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Science and Technology Committee

UK space strategy and UK satellite infrastructure

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Science and Technology Committee

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Contacts

All correspondence should be addressed to the Clerk of the Science and Technology Committee, House of Commons, London, SW1A 0AA. The telephone number for general inquiries is: 020 7219 2793; the Committee's e-mail address is: scitechcom@parliament.uk.

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Summary

The use of space and satellites is essential for day-to-day life: satellites support a range of public services such as navigation, weather forecasting and, telecommunications. It is estimated that over £360 billion (about 17%) of the UK's non-financial business GDP per year is dependent on satellites and that the negative financial impact of the UK losing access to global navigation systems could be as high as £5.2 billion for a five day disruption.

In the past few years, the Government has signalled its support for the UK space industry, with investments made to establish UK launch sites and the publication of the National Space Strategy and the Defence Space Strategy. The Government also made a significant investment when it purchased the satellite communications company OneWeb. Despite these interventions, the Government's strategy for the UK space industry lacks coherence and more must be done to secure the sector's future success. There have also been significant concerns about the Government's investment in OneWeb.

The Government must also improve its approach to leadership on space. Currently, the approach to space policy across Whitehall is disjointed and unclear. This has been exacerbated by the National Space Council, which was only established in 2020, being disbanded earlier this year without explanation or clarification of new governance arrangements. The Government must clarify the new governance arrangements for space and publish detailed implementation plans for the National Space Strategy, which lacks specifics and a clear programme of work.

It is disappointing that