satellite communications (SatCom) to locate the emergency, find the quickest route there, and to communicate with controllers. Increasingly, earth observation (EO) satellite services can also provide vital information to coordinate response and recovery efforts on the ground – for instance in the event of flood, fire, or severe weather events. New services have been developed that are able to monitor changing situations on the ground in real-time to help operations centres manage the deployment of vehicles and personnel.

It is estimated that satellite services support over £300b of GDP across the wider UK business economy. A recent study by London Economics estimated that a single five-day disruption to GNSS would cost the UK economy £5.2b. A 2018 Innovate UK study estimated the value to the UK government of satellite-derived EO at a conservative £64m per annum, projected to increase to more than £200m per annum by

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1 Deloitte. 2018. Mobile Consumer Survey

2 London Economics. 2019. The Size and Health of the UK Space Industry 2018

3 London Economics. 2017. The economic impact on the UK of a disruption to GNSS
However, few public sector decision-makers are aware of just how dependent we are on space-enabled technologies.

The UK space industry generated income of £14.8b in 2016/17, and was forecast to grow to £15.5bn in 2017/18. 82% of that income was from consumer and business customers, and a further 15% was from defence budgets, with only £400m in income coming from UK civil government budgets. This is a clear indication of how far the UK public sector lags behind the private sector in taking advantage of space-enabled technologies.

The UK space industry has high ambitions to grow to £40b per annum by 2030 - capturing a 10% share of a projected £400b global market. Global growth forecasts are impressive. Morgan Stanley estimates that the global space economy will be worth US$1 trillion by 2040.

There is a clear commitment from the current UK government to support growth in the sector by providing public funding for R&D. However, UK public authorities could play a more important role in achieving that growth ambition by becoming better-educated consumers of space-enabled services, adopting technologies that have already become commonplace in the private sector, and by acting as pilot customers for new solutions.

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5 London Economics. 2019. The Size and Health of the UK Space Industry 2018
6 Space Growth Partnership. 2018. Prosperity from Space: A partnership strategy for the UK
7 Morgan Stanley. 2019. Space: Investing in the Final Frontier
SPACE AND BREXIT

While there has been much discussion on the impact of Brexit on the UK space sector’s continued growth, there has been less discussion of the fundamentals of the UK space economy that will serve to cushion the impact on the sector of the UK leaving the EU. The aforementioned London Economics report on the size and health of the UK space industry shows predicts continued growth in the industry, with increases in income, employment and exports, reflecting confidence in the sector despite the uncertainties of Brexit.  

Approximately half of the industry’s income comes from the EU (however, that income is not wholly reliant on European Commission space missions). UK space industry income is predominantly (82%) from commercial sources, rather than government budgets, which serves to insulate it to some degree from the impact of losing access to EU-funded programmes. Indeed, a large proportion of the UK’s satellite exports are independent of European Commission procurement, with ESA generating 29% of total satellite exports; France accounts for 40% of single country exports, and the US accounts for 8%.  

As the UK is one of the four central members of the European Space Agency (ESA), and the leading funder for key space-related ESA programmes, UK companies will continue to be able to access ESA contracts, as well as contracts through domestic programmes such as the UK Launch Programme and National Space Technology Programme. The European Commission is ESA’s single largest funder, accounting for roughly 25% of ESA’s budget (€1.25b of €5.72b). Although the UK will not be eligible to participate in EU-funded missions when it leaves the EU under current arrangements (this is a matter for future negotiations), the government has expressed its intention to continue UK engagement with European partners through its ESA membership.  

It has been reported that nearly a third of investments in the new commercial space sector in Europe were initiated by the UK. The UK represents a liberal and innovative force within the space sector, with a focus on building an enabling ecosystem for space businesses. As such, the EU risks losing a driving force behind the strategic European vision for a commercial space sector. Collaborative missions with other space agencies around the world also create export opportunities: the UK recently signed an agreement with the Australian Space Agency to deepen cooperation between the two countries in the areas of space science, technology and applications, space policy, law and regulation, and human capital development. 

Nonetheless, there is no question that there will be a significant impact on the UK space sector if UK companies and research institutions are blocked from participating in European Commission funded space missions. In 2018, the European Commission proposed a budget of €16b for space capabilities over the 2021-2027 period, and has introduced legislation to consolidate its various space activities under the management of a single new space programmes agency that will be based in Prague. 

10 BBC. 2019. Brexit Britain will be 'lost in space'

8 London Economics. 2019. The Size and Health of the UK Space Industry 2018
9 Ibid.
10 Ibid.
12 GOV.UK. 2018. Britain and Australia enter into space agreement
13 European Commission. 2018. EU Budget for the Future: The EU Space Programme
UK companies and researchers have been deeply involved in creating much of the capability in EU-funded space systems to date, and have benefited from the ability to influence the future direction of those programmes. A substantial proportion of Horizon 2020 space funding has gone to UK companies, researchers and academic institutions. This will be lost in the event that the UK leaves the EU with no negotiated agreement to continue participation. UK-based researchers will, however, be able to apply for Horizon 2020 calls open to third country participants.

Additionally, tariff-free trade within the EU helps to keep space construction and infrastructure costs down, as well as minimising bureaucratic friction across the supply chain. After Brexit, the UK may face barriers to accessing critical technologies and supply chains. Furthermore, leaving the EU could hinder the flow of talented individuals and expertise into the UK, which is a vital ingredient for continued innovation in the sector.

The EU awards contracts for space every seven years, with the next round of contracts being awarded in 2020. These contracts are usually only awarded to EU member states, and the UK would likely lose access to these if leaving without a deal. Indeed, the EU has already begun the process of excluding UK companies as part of their preparations for the UK’s exit. Brexit clauses in current contracts with UK-based companies have been claimed to threaten the viability of those companies that critically depend on contracts from the EU for a substantial proportion of their revenue. Consequently, this may lead to high-tech space firms leaving the UK. Although a significant amount of funding opportunities are available independently of EU membership, procurement opportunities are not, which affects UK companies’ ability to sell their products. New startups may choose not to base their offices in the UK if there are more funding and procurement opportunities available within the EU.

The UK government has taken steps to try to mitigate the impacts of Brexit on the sector. In particular, it has made efforts to secure continued participation in Horizon 2020 and has pledged to fund research programmes that currently receive funding from Horizon 2020 post-Brexit. The funding guarantee will cover the full duration of projects up to 2020. The government has also invested in important infrastructure to build the UK space industry’s capacity independently of the EU’s. This includes building satellite launch capabilities and testing centers, and conducting feasibility studies for new projects.

**Galileo - The EU’s Global Navigation Satellite System**

UK companies have been central to the deployment of this system, and the government has invested a reported £1.5b in its development (roughly 14% of total funding). All 22 of the Galileo satellite payloads, since the first launch in 2005, have been built in Guildford by **Surrey Satellite Technologies (SSTL)**. The security systems underpinning the encrypted Galileo secure Public Regulated Service (PRS) have also been developed in the UK. Under EU rules, non-member states are not allowed to participate in the development of PRS, which is intended to be used in military and emergency services by member states, due to security concerns. The UK will thus play no further role in the development of PRS. It has been reported that the UK will not use the Galileo system for either defence or critical national infrastructure, due to fears that the UK may become critically dependent on a system which it has no ability to influence.
The government has announced the investment of £92m, from the Brexit readiness fund, to conduct an 18-month feasibility study for an alternative UK GNSS. The study will inform a future decision about whether the UK will seek to build a new GNSS system as an alternative to Galileo. A new GNSS system is estimated to cost between £3-5b. With an annual UK space budget of £370m, of which a substantial proportion goes to ESA, it is unclear where the UK will find the funding for a new GNSS system.

If the UK leaves without a deal, UK users will still have access to the free services provided by Galileo. UK businesses, academics and researchers will have less opportunity to participate in future developments as procurement terms can be restricted to companies that are based in EU member states. Companies which host Galileo ground infrastructure, may not be able to complete existing contracts, potentially leading to job losses. SSTL has not been allowed to bid for the contract to produce the navigation payload for the fourth generation of Galileo satellites, despite having built all 22 of the Galileo satellites thus far. Contracts from the Galileo programme reportedly account for half of SSTL's annual revenue, and are in jeopardy if the UK leaves the EU without a security agreement. Airbus, SSLT's parent company, lost the follow up tender to continue running Galileo's sensitive ground control operations in Portsmouth. Both SSLT and Airbus have been forced to move certain operations to continental EU.

Copernicus is an EO programme that uses a set of satellites in Earth orbit, along with ground-based sensors to study the Earth's air, land, and sea conditions. Copernicus’ seven Sentinel satellites monitor weather, land use, air quality, agriculture, and other environmental factors that can be used in a variety of sectors, from urban planning to climate change mitigation. In addition, Copernicus offers data from more than 50 contributing missions. The programme delivers 15 terabytes of data every day, making Copernicus the biggest provider of EO data in the world.

Copernicus Sentinel data is produced under a free and open data policy, and thus will continue to be freely available to UK users after Brexit. The same is not true of the vast supply of data sourced by Copernicus from its contributing missions. UK users will lose access to that data after leaving the EU. The UK has been heavily involved in both building the satellites and analysing the data that comes back. If there is no agreement to continue UK participation, UK-based businesses, academics and researchers will be unable to bid for future Copernicus contracts tendered through the EU, or through any other process that applies EU procurement rules. It is currently unclear what will happen to existing contracts with delivery dates running past Brexit.

There are a few Copernicus sub-programmes that are funded by ESA subscriptions rather than the EU. UK entities should still be able to compete for those contracts. The UK's membership in the European Center for Medium-Range Weather Forecasts (based in Reading and funded by member-states) and Mercator Ocean, which runs the Copernicus Marine Service (funded by the European Commission) is unaffected by Brexit. UK entities will therefore be able to bid for Copernicus contracts tendered through these organisations. The UK will also continue to have access to the data sets generated by these programmes.

21 GOV.UK. 2018. Space sector to benefit from multi-million pound work on UK alternative to Galileo
23 SpaceNews. 2018. UK ends Galileo talks, says it will explore a homegrown alternative
24 Financial Times. 2018. Brexit restrictions force UK satellite maker to send work to Europe
25 European Space Agency. 2019. New financial resources for Copernicus space component
26 GOV.UK. 2019. Satellites and space programmes if there’s no Brexit deal
**European Space Surveillance and Tracking System (EUSST)**

EUSST is an EU-funded programme to track the thousands of pieces of space debris that could cause a threat to satellites in Earth orbit. It also provides civil contingency services with accurate data about space objects (satellites or debris) re-entering the Earth’s atmosphere on a scheduled or unscheduled basis.

The programme was set up in 2014, with the UK as one of five participating EU countries. The UK’s National Operations Centre provides fragmentation analysis for the programme and a back-up service for re-entry warnings. The system has not been fully built yet, but has been partially operational since 2016.27

If the UK leaves the EU without an agreement to continue its participation in EUSST, UK organisations will not be able to provide services to the programme, participate in the scientific and technical groups shaping its future development, nor receive any related grant funding. 28

The UK is not reliant on this programme to safeguard UK-based satellite operations as it has a longstanding partnership with the US for space surveillance and tracking. Unlike France and Germany, the UK has not invested any major national assets in the programme, limiting the potential impact of being excluded from the programme.29

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**EU GOVSATCOM - EU Secure Satellite Communications System**

EU GOVSATCOM is an EU-funded programme to develop a secure satellite communication system for EU member states. It proposes to offer member states guaranteed access to secure satellite communications to support national police, civil defence, marine and border protection forces. It also aims to provide robust and secure connections between Brussels Headquarters and country delegations around the world for the European External Action Service.

With its own secure communications systems in place, the UK has engaged with the GOVSATCOM programme, but it has not been a UK priority. European Commission reports claim that the effects of Brexit on EU GOVSATCOM are uncertain.30 Important commercial SatCom operators are headquartered in the UK, but have subsidiaries in continental Europe to which operations could be transferred. Participation of third countries in EU GOVSATCOM is under consideration.

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27 GOV.UK. 2019. Satellites and space programmes if there’s no Brexit deal
28 Ibid.
29 European Parliament Policy Department for Economic, Scientific and Quality of Life Policies. 2018
30 European Commission. 2018. GOVSATCOM Impact Assessment
GLOBAL TRENDS IN SPACE

Historically, the global space market has been dominated by large organisations, often owned in part or in whole by government, delivering complex, high-cost projects for large corporate or government customers.

The past decade has seen the emergence of a ‘new space’ market, with a rapidly growing number of new entrants offering innovative products and services. The large-scale investments and mainstream recognition of high-profile, wealthy entrepreneurs, such as Richard Branson, Jeff Bezos, and Elon Musk (although all three of these have also significantly benefited from public sector investment), have ignited investors’ interest and inspired a whole new generation of entrepreneurs to enter this new space race.

While the emerging market includes a focus on the use of satellite data for Earth applications, it is also equally centered around new developments in the satellite manufacturing and launch processes.

CASE STUDY

ORBEX MICRO-LAUNCH PROVIDING ACCESS TO SPACE

Orbex is a small satellite launch provider specialising in micro-launch vehicles, taking payloads between 100kg and 220kg into orbit. Orbex’s launch vehicle has an innovative architecture enabling it to overcome the fundamental mass challenge of small launchers and take PocketQubes and CubeSats into space.

Together with Lockheed Martin, Orbex received funding (£23.5m and £5.5m respectively) from government in 2018 to develop the UK’s first vertical launch Space Hub in Sutherland, Scotland. Orbex was chosen for its expertise in launching small satellites into orbit, as small satellites will underpin the development of the UK’s new space sector and small satellite launch will enable access to the commercial space industry for many companies.

Combining the capability of large companies, such as Lockheed Martin, to deliver the infrastructural outlay with the innovation capabilities of startups proves to be a successful model, with companies such as Astrocast and Elecnor Deimos already contracting launch serviced from Orbex in Sutherland.

31 GOV.UK. 2018. Lockheed Martin and Orbex to launch UK into new space age
Some of the global trends that are driving up the use of satellite data and services, include:

- Increasing popularity of context-aware applications and location-based marketing: many of these rely on devices that are continuously receiving and sending location signals. Smartphones and tablets have vastly expanded beyond the capability of sending text messages or making calls, and are now personal navigators, storage devices, arcades, and social hubs. Emerging new augmented reality applications are also driving growth in this area.

- Global mass-market adoption of the Internet of Things (IoT): devices for purposes such as connected vehicle use, healthcare, water, waste and energy management, and supply chain tracking. The total installed base of IoT devices is projected to grow to 75.44 billion worldwide by 2025. That will equate to roughly ten IoT devices per person on the planet.

- Growth of wearables for health and fitness applications: CCS Insights predicts that sales of smart wearables will reach 142 million units worldwide in 2019 and that increasing adoption of smartwatches, smart hearables (wireless in-ear headphones), and smart sports shoes will lead to sales of 260 million units in 2023, creating a market worth almost US$30b. All of these devices depend on ‘always on’ mobile data connections.

- Advent of ‘Smart Cities’ and connected urban ecosystems: these require integrated systems for collecting, measuring, collating, and broadcasting data from a multitude of sensors to create accessible and efficient governance, effective urban development, and resource management for stakeholders.

- Increased global concerns about sustainable development and the environment: this is driving up demand for climate change monitoring and modelling, using data from the rapidly growing number of EO satellites.

- Roll-out of 5G mobile broadband: 5G networks will be moving more data, faster, resulting in increased dependence on precise timing and synchronisation. Given the scale of infrastructure required for 5G networks, GNSS is likely to underpin the process. As part of the work of the 3rd Generation Partnership Project, satellite communications can adhere to 5G standards and can therefore be embedded in any 5G solution. This is being seen in projects from Department for Digital, Culture, Media and Sports (DCMS) and developed by organisations like the Satellite Applications Catapult.

- Decreasing cost, complexity, and size of satellites: satellite data is becoming faster, cheaper, and easier to source. Startups such as Skywatch are creating intermediary services, aggregating satellite data, and making it cheaper and easier for users to procure only what they need.

- Democratisation of access to space: startups like Open Cosmos and Blue Skies Space are developing new business models to enable shared platforms for space-enabled services, for both commercial and research purposes, reducing risks, costs, and delivery times for end users.

- Developments in artificial intelligence and machine learning: new statistical techniques allow for satellite data to be integrated with other relevant data sources to generate new insights and power new services.

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32 Statistica Research Department. 2016. Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)
34 CCS Insight. 2019. Optimistic Outlook for Wearables

THE PAST DECADE HAS SEEN THE EMERGENCE OF A ‘NEW SPACE’ MARKET, WITH A RAPIDLY GROWING NUMBER OF NEW ENTRANTS OFFERING INNOVATIVE PRODUCTS AND SERVICES
SKYRORA

Driving Improvements for Fuel Storability

Founded in 2017, Edinburgh-based Skyrora manufactures satellite launch vehicles with 3D-printed rocket engines which take small payloads (max 315kg) to orbit. In 2018, Skyrora was the first private company to launch a suborbital rocket in the UK, and aims to be the first to launch a private rocket into space from the UK.

Skyrora is working to solve a problem that is faced by almost all small satellite companies: the costs and inefficiencies related to disruption in satellite launch schedules. The UK’s cloudy weather means that rockets can often miss their window for launch and have to wait for conditions to improve. This can result in a backlog of small satellites waiting to be launched. Due to the limited storability of traditional liquid oxygen rocket fuel, engines need to be detanked and refueled during this waiting period, increasing the cost of launch missions.

Skyrora’s solution is to use fuel with improved storability. The company’s rocket engines use hydrogen peroxide and kerosene, which can be stored in the engine for long periods of time without needing to detank and refuel. The combination also produces 45% less greenhouse gasses than liquid oxygen. The Skyrora launch system is thus responsive to local conditions: delays to rocket launches caused by bad weather do not require refuelling, helping to keep costs down. It also increases access to space for small satellites as rockets can sit waiting for a brief window of good weather in which to launch.

OPEN COSMOS

End-to-End Satellite Launches

Backed by a £6m Series A round,37 Open Cosmos has taken on the business of democratising space by simplifying the burdensome and arduous processes that have traditionally been roadblocks for industries attempting to access the benefits of space technology. As the number of industries that are considering utilising satellite technology rapidly increases, the demand for a comprehensive satellite service expands as well. To meet this demand, Open Cosmos provides a start-to-finish small satellite service that allows their customers to launch and task small satellites for specific, bespoke business applications.

Open Cosmos not only provides the design, testing, and building of the satellite required by the customer, but also handles the regulatory requirements to launch satellites. Once the satellite is complete, Open Cosmos arranges the launch and operates the mission, providing the customer with their data quickly and efficiently. The Open Cosmos model is based around three compartmentalised levels of service. The beeInnovative stage provides assistance with the design of the mission architecture; the beeReady stage gives access to full payload development and testing; and the final beeOrbital stage provides flight preparation, launch and orbital exploration.

These developments are pushing forward innovation across the space sector with a raft of new startups developing exciting new products and services. The latest survey found that the average annual number of new entrants to the UK space sector nearly doubled between 2012 and 2016.35 The burgeoning new UK space industry is viewed as world-leading by the rest of the global space sector. Indeed, seven of the top ten companies named in the New Space People 2018/19 Global Ranking Report are UK companies.36

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35 London Economics. 2019. The Size and Health of the UK Space Industry 2018
37 Tech.eu. 2018. Open Cosmos raises $7 million to make satellites more affordable
In 2017, the UK government published a long term Industrial Strategy, which identified certain ‘grand challenges’ as a focal point for government industrial policy. The aim of the strategy is to ensure the UK is able to take advantage of major global changes and position its economy competitively at the forefront of key industries of the future. The focus of the first four grand challenges is on global trends that will impact the future for all of us:

- ARTIFICIAL INTELLIGENCE AND DATA
- AGEING SOCIETY
- CLEAN GROWTH
- FUTURE OF MOBILITY

As we explore in this report, innovative space companies are developing new space-enabled technologies that will support the government’s ambitions across these grand challenges.

The benefits of working with public sector customers are substantial: they have large budgets, offer long term commitments, establish solid credibility for a company, and bring high-profile PR value. They also have public commitments to pay promptly (the current target is under 30 days for undisputed invoices) and to increase the proportion of their spending that goes to Small to Medium Enterprise (SME) suppliers (the government target is for 33% of procurement spend to go to SMEs by 2022). However, it is no secret that smaller companies, especially startups, may find public sector customers more challenging to do business with than commercial customers.

Having engaged with over 50 space sector startups about their experiences of working with government, the following have been identified as key barriers (real or perceived) that put startups off serving public sector customers.

Is Space too Expensive?

There is a misconception on the part of budget-holders that space solutions are high-cost and high-complexity. While potentially true in the past, costs have rapidly decreased, and integration with other technologies means companies are now able to offer much more affordable solutions.

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38 GOV.UK. 2017. Industrial Strategy: building a Britain fit for the future

39 GOV.UK. 2019. HMRC’s small and medium enterprise action plan for 2019
**CASE STUDY**

**HIBER**

**PROVIDING GLOBAL CONNECTIVITY FOR PENNIES A DAY**

Hiber is an IoT connectivity service startup, based in The Netherlands, that utilises low-earth orbiting nanosatellites and energy-efficient modems to provide a cheap method of transmitting data to the cloud. Hiber satellites provide global connectivity, circling the earth multiple times a day to receive modem signals, pinging them back to Hiber’s ground station to quickly transfer to the cloud platform of the customer’s choosing.

Hiber distinguishes itself from other satellite companies through its extensive low-power, low-cost systems. On the current rate of one message per day, Hiber modems are able to remain in operation for up to ten years on a single charge as they are only online when there is a nanosatellite passing overhead. For the vast majority of the time, these modems are effectively hibernating. This allows for extremely cost-efficient satellite services. In terms of price points, Hiber operates on a payment system of only a few Euros per device per year. This low-cost system can be utilised in providing connectivity in countries where traditional land-lines may be too costly or inaccessible to establish.

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**INNOVATIVE NEW TECHNOLOGIES THAT OFFER A SIMILAR (OR BETTER) SOLUTION AT LOWER COST WILL MEET WITH LIMITED DEMAND IF REGULATIONS ARE DRAFTED IN SUCH A PRESCRIPTIVE WAY**

**Does it Comply with Regulations?**

Some regulations can serve to lock in legacy solutions by prescribing the technology or data that will be accepted as evidence of compliance with statutory obligations. Clearly, innovative new technologies that offer a similar (or better) solution at lower cost will meet with limited demand if regulations are drafted in such a prescriptive way. This can dampen incentives to innovate on the part of both customers and potential suppliers.

**Who Decides?**

It is often difficult for companies to understand who the actual decision-makers are in a public sector body. Once a relationship is built, officials (and sometimes ministers and advisors) change roles with surprising speed and frequency, so the company may find itself back to square one. For a small company with limited resources, that can seem like a frustrating waste of time and effort.
Where is the Purchasing Power?

Understanding who the buyer is can be further complicated by devolution of power, which puts many budgets and decision-making powers in the hands of the separate parliaments, assemblies and executives for Scotland, Wales and Northern Ireland (budgets and decision-making for England rests with the UK parliament and UK government). Some budgets and powers are further devolved to a local level through councils, unitary or combined authorities, or metropolitan boroughs. As there are 418 principal councils in the UK, that can seem like a vast and fragmented customer base.

Do Grants Lead Anywhere?

There is a substantial amount of R&D funding available through a wide variety of different programmes, but application processes are time-consuming and there is no guarantee of a commercial contract at the end of a project. Many successful space companies use R&D grants or loans from government programmes to fund product development, which they then market to commercial clients or even to public sector clients in other countries, rather than attempting to market to UK public sector customers. This is a wasted opportunity for UK public services to benefit from UK taxpayer-funded innovation.

What is the Process?

Many smaller companies do not know how to get through public procurement processes, or even how to get started. New streamlined public contracts were introduced in 2018. The Crown Commercial Services offers advice to companies about how to bid and how to apply to join framework agreements. Nonetheless, the process can be time-consuming and involve a significant investment of stretched resources, with no guarantee of success. At the time of publication, most of the procurement framework agreements relevant to the sorts of space-enabled services described in this report are not open for new applications and it is not clear when they might open up again.

Later in this report, we outline several recommendations for how the government can support the space sector to overcome some of these key challenges.
WHERE SPACE CAN CHANGE THE GAME

Space-enabled services can deliver operational cost-savings, enhance public service delivery, and support better-informed policy decisions. Satellite services are vital to public services where location and mobility are critical factors, such as ‘blue light’ services. Satellite data plays a valuable role in regulatory compliance monitoring at both the national and local levels, while SatCom is used to connect remote communities and fill in coverage gaps where broadband and mobile networks do not reach.

Just as we have become reliant on satellite services for so much of everyday life, space-enabled GovTech cuts right across the policy spectrum. This report does not aim to provide a comprehensive survey of all potential use cases, but instead highlights examples from a few key policy areas where space-enabled solutions could deliver even greater benefits than they do today.

HEALTH AND SOCIAL CARE

In our 2018 report ‘The Promise of HealthTech’, we identified nine key trends that are priorities for the NHS both nationally and locally. The NHS Long Term Plan, published in January 2019, echoed these top priorities for UK health and social care policy and delivery.

The NHS Long Term Plan sets out ambitious aims for a new service model which shifts the emphasis of many care interactions from the hospital to the home. The plan includes a target for every patient in the UK to be able to access online digital GP consultations within five years. The plan commits funding for new prevention programmes, including reducing obesity and air pollution, and for increasing the take up of screening programmes. It is committed to a continued focus on improving outcomes for a range of illnesses, including cancer, dementia, and respiratory conditions, amongst others. Space-enabled technologies can have a transformative impact in all these areas.

Wearable technology that records and shares data to monitor fitness and health conditions are growing in popularity. Many of these use GNSS signals to measure distances covered and time spent exercising. Devices that use GNSS signals to enable greater independence for dementia sufferers are already available.

PUBLIC. 2018. The Promise of HealthTech
National Health Service. 2019. The NHS Long Term Plan
For instance, carers can programme the parameters of a safe geo-fenced area and will receive an automatic alert if the individual strays beyond set boundaries, giving patients greater freedom to move around independently.

Empowering individuals to take charge of their own health is an emerging policy theme. EO satellites can send data to smartphones to alert people with respiratory conditions of poor air quality, so they can take action to limit their exposure. For example, Cambridge Environmental Research Consultants use Copernicus data to offer the airTEXT alert service which sends daily forecasts of pollution, UV, grass pollen, and temperature to users’ mobile devices.

Almost 30% of preventable deaths in England are due to non-communicable diseases specifically attributed to air pollution.\(^4\) EO satellites can provide air quality monitoring, identify pollution hotspots and help pinpoint causes so that action may be taken.

There are also apps that use satellite data to help people monitor their exposure to UV rays from the sun, so they can take action to avoid harmful skin cancer risks. Conversely, there are skin conditions that require patients today to attend clinics to be treated with artificial UV lamps. Dundee University Hospital has been piloting an application that allows the patient to manage and track their exposure to UV light from the sun, using space-enabled technology, to access a more natural source of treatment and avoiding the inconvenience (and cost to the NHS) of spending time in the clinic.

\(^{42}\) National Health Service. 2019. The NHS Long Term Plan

\(^{4}\) National Health Service. 2019. The NHS Long Term Plan

CASE STUDY

SIHEALTH SATELLITE REMOTE SENSING FOR PERSONALISED HEALTH DECISION SUPPORT SYSTEMS

Oxfordshire-based siHealth combines EO data and atmospheric monitoring from satellite remote sensing with personal data provided by the end user to offer personalised mobile health diagnostics using artificial intelligence solutions. Based on these personal diagnostics, siHealth’s applications make recommendations to support health-conscious decision-making. Diagnostics can be shared with doctors and pharmacists to assist the making of smart diagnosis and treatment plans.

siHealth’s decision support applications utilise its proprietary satellite-based HappySun sensorless solar radiation dosimeter, validated in collaboration with Public Health England and developed with ESA support, to provide real-time assessments of the impacts of solar radiation on human health. Applications based on HappySun technology take into account the personal characteristics of the end user, as well as the environmental factors they are exposed to, and the spectral effects of skin care products they use, to inform individual decision-making.

The insights and data generated by these applications can also be made available, in a GDPR-compliant manner, for further business intelligence services, as well as to epidemiological practitioners and researchers. One further application of the HappySun technology is the development of digital tele-medicine home systems which use daylight Photo-Dynamic Therapy for the early diagnosis and treatment of skin cancer.
Going forward, individuals managing their own health conditions will need the ability to self-test and share results reliably and securely with clinicians for assessment and treatment. Resilient mobile data connectivity will also be required for secure data sharing across community health teams.

SatCom has an important role to play in integrated data transfer solutions, particularly over wide geographic areas and in circumstances where practitioners need to be mobile. This is particularly true for some devolved health authorities in geographies such as the Highlands and Islands of Scotland and rural Wales. However, as highlighted in Ofcom’s 2018 report ‘Connected Nations’ nearly all health economies will have hot spots for terrestrial networks (mobile or fixed line). Therefore to deliver equitable health services, the UK should look at the blend of terrestrial and non-terrestrial (satellite) networks.

SatCom can also provide a cost-effective solution to providing broadband connections to homes in sparsely populated areas. This will be an essential enabler of the NHS Long Term Plan’s commitment for all patients to have access to online consultations.

Integrating SatCom with other technologies can drive down costs of mobile screening and offer greater patient convenience and flexibility, which will in turn increase take up of screening programmes.\(^{43}\)

**CASE STUDY**

**CORPORATEHEALTH INTERNATIONAL**

**SATELLITE APPLICATIONS FOR BOWEL CANCER SCREENING**

As part of the NHS’ commitment to improving cancer survival rates through early diagnosis, NHS Arden & Greater East Midlands Commissioning Support Unit (AGEM CSU) have partnered with the Satellite Applications Catapult and a number of commercial and research partners to develop this new approach to conducting endoscopies.

One of these partners, CorporateHealth International, specialise in delivering video capsule endoscopy services. As an alternative to the traditional endoscopy, which can be painful and time-consuming, the ingestible capsules record and wirelessly transmit images of a patient’s digestive system to a belt-worn recorder, and then through satellite technology for analysis. A patient can be screened for bowel cancer just by swallowing a capsule and transmitting the captured footage to their doctor. The technology removes the need for patients to travel to a clinic to be screened, resulting in a more cost-effective process for both patients and the NHS. CorporateHealth International also provides the service of analysing the video footage and making diagnoses, thereby alleviate the burdens on stretched health care providers.

With the imminent roll-out of the capsules across Scotland, this project shows how effective satellite-based technologies can be for designing new solutions to long-standing public challenges.
The UK 25 Year Environment Plan sets out the government’s goals for improving the environment within a generation and leaving it in a better state for the future. These goals include ensuring clean air, clean and plentiful water, encouraging thriving plants and wildlife, reducing risk of harm from environmental hazards, and using resources from nature more sustainably and efficiently. Additionally, plans aim to enhance the beauty, heritage and engagement with the natural environment whilst mitigating and adapting to climate change, minimising waste, managing exposure to chemicals, and enhancing biosecurity.

The only area of the plan in which the potential use of remote sensing and EO satellites are mentioned is with respect to the marine environment, where the following commitment is set out for the UK and British overseas territories:

‘WE WILL ADAPT OUR APPROACH TO RESPOND TO CHANGING PRESSURES ON THE MARINE ENVIRONMENT, INCLUDING CLIMATE CHANGE, AND DEVELOP NEW AND INNOVATIVE TECHNIQUES TO HELP WITH THEIR MANAGEMENT. THESE MIGHT INCLUDE REMOTE SENSING, EARTH OBSERVATION SATELLITES AND THE USE OF AUTONOMOUS VEHICLES.’

However, as we show below satellite applications are relevant to most, if not all, of the above goals.

The first EO satellite, Vanguard 2, was launched in 1959 to measure the earth’s cloud cover and atmospheric density. It is still in orbit 70 years later. Today, there are more than 660 EO satellites orbiting the earth with cameras, radars, and sensors to monitor every aspect of our planet: weather conditions, marine conditions, air and water quality, ozone depletion, CO2 levels, vegetation density and health, soil moisture levels, evidence of illegal dumping and environmental hazards, flood risk assessments, land use compliance, and even identifying potentially interesting archeological sites beneath the earth’s surface.

In a recent speech entitled ‘Escaping the Jaws of Death’, Sir James Bevan, CEO of the Environment Agency, made the stark observation that within 20 to 25 years the UK will reach ‘the point at which, unless we take action to change things, we will not have enough water to supply our needs’. Water companies in England and Wales lose more than three million litres of water to leakages every day. Satellites can play a valuable role in helping water companies identify leaks and monitor pipelines over large distances.

Earth-i is a geospatial intelligence company using machine learning, artificial intelligence and EO data to provide insight and intelligence to businesses, governments, and other organisations.

From 2021, Earth-i will be launching new, pioneering satellites offering full-colour video from space, on a fully commercial basis. The Vivid-i Constellation will provide sub-1m resolution data, multiple-frame rate data collection, and fast-streaming to ground stations across the globe.

Earth-i has partnered up with water services company Severn Trent to tackle the issue of identifying pipe leakage with a more effective methodology in order to meet leak reduction targets. Over a number of months, Earth-i have conducted analysis on imagery of Severn Trent’s supply area, stretching from the Bristol channel to Humber, mid-Wales and the East Midlands, encompassing an area of roughly 20,000km². Earth-i utilised a technique known as Normalised Difference Vegetation Index (NDVI) analysis, in addition to a customised artificial intelligence and machine learning algorithm, in order to pinpoint leak locations across Severn Trent’s supply area. Earth-i identified locations where grass or vegetation were unusually bountiful and healthy for the usually dry summer months, and cross-reference it against the location of the water pipelines to determine potential areas with leakage.
Although the UK currently has only one major desalination plant in operation based in London, the Institute of Chemical Engineers has predicted that there could be as many as four major municipal plants, and up to 800 smaller units on UK coastlines and estuaries by 2050. These plants discharge waste back into the sea containing a high salinity level as well as a high concentration of other suspended particles, which can have a negative impact on the surrounding water quality. EO satellite imagery can help reduce the environmental impact of desalination plants by monitoring seawater quality, thereby facilitating preventative action against ecological and biological impacts.

Environmental policy and planning powers are primarily devolved, so specific policies and programmes to achieve these aims may differ across Scotland, Wales and Northern Ireland. Indeed, Scotland is notable for an apparent openness to exploring the use of space-enabled technologies to tackle environmental issues.

Through the development of a peatland integrity index and water quality risk information layer, Rezatec has been able to help Scottish Water prioritise the areas of peatland that require the most urgent restoration processes. The portal developed by Rezatec has been integrated into Scottish Water’s Strategic Research Plan for dissolved organic carbon, reducing the time and cost needed to monitor the areas that Scottish Water extracts drinking water from by identifying areas with degraded peatlands without having to physically visit the peatlands themselves.
Local Authorities (LAs) in the UK are required by law to review air quality in their area, designating Air Quality Management Areas if improvements are necessary and putting Air Quality Action Plans in place to reduce pollution. This involves the deployment of expensive monitoring equipment, sophisticated data analysis and modelling, annual reporting to the Department for Environment, Food and Rural Affairs (DEFRA), and prioritising resources where action is most needed.

The vast pool of available EO data, most of which has been funded by taxpayers for scientific purposes, remains a relatively untapped resource that could be brought to bear to help LAs meet their regulatory obligations, helping to make the UK a healthier place to live.

Conversations with companies offering these services have indicated that regulations have been drafted in such a way to make it difficult for LAs to submit satellite-derived data as acceptable evidence. Those LAs that are using space-enabled solutions as a low-cost way of monitoring air quality over large areas still have to invest in terrestrial monitoring technology to gather the data they submit as evidence in their annual reporting to DEFRA.

**CASE STUDY**

**EARTHSENSE**

**MONITORING AIR QUALITY FOR URBAN DEVELOPMENT AND TRANSPORT**

EarthSense is a data analytics driven firm specialising in the provision of air quality data, with the goal of monitoring and modelling air quality data for decision-making pertaining to developments in urban development, environmental analysis, and general air quality trends on a global scale.

To accurately measure air quality, EarthSense has developed the Zephyr compact air quality sensor which is able to accurately measure nitrogen dioxide, nitric oxide, temperature, and humidity, with additional optional particulate sensors and cartridges to measure carbon monoxide, sulphur dioxide, hydrogen sulfide, carbon dioxide, and total volatile organic compounds. Zephyr comes integrated with GPS and GSM data capabilities for remote monitoring and communications. EarthSense provides data hosting and management, providing access to the data via an API, website dashboard, or can integrate the data into detailed air dispersion city models called MappAir.

Through Zephyr, EarthSense has collaborated with logistics provider Kuehne + Nagel and is supported by the first UK Centre of Excellence for low-carbon tech, Cenex, on the ‘Temperature-controlled Range-extenders and Integrated Urban Mapping of Pollution’ (TRIUMPH) project. As part of the project, EarthSense collected real-time data on pollution measurements to help Tevva develop zero-emission strategies for environmentally friendly commercial vehicles and their cooling units. The goal of the data is to present a business case for investment in intelligent zero-emission temperature controlled transport.
The government has announced the introduction of a new Environment Bill to put the 25 Year Environment Plan on a statutory footing, and has introduced a new Office for Environmental Protection, committing future governments towards publishing an annual independent assessment of progress in this area. This may be a good opportunity for policy-makers to take a fresh look at the valuable role that space-derived data and space-enabled services can play in assessing environmental conditions, identifying ‘hotspots’ for action, monitoring compliance, and supporting behaviour change initiatives.

**TRANSPORT**

The Department for Transport’s (DfT) mission is to create a safe, secure, efficient and reliable transport system that works for the people who depend on it.52 The policy priorities supporting this mission focus on the creation of a stronger, cleaner, more productive economy. Policies also aim to help connect people and places by balancing investments across the country, making journeys easier, more modern and reliable. Furthermore transport should be safe, secure and sustainable. Ultimately the DfT’s policies aim to prepare the transport system for technological progress, an important aspect of which is promoting a culture of efficiency and productivity.

As the leader of the government’s ‘Future of Mobility’ grand challenge the DfT oversees commitments to invest £1b over ten years into the development of low-carbon powertrains, and £246m into the Faraday Battery Challenge to develop safe, cost-effective and high-performance batteries for electric vehicles.53 The strategy also includes the provision of grants to help people buy ultra low-emission vehicles, as part of a £1.5b investment between 2015-2021 to support the growth of this market. To further support the market investments will be made in electric vehicle charging infrastructure and hydrogen vehicle refuelling stations. The DfT will also work together with the automotive industry to deliver the Automotive Sector Deal.

Many aspects of transport policy are devolved to Scotland, Wales and Northern Ireland. For instance, decisions about passenger rail franchises, road signs, speed limits, and air passenger duties are all devolved in Scotland. Most policy decisions relating to aviation, shipping, and road traffic law are taken in Westminster and apply to the whole of the country.

In England, Highways England will be investing up to £25.3b between 2020-2025 in making the road network safer, more reliable, greener, more integrated, and smarter.54 Technology innovation has a critical role to play in achieving those objectives. In particular, changes to road transport are expected to be driven by

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52 Department for Transport. 2019. Single departmental plan
54 Department For Transport. 2018. Draft Road Investment Strategy 2
innovations in digital connectivity, automated vehicles, electric vehicles, increasing data generation and usage, and new emerging models such as ‘mobility as a service’.

The number and capability of connected vehicles is expected to grow rapidly. There are approximately three million on the road today and the Transport Technology Forum has estimated that 50% of all new vehicles will be digitally connected by 2020. Just as most connected vehicles currently make use of SatNav services, satellite-enabled services will be key to unleashing the potential capabilities of future connected vehicles.

The sale of new conventional petrol and diesel cars and vans is expected to be banned by 2040. There is a plan to tackle roadside nitrogen dioxide concentrations, with £475m of funding available to support LAs with the biggest pollution problems to tackle hotspots in their areas (part of a wider £3.5bn spending commitment to air quality and cleaner transport). As mentioned previously, satellite-enabled services can provide valuable tools to identify hotspots and monitor the efficacy of actions taken by LAs.

The government’s ambitious policy goal of phasing out petrol and diesel engines and encouraging take-up of ultra low-emission vehicles also requires significant investment in electric vehicle charging infrastructure. The Clean Growth Strategy includes a commitment to invest £80m (alongside £15m from Highways England) to develop one of the best electric vehicle charging networks in the world. Satellite-derived modelling and analytical tools can play a vital role in supporting the design and planning of that network, as well as helping to monitor the condition of charging points over time.

In 2018, UK-based Energeo took strides towards sustainable energy development by applying machine learning to aerial photography and satellite EO data to help overcome the infrastructure hurdles in the transition to low-emission vehicles. Funded in part by the UK Space Agency (UKSA), Energeo extracts and measures roadside features such as pavement widths and obstructions, on-street parking levels, and street light locations. This geospatial data enables rapid assessment of optimal electric vehicle charging station locations.

While this project was centered around providing the Bournemouth Borough with the data necessary to make educated decisions involving electric vehicle charging point installations, this type of information will eventually become globally applicable as the electric car market continues its inevitable growth. As electric cars have become increasingly prevalent over the last decade, with companies like Tesla popularising the technology, current charging infrastructure within cities and rural areas alike must be upgraded to match the increasing demand. In the future, Energeo plans on integrating a grid impact tool to measure how such electric vehicle charge points may affect the local electric power grids.

55 Department for Transport. 2018. Technology and RIS2
56 Ibid.
58 GOV.UK. 2017. Industrial Strategy: building a Britain fit for the future
City Science uses big data to help cities become more efficient by using data driven solutions in the transport and infrastructure industries. In particular, the company uses data to inform policy-making, optimise transportation projects and implement low-carbon systems.

With funding from the UKSA, City Science combined satellite position, navigation and timing (PNT) data with GPS data, vehicle counters and junction performance models to develop a Digital Twin of the key transport routes around Sedgemoor. Using this Digital Twin, Sedgemoor District Council was able to explore the impacts of the absolute number and time schedules of heavy goods vehicles (HGVs) on transport networks under a range of different scenarios. City Science developed a digital interactive notebook enabling the council to test different HGV scheduling options at a fraction of the cost of building a traditional transportation model.

The Transport Secretary announced in 2017 that £48b would be invested between 2019-2024 to maintain the nation’s rail networks, and additional funding would be made available for upgrades and innovation to improve rail travel technology and reduce its environmental impact. Satellite-enabled services can play a significant role in monitoring track conditions over large distances. Ground conditions can be analysed using EO data to ensure the structural integrity of tracks and bridges. EO and weather data from satellites can also underpin flood risk analysis and real-time monitoring to avoid or manage unplanned station closures.

Ambiental Risk Analytics works with public authorities to improve understanding of the impacts of climate change, ever-evolving cities, shifting populations and changing landscapes on flooding. After severe flooding in Hull in 2007 showed that flood modelling for heavy rainfall in towns needed to improve, Ambiental helped government agencies and insurers to develop more effective flood modelling to strengthen their capabilities to better price the risks and help towns avoid future unforeseen, potentially catastrophic, flood events.

By providing advanced tools, data, digital maps, SaaS solutions and expert advice on flood risk assessment and management, Ambiental helps to predict the location and severity of flooding, prevent damage, and protect lives, property and assets.

With International Partnership Programme funding from the UKSA, Ambiental has integrated satellite and terrestrial data into a solution for the Malaysian government that predicts flood events in time to allow orderly evacuation of villages and towns, saving hundreds of lives. Currently, with a Space for Smarter Government R&D grant, Ambiental is working with Transport for London and Thames Water to develop a system that provides early warning of track and station flooding, allowing for planned closures instead of costly disruption. The solution also helps monitor and manage flood events in real time, delivering significant operational benefits to public transport operators.
As part of ensuring the safety of rail networks when dangerous goods are transported via rail, satellite technology can be used for location tracking and communication with the goods owners to mitigate potential issues and manage loss risks. Companies will be able to monitor the situation of their goods at all times.

This is also true for the shipping industry, where goods may spend long periods of time on container ships that are not easily trackable out in the vast shipping lanes of the open oceans. Innovative startups like SiriusInsight.AI are fusing satellite data with other sources of geospatial data to track ships and provide detailed analysis of where a ship has been and what it might have come into contact with on its travels.

Today the UK has the largest aviation network in Europe and the third largest in the world. It is a rapidly growing industry that contributes at least £22b to the UK economy, along with over 230,000 jobs. Passenger numbers have been increasing for seven consecutive years, and it is estimated that UK passenger traffic could soar from 284 million in 2018 to 435 million by 2050. The government has just concluded a consultation to set the UK’s civil aviation strategy through to 2050.61

The consultation document highlights the need for innovation: £1.95b aerospace R&D investment has been committed from 2013-2026 to push forward advances in automation, electrification, digitalisation, and data sharing. Innovation is needed to deal with the explosive growth of drones, and developing solutions which realise the social and economic benefits presented by unmanned aircraft, while maintaining public safety and confidence. The UK needs a highly automated system capable of tracking and coordinating unmanned air traffic. The UK also needs to develop more advanced automated systems for sensing and avoiding other aircraft.

Innovation is further needed to position the UK to capture a share of the emerging hybrid and fully-electric aircraft market, which has the potential to transform aviation through opening up new routes, reducing carbon dioxide and NOx emissions, and noise impacts.

Space-enabled technology and systems have a critical role to play in transforming civil aviation. For example, the UK has taken a leading role, in collaboration with Canada, to bring about a change in the safe use of global airspace by piloting a new satellite-based surveillance system.

In April 2019, NavCanada and the UK air traffic control operator NATS launched a trial of a new Air Traffic Control system called Aireon. It uses technology installed on aircraft that automatically broadcasts data about position, speed and altitude via a global satellite network, enabling real-time air traffic surveillance and tracking for civil aviation authorities everywhere the aircraft fly.

Prior to this system, traditional ground-based surveillance covered just 30% of the globe,62 meaning that civil aviation authorities had to rely on position updates from aircraft every 10-14 minutes to track aircraft outside of radar coverage. The system is expected to significantly reduce flight safety risks, deliver cost savings to aircraft operators, and reduce carbon dioxide emissions by two tonnes per flight, based on an analysis conducted by NATS and the International Civil Aviation Organization.63

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60 Department for Transport. 2018. Aviation 2050: The future of UK aviation
61 Ibid.
62 NATS. 2019. Aireon system goes live - trial operations begin over the North Atlantic marking new chapter in aviation history
63 Ibid.
ENERGY

While some energy policy matters are devolved in Northern Ireland, policy direction for most of the UK is set through the central government Department for Business Energy and Industrial Strategy (BEIS). The BEIS Single Departmental Plan sets out an overarching aim to ‘ensure the UK has a reliable, low cost and clean energy system’. BEIS is pursuing four key policy objectives relating to this aim:

1. **MAXIMISE THE ADVANTAGES FOR UK INDUSTRY FROM THE GLOBAL SHIFT TO CLEAN GROWTH**

2. **ENSURE THAT OUR ENERGY SYSTEM IS RELIABLE AND SECURE**

3. **DELIVER AFFORDABLE ENERGY FOR HOUSEHOLDS AND BUSINESSES**

4. **MANAGE OUR ENERGY LEGACY SAFELY AND RESPONSIBLY**

In 2018, BEIS updated The Clean Growth Strategy which sets out the government’s key policies and proposals to drive economic growth while cutting greenhouse gas emissions. The Clean Growth Strategy forecasts that the UK’s low carbon economy could grow by an estimated 11% per year between 2015-2030 (four times faster than the rest of the economy) and could deliver between £60b and £170b in export sales of goods and services by 2030.

The UK government has committed to invest more than £2.5b in research, development and demonstration of low carbon energy, transport, agriculture, and waste solutions by 2021. Two significant Industrial Strategy Challenge Fund programmes have already been announced relating to this policy ambition: the £17m Grand Challenge Mission to establish the world’s first net-zero carbon industrial cluster by 2040 and at least one low-carbon cluster by 2030; and the £170m Grand Challenge Mission to at least halve the energy use of new buildings by 2030.

In April, UK Research and Innovation also launched a £30m Detailed Designs for Smart, Local Energy Systems competition as part of the Industrial Strategy Challenge Fund Prospering from the Energy Revolution Programme.

There is a clear opportunity for satellite-enabled solutions to play an important role in all of these key policy areas.

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**CASE STUDY**

**METHERA: TRANSFORMING OIL AND GAS EXPLORATION**

Methera is developing a satellite broadband service that will deliver strong broadband connectivity to targeted regions, with the potential to dynamically change areas where the services are provided.

The broadband service will revolutionise the manner in which oil and gas exploration is conducted by allowing the complex analysis of geological and scientific data to be performed centrally, as opposed to locally on individual exploratory oil rigs or survey vehicles. This will be brought about through the provision of ultrafast connectivity that will support the near real-time transfer of terabytes of data from exploratory rigs back to analysis centres. Additionally, the system will enable the rigs to be controlled remotely in order to ensure that the most relevant information is collected at the source and that minimal time is wasted between collecting samples.

The unique advantages of the Methera system is that the vast capacity density (broadband delivered per km²) supports the operation of multiple rigs and survey vehicles in close proximity, each accessing ultrafast broadband connectivity.
EO satellites can be used to monitor the condition of renewable energy infrastructure, especially in remote or offshore locations, to target maintenance efforts. In addition, highly accurate satellite-enabled weather forecasting supports more robust output predictions for solar, wind, and hydro energy, helping to reduce reliance on fossil fuels.

Likewise, EO satellites can also play a significant role in ensuring the reliability and security of energy distribution across the electricity grid. There are approximately 280,000 km of overhead power-lines in the UK. When a pylon or power line is interfered with, it can cause significant disruption and even potential danger to those nearby. Fallen trees, human interference, snow, and pylon displacement are all common hazards that can be spotted from space, raising alerts for faster resolution and proactive prevention.

There are also satellite applications in the arena of gas distribution. Approximately 85% of UK homes are heated by natural gas. The UK National Transmission System is a network of more than 7,600 km of gas pipelines that supply gas to about 40 power stations and large industrial users from natural gas terminals situated on the coast, and to gas distribution companies that supply commercial and domestic users.

Any major issues with the security or integrity of pipelines must be resolved as quickly as possible to ensure resilience of supply and to avoid potentially dangerous faults. Pipeline damage is usually caused as a result of construction activity and ground movement. Satellite imagery can monitor changes and generate alerts so preventative action can be taken. Additionally, sensors on the pipes themselves could regularly send data reports and communications to satellites, allowing for a better understanding of their condition.

The move to Smart Grids, with near real-time digital monitoring and control of energy use and supply, is an important cornerstone in the government’s energy policy. The government is committed to ensuring that every home and small business in the country is offered a smart meter by the end of 2020.

For the benefits of Smart Grids to be realised, suppliers need timely notification of incidents such as high energy consumption, power outages, and tensioning of the electrical system. When these changes are detected, resilient data connections with field equipment are required. SatCom networks can extend high-speed broadband and advanced communications applications to the most remote locations. For utilities, this means reaching the furthest points on the grid in a more cost-effective way than other core network technologies.

Satellites can also play a useful role in managing the UK’s energy legacy. The Nuclear Decommissioning Authority has observed that EO data, when combined with aerial and land-based observations and measurements, can “reveal additional information, helping with long-term predictions and planning in ways that would not be achieved with any of those methods alone.”

The Nuclear Decommissioning Authority is responsible for decommissioning and cleaning up 17 nuclear sites across England, Wales and Scotland. At the time of construction in the 1940s and 1950s, detailed records were not always made, making the task of decommissioning more challenging. EO imagery of sites could aide with planning and monitoring decommissioning operations across the 16,000 acres of nuclear estate.

Another area where satellite-derived data might add value is in monitoring groundwater flow. There are hundreds of boreholes across the estate that are manually sampled to provide data about water levels and radionuclide movement. If indicator plant species were to be identified (or planted) in and around the areas of interest, satellite imaging could be used to detect changes that might indicate groundwater movement, enabling better predictive analysis and helping to target manual sampling efforts.

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67 EMFs.info. 2011. Overhead power lines
69 National Grid. 2019. UK principal operations
70 European Space Agency. 2018. The Safety and Security of Critical Infrastructures
72 GOV.UK. 2017. Technology that’s out of this world
73 Ibid.
The 2015 National Security Strategy and Strategic Defense and Security Review document includes the observation: ‘The UK is reliant on access to space for our security, our economy, disaster management, and military capabilities’. Space was designated as a Critical National Infrastructure sector in 2015 in recognition of the critical role space assets and services play in our security. Increasing reliance on space was also flagged in the 2017 National Security Capability Review.

Space-enabled services play a crucial role in keeping us safe. Police and fire services depend on satellites to navigate the fastest route to emergencies. They can use mobile phone location signals to search for people who have dialled 999 for assistance, and through a technology called Advanced Mobile Location and GNSS they can pinpoint the location of the emergency to within a few metres. The UK is one of only eight European countries to have activated this capability to date, even though the technology is standardly included on smartphones.

This is an area where the UK could help save lives by sharing its policy and technical expertise with other European countries.

Increasingly, police in the UK are also able to draw on the data that is continually broadcast by mobile phones, relying on GNSS signals for position and timing to place a suspect at the scene of a crime.

In February 2019, the Justice Secretary announced the national roll-out of new satellite tagging for offenders which will provide 24/7 location monitoring. The introduction of this technology aims to strengthen supervision, enforce exclusion zones, and give victims greater peace of mind. If a tagged domestic abuser or stalker enters a banned area or a gang member is found somewhere they should not be, the system will issue an automatic alert and their whereabouts will be known. Victims will be able to feel safer with the knowledge that any breach of an exclusion zone will result in an immediate alert. The tags also provide a tougher option for community sentences which can be used alongside requirements like alcohol or drug treatment programmes.

The maritime sector is essential to the UK economy with around 95% of all imports and exports being transported by sea. It is estimated that the sector directly supports just over £40b in business turnover, £14.5b in Gross Value Added, and over 185,000 jobs for UK employees. The Maritime and Coastguard Agency is responsible (amongst other things) for responding to maritime emergencies, coordinating a 24-hour search and rescue service throughout the UK, preventing maritime pollution, and monitoring vessel movements within UK waters.

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75 Eurisy. 2018. The tech solution that can revolutionise search and rescue. Yet remains unknown to most.
These are all areas where satellite-enabled services can be of considerable value. In the event that a person is missing in a remote area, such as at sea or in mountainous regions, satellite data could enable a fleet of drones to quickly search a large area and locate the missing person. SatCom will allow for communications while earth orbiting satellites with GNSS can help rescuers search difficult terrains with ease.

EO satellites can monitor maritime conditions over large distances, issuing alerts when pollution levels rise, and providing evidence to identify and confront polluters. Likewise, satellite-derived data can be used for near real-time monitoring of vessels using sea lanes and waterways without having to send out so many ships and pilots. Those resources could then be better targeted on vessels that have been identified as ‘of interest’.

**CASE STUDY**

**SIRIUSINSIGHT.AI**

**TRACKING SHIPPING PATTERNS WITH EARTH OBSERVATION**

The SiriusInsight.AI platform, which received grant funding from the European Space Agency, collects and analyses geospatial data from satellite, land and air-based sensors to track shipping patterns and abnormalities in real-time. Using artificial intelligence, the company produces a ‘pattern of life’ for ships and is able to evaluate the performance of vessels along a route and detect unusual changes in environment based on deviations from this pattern.

Many Automatic Identification Systems (AIS), which ships use to communicate their location, are often inaccurate, incomplete, and can be switched off. By fusing AIS information with satellite EO and other data sources, SiriusInsight.AI is not vulnerable to the fallibility of AIS and thereby distinguishes itself from other tracking companies. This places stakeholders (such as fleet managers, shipowners and marine brokers) in a position to respond to situations in real-time, enhancing the safety and efficiency of shipping routes and supply chains. The platform also contributes to a greater transparency across the shipping industry, making it easier for governments and international organisations to identify sanction breaches, smuggling and illegal fishing.
This report has surveyed a number of key challenges to the widespread adoption of space and satellite technologies across the public sector. In this section, we outline ten practical recommendations for how the government can overcome some of these challenges, and support the UK to become a world leader in space-enabled GovTech. These recommendations can be segmented into the following four themes:

**BUILDING THE SPACE ECOSYSTEM**
To maintain the UK’s global influence, the government must take steps to continue to build the space ecosystem, and guarantee that there is a dynamic and well-funded market of new companies and startups.

**DATA PROCESSING & SHARING**
Some of the most immediate challenges facing the sector relate to the processing and sharing of spatial data across multiple government agencies. To tackle some of these challenges, the government must be proactive in establishing common standards for sharing and using data.

**PROCUREMENT & COMMERCIAL PROCEDURES**
Currently, there are a number of major commercial and procedural barriers to incorporating innovation from the space sector into the wider public sector. This needs to change for space and satellites to become a central part of the design and delivery of public services.

**PROMOTING SPACE ACROSS GOVERNMENT**
Arguably the greatest challenge for using space and satellites in the public sector is to change current cultural and organisational barriers to using space across government.
Space innovations financed through grants and other R&D funding mechanisms often struggle to find a recurring public sector route to market, or fail to be developed into market-ready products. The result of this is that companies often lack some of the key financial, commercial and operational requirements to be able to properly compete for public sector contracts.

Further, R&D-focused financing can provide little incentive for companies or research institutions to produce commercially viable products: in fact, some companies told us during interviews that they felt incentivised to pursue multiple consecutive R&D projects, due to the relative abundance of these funding streams.

This is also a problem for research institutions and universities, who often struggle to commercialise technical research outcomes, resulting in a cycle of innovation without commercialisation.

The government should consider funding programmes which aim to convert publicly-funded research into market opportunities. Programmes could take the form of entrepreneurial education schemes for scientists, providing assistance with prototyping, proof-of-concept and business model development, such as the Innovation Corps Program run by the Division of Industrial Innovation and Partnerships of the federally funded US National Science Foundation. Similarly, Australia’s government-owned corporate research body, the Commonwealth Scientific and Industrial Research Organization (CSIRO), runs an accelerator programme for publicly funded researchers.

The Australian government uses a variety of matched funding schemes to help convert research into end products. The Accelerating Commercialization scheme provides expert advice and match funding to researchers and startups to get products to market. Through the CSIRO kick-start programme, the government provides up to A$50,000 matched funding for research of ideas with commercial potential in collaboration with CSIRO™. The CSIRO Innovation Fund provides venture capital funding for startups built on the back of publicly funded research, and has invested in two space tech startups thus far: Gilmour Space and Myriota.
2. MOD, UKSA AND OTHER RELEVANT STAKEHOLDERS SHOULD WORK TOGETHER TO ESTABLISH A DEDICATED VEHICLE TO CONVERT SPACE AND SATELLITE INNOVATION IN THE MILITARY SECTOR INTO THE WIDER CIVILIAN COMMUNITY

The military is the larger customer of space technology and data. Consequently, the defense industry is a major source of innovation for space technologies, with novel technologies and applications emerging from innovation hubs such as jHub, the Defense and Security Accelerator and the Defense Science and Technology Laboratory. These technologies often have uses which range far beyond their utility for the defense industry. For example, the satellite-based GPS developed by the US military is the foundation for a vast range of services and applications which civilians around the globe use in everyday life. Government should explore how the benefits of technologies developed by the military can be transferred to the wider civilian population. Data from military technologies and programmes could also be made available to businesses to build applications and services. The Israeli Ministry of Defense (MOD) hosts a data science challenge programme in which military datasets (which are usually highly confidential) are made available to allow innovators to solve defined problems set by the Ministry.

CASE STUDY

US - APPLYING INNOVATION FROM THE DEFENSE SECTOR

Technology transfer is one of the mandates of the US Department of Defense (DOD) and it employs various mechanisms to fulfill this mandate. Cooperative R&D Agreements allow federal agencies to partner with commercial and academic actors to undertake research collaboratively for mutually beneficial ends, share resources, expertise, and intellectual property, catalysing commercialisation of technologies developed by agencies within the DOD. The Defense Advanced Research Projects Agency runs a Transition & Commercialisation program to facilitate technology exchange between DARPA projects and small businesses.

The Federal Laboratory Consortium is a national network of laboratories and research centers which commercialize and develop new applications for federally developed technologies. The Office of Research and Technology Application provides grants between $5,000 and $50,000 for pilot programmes which facilitate technology transfers. The US Navy has piloted several programs with this funding. A programme that proved successful was a series of Innovation Discovery Events in which navy inventors presented their innovations to a panel of experts for collective assessment of its commercial potential. Similar events could be held for military space innovations.

79 Institute For Defense Analyses. 2013. Exemplar Practices for Department of Defense Technology Transfer
A growing trend across Europe is governments offering financial support to venture capital funds making space technology investments. Most notably, the French National Center for Space Studies (CNES) has partnered with ESA to launch CosmiCapital, a €100m space venture capital fund, offering a new source of finance for companies on the ESA Business Applications Programme. The Italian Space Agency (ASI) has received €30m from the European Investment Fund to set up Astra Venture, a €80m venture capital fund for the Italian space economy (30% of the funding is expected to be raised from private sources). Following in the UK’s footsteps, with the British Business Bank’s (BBB) investment into Seraphim Capital, national governments have realised that there is value in a dedicated investment fund for space technology. Nevertheless, market engagement has highlighted that there is still a perceived need for more venture capital investment in space and satellites.

During interviews, many startup founders expressed concern that there is not a large enough variety of venture capital funds dedicated to the space and satellites market, and that it was therefore difficult to secure investments. To support greater diversity of businesses in the new space ecosystem, government should explore how to stimulate the establishment of new space venture capital funds, especially space funds with different priorities. Such a review should include a consultation with investors to understand what deters them from entering this market. Government should also explore whether it could assist startups in attracting investment by cultivating an active network of space angel investors.

80 European Space Agency. 2018. CosmiCapital venture fund to boost New Space ecosystem in Europe
81 European Space Agency. 2019. Primomiglio SGR and ESA Business Application to boost New Space ecosystem
4. THE GOVERNMENT COMMERCIAL FUNCTION SHOULD UNDERTAKE AN AUDIT OF CURRENT GOVERNMENT SPEND ON SPACE AND SATELLITE SERVICES, WITH A PARTICULAR FOCUS ON IDENTIFYING ANY UNNECESSARY DUPLICATION IN SPEND

Public spending in the space sector is uniquely difficult to track and analyse. There are a number of reasons for this. First, space contracts are often large, with a single contract covering a number of different requirements and services. As such, it is extremely difficult to properly track which services are included within the scope of a given contract. Second, the classification system for space contracts is complex and irregularly used, meaning that tracking space spend is often impossible. The main Common Procurement Vocabulary (CPV) code for space contracts is 34700000: Aircraft and spacecraft, but as outlined throughout this report, space and satellites services, especially data and analytics can be classified under more mainstream digital and data CPV codes such as 48000000 and 72000000. Even within the context of the UK’s generally poorly reported and opaque contract data, the space sector has particularly low contract visibility.

To counteract this, we recommend that the Government Commercial Function (GCF) undertakes a review of current government spend on the space sector, to give the public sector better oversight of where it is currently spending money. In particular, we recommend that the GCF attempts to identify any unnecessary duplication in contract spend, where public authorities could either combine or otherwise streamline contract or licensing agreements. On the back of this audit, GCF will be in a position to make recommendations to public sector authorities about where they can purchase shared space services.

EXPLAINER

GOVERNMENT COMMERCIAL FUNCTION

The Government Commercial Function (GCF) is a cross-governmental network of 4,000 civil servants and procurers that aims to institute commercial reform across government. The GCF sets out guidelines in its commercial operating standards for good commercial performance to ensure consistency in purchasing activities across government. The GCF is also responsible for developing the government’s commercial strategy and providing direction on how it should be implemented.

In February 2019, the Cabinet Office and the GCF published its ‘Outsourcing Playbook’ to provide guidance to departments on how to work with external suppliers. Beyond this, GCF supports public officials on complex procurement activities, provides departments with market and supplier intelligence, and creates training programmes to improve commercial capability across government. We recommend that this initial audit of procurement spend on space services should be followed up with ongoing support from the GCF for the space sector.

5. UKSA SHOULD PUBLISH GUIDELINES FOR HOW GOVERNMENT AGENCIES CAN PROCURE SPACE AND SATERNITE SERVICES

We have argued throughout this report that one of the main challenges to the greater adoption of space and satellite services across government is that public authorities suffer from a knowledge problem. Space continues to be treated as a niche technology area, with commercial and policy teams often unwilling to see it as a viable route for developing or purchasing public sector solutions. In particular, the commercial processes for space solutions are perceived to be complex and difficult to navigate, largely because they are less common and are different from processes used for purchasing common goods and services.

To build more confidence in purchasing space solutions across the public sector, we recommend that the government publishes an accessible and practical set of guidelines for how to procure space and satellite services. This would include developing a small checklist for commercial teams to keep in mind when buying space solutions, and a clear explanation of different commercial or licensing models that can be used. These guidelines would likely be written by UKSA, with support from wider government commercial functions, and potentially from internationally-renowned space and satellite research institutions. This model would be based on recent work undertaken by the Office for AI in partnership with the World Economic Forum (WEF), who are currently jointly writing procurement guidelines for public authorities in the UK looking to procure AI-based solutions.

Part of the motivation for that project is that AI-based solutions are perceived to be similarly complex and unfamiliar by commercial teams. A second motivation, however, is that the UK government is attempting to position itself as a world-leader in public sector applications of AI. There would be a similar strategic advantage in the UK government developing the world’s first comprehensive set of guidelines for purchasing space solutions in the public sector: helping to position the UK as the world’s leading government in space and satellites.
Procurement and commercial barriers continue to stifle innovation in the space sector, often locking out startups and new companies from entering the market. This, of course, is not a problem unique to space and satellites: almost every area of government-spent suffers from the same problem. However, due to the level of technical and specialist expertise involved in the space sector, it is one of the single greatest areas of procurement where the public sector should be looking to the market to drive innovation.

The key challenge for government, therefore, is to implement the right commercial processes to ensure that public sector spending and policy on space is being led by its world-class sector of companies and innovators. To do this, we recommend that government scales-up existing ‘challenge-based’ procurement procedures, where final spending decisions are made following the submission of ideas or solutions from the market.

The most notable example of this kind of procurement in the UK is the GovTech Catalyst, a recent £20m Cabinet Office initiative that serves to identify important public challenges and match them with innovative tech-based solutions offered by private companies. Challenges within this programme have been diverse, with only a few relevant to the space sector, including the recent ‘challenge’ to use geospatial imagery to improve the building of new housing. In addition to scaling up this funding to cover more space-related public sector challenges, we recommend that Government considers alternative procurement routes when buying space solutions. In particular, we recommend two OJEU procedures that could benefit the space sector: innovation partnerships and design contests.

Innovation partnerships allow contracting authorities to launch a tender without pre-specifying the desired product or service, which leaves room for suppliers to design an innovative solution within a contractual partnership. The authority can then enter into a contract with multiple partners within a single procedure, and structure the procedure into successive stages of research and development, without having to go out to further procurement at each stage. This process has been used extremely effectively by the Satellite Applications Catapult and NHS Arden & GEM, and should be used more widely by the sector.

A design contest is a procedure that allows a contracting authority to run a competition for the submission of designs or proposals from the market, before reviewing those submissions with an expert jury, and awarding either prizes or a follow-up contract to the selected winner. This would allow authorities with little expertise in space and satellites to engage with the market about how different solutions could solve their major business and policy problems.

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CASE STUDY

**UK - USING INNOVATION PARTNERSHIPS TO SOLVE PUBLIC SECTOR CHALLENGES**

Earlier in this report, we explained how satellites were enabling more accessible and less invasive endoscopy procedures via video-enabled capsules. Interestingly, this project is one of few examples of an innovation partnership being deployed in a non-military context in the UK. The Satellite Applications Catapult and NHS Arden & GEM worked with a number of different suppliers throughout the lifecycle of the contract to design the best possible solution for the local health ecosystem. Partners for the contract included SMEs such as CorporateHealth International, Openbrolly, and Wolfram Research Europe, as well as a number of universities and research institutions. With the imminent roll-out of the capsules across Scotland, this project shows how effective innovation partnerships can be for bringing together multiple stakeholders to design new solutions for long-standing public challenges.
There are very few common standards which public authorities can follow when using space data. In particular, there are no standards dictating methods for space data collection and utilisation, addressing criteria such as image resolution or frequency of measurements. The lack of common standards hinders the widespread use of space data across the public sector, as data is difficult to share and re-use when both the format and quality may be inconsistent across government. The implementation of the National Spatial Data Infrastructure in Singapore has accelerated the adoption of geospatial information and technologies in the public sector. All Singaporean governmental agencies have adopted the same standards for geospatial data management, enabling geospatial data to be used for different purposes in different public sectors. The UK has a national guideline for open access to geospatial data: however, a 2018 report by the Open Data Institute has highlighted major inconsistencies in its application.

Furthermore, not all satellite data is geospatial data. To enable the widespread adoption of spatial data across the public sector, national data standards should be extended to include all forms of satellite data. Satellite data policies are often designed to address the issue of data security, access, and distribution, whilst neglecting the issue of data standardisation and interoperability, as is seen in Germany’s National Security Policy for Space-Based Earth Remote Sensing Systems (2010), India’s Remote Sensing Data Policy (2011). A notable exception is Australia which has adopted FAIR (Findable, Accessible, Interoperable, Re-usable) data principles for geoscience data across government, including EO and remote sensing data.

The United Nations Task Team on Satellite Imagery and Geospatial Data has published a guideline on using earth observation data for national statistics, drawing on pilot programmes in Australia, Mexico, Colombia and Canada. In light of these pilot projects and other additional case studies, the UN framework addresses topics such as the institutional environment in which the data is used, relevance of data, timeliness (including frequency), accuracy, coherence, interpretability, accessibility, storage, management, and integration. The National Space Council should explore adopting this framework, or use the framework as a basis for establishing common standards for EO to be effectively shared and used across public sectors.

**CASE STUDY**

**USA - BUILDING COMPREHENSIVE SPACE DATA STANDARDS**

In 2013, the US published the National Strategy for Civil Earth Observations, designed to coordinate and standardise the production and use of EO data across federal agencies. Under this strategy, all data must go through quality control processes, the details of which should be published alongside the dataset, and are subject to a process of peer review. All data must be handled in accordance with the Group on Earth Observation (GEO) ‘Quality Assurance Framework for Earth Observation’, which provides community reference standards and detailed guidelines for data processing including uncertainty analysis, modeling, and algorithms. Documentation of metadata should be done at an appropriate time and in a standardised form. Common language and vocabulary should be employed, and data should be offered in formats which are compatible with a broad range of scientific tools and applications. Data should be catalogued in a way that would make it easy for other federal agencies to find the data.
The government should develop a clear plan to mitigate the effects of Brexit on the UK space industry, which includes a framework for working together with space bodies in Europe to secure access to the data, technology, and talent necessary to sustain the UK space industry. After France, Germany, and Italy, the UK is the fourth largest recipient of ESA funding, having received 8.8% of ESA’s budget in 2019, equivalent to approximately €369m. The sentiment that the UK is a highly valued member of ESA was repeatedly expressed in a roundtable of industry experts on ‘Brexit and Space’ hosted by the House of Lords. ESA has expressed its commitment to continue working with and investing in the UK, a commitment which was echoed in an interview with an ESA representative. Several UK space application startups have benefitted from ESA funding, including Hummingbird Technologies, Energeo, and Vidrona. It is vital to the interests of the UK’s space startup ecosystem that it maintains access to ESA funding for both current and future projects. Government should ensure that the UK remains a competitive force in the EU space sector through its membership in ESA, by maintaining an effective and productive relationship with a guarantee of access to funding.

As is already being done with the GNSS feasibility study, the government should invest in a national space programme, supplementing investments from ESA, to build the infrastructure to support space innovation and business.
As part of its Space for Smarter Government Programme, UKSA launched the ‘Introduction to Satellite Applications for the Public Sector’ course aimed at raising awareness amongst civil servants of the solutions space and satellite-based applications can offer to policy issues. UKSA also has a series of training videos on space technologies, programmes, and applications, and offers a catalogue of courses and webinars addressing space-related topics for public employees. Whilst these are extremely important initiatives, the current scale is too small to be effective. For instance, the satellite applications course is a one day course, only offered a few (on average three) times per year.

Again, these problems generalise across the public sector, and any recommendation for raising awareness about space and satellites could be applied to any other area of technical training. That said, space is a sector where general awareness across the public sector is low, and so improved training initiatives would be particularly helpful.

First, in-person learning opportunities should be scaled up and made more regular. In doing this, the government should take inspiration from Argentina’s LabGobAr model, which is arguably the world’s most systematic programme of training and workshops in Public Innovation, Digital Skills, and Technology for civil servants. This includes a dedicated initiative for public servants from central government offer training in technical subjects to local and provincial governments. Finally, we recommend that any scaled-up programme of training and knowledge-sharing in the space sector should involve engaging directly with startups and innovators, in order to understand the current art-of-the-possible.

CASE STUDY

SINGAPORE - NEW PLATFORMS FOR BUILDING DIGITAL SKILLS

Singapore has a dedicated Civil Service College (CSC) to train public officials for the future of government. CSC has partnered with leading third-party platforms such as Coursera and Udemy to provide courses to civil servants. Through its partnership with Udemy, CSC has built LEARN, a mobile app for civil servants. The app offers over 2,500 course and civil servants can follow curated pathways of courses to build up specialisations such as Data Analytics, Public Innovation, and Digitization. Content is composed of videos, quizzes, infographics and articles. We recommend that the UK government explores the creation of a similar platform with a dedicated Space pathway.
TIME FOR LAUNCH

One key way for space-enabled services to be adopted more widely across the public sector would be for space and satellite data to be used in landmark government projects. This would provide significant opportunities for the new space sector to work with government, but also serve to function as important case studies for the wider public sector to follow going forward.

Across the five key sectors detailed in this report, and other cross-cutting areas of government spend, there are multiple opportunities for space applications to be used in landmark government projects and initiatives. This includes projects being managed by the Infrastructure and Projects Authority (IPA), which oversees 130 highly complex and high-value procurements in its Government Major Projects Portfolio (GMPP). To properly integrate the space sector into these projects, we recommend that the new National Space Council should explore which current projects within the GMPP could benefit from space services. Going forward, we recommend that a representative from IPA is appointed to the National Space Council.

Beyond that, other key projects for the new space sector include the roll-out of 5G broadband with WMCA, a series of new border and port operations projects being led by DfT, and the Future High Streets Fund, a new urban regeneration project administered by MHCLG.

CASE STUDY

UK - WIGAN’S REGENERATION AS PART OF THE FUTURE HIGH STREETS FUND

The Ministry of Housing, Communities & Local Government has set up a £675m Future High Streets Fund to regenerate the UK’s high streets, thereby supporting small and local businesses, primarily by increasing footfall. Wigan is one of 51 towns selected to receive £150,000 from the Future High Streets Fund to develop a detailed business case for high street regeneration. Wigan’s proposal is based on the Wigan Town Centre Strategic Regeneration Framework, which outlines the town’s strategic priority projects. One such project in which space-enabled technologies could come into play is the development of a new car park strategy to support access to new businesses, based on a review of current car park strategy, to support access to new businesses, based on a review of current car park utilisation and distribution. Indeed, assessing transportation links and accessibility to town centers is also listed as a priority project for Morecambe, another town to receive funding from the Future High Streets Fund. Startups such as Travel AI and City Science use GPS data to track and model transport, mobility and congestion patterns which could assist Wigan town with developing a car park strategy for effective access to the high street.
GLOSSARY

EO
Earth Observation – Satellites gathering sensor data and imagery of the Earth at regular intervals, which is then beamed back down for use in a wide range of applications.

ESA
European Space Agency - Intergovernmental organization coordinating European space exploration and promoting the European space industry. ESA is comprised of 22 member states, and is funded both by member subscriptions and the European Commission.

GEOSPATIAL DATA
Information with a locational / geographical component to it, implicitly or explicitly representing a location relative to Earth.

GNSS
Global Navigation Satellite Systems – Satellites sending signals to receivers that allow the tracking of geographic position, movement, and time.

GPS
Global Positioning System - A constellation of satellites around the globe which work together by sending signals to a GPS receiver, to enable the receiver to deductively pinpoint its location.

NEW SPACE
Refers to the commercialisation of the space sector, in which the key players are private actors rather than government agencies. The new space industry is characterised by companies attempting to provide low-cost access to space technologies, services, and space flight.

SATELLITE COMMUNICATIONS
Satellites transporting data and voice communications over long distances, providing broadband connectivity to remote areas and broadcasting television signals directly to homes and offices.

SATELLITE REMOTE SENSING
Satellites estimating the properties of objects on Earth's surface, atmosphere, and oceans, without making physical contact, by measuring the electromagnetic energy emitted or reflected by these objects.

SSA
Space Situational Awareness - Information regarding objects, both manmade and natural, in Earth's orbit and near Earth. SSA programmes attempt to monitor space objects and space weather to identify potential hazards.

SSTS
Space Tracking and Surveillance Systems - Constellations of satellites in low earth orbit which detect and track missiles, active and inactive satellites, and space debris, for the purposes of national security.

UKSA
UK Space Agency - Governmental executive agency responsible for developing strategy for the UK civil space programme, supporting the UK space sector and coordinating UK civil space activities.

SMALL SATELLITES
Satellites with a mass <500kg, categorized by mass. These include nanosatellites (1-10kg) and picosatellites (0.1-1kg). Smaller satellites are cheaper to build and launch, and can piggyback on larger vehicles with excess capacity.

SOLAR RADIATION DOSIMETER
Device used to measure the amount of energy deposited by ionising solar radiation.
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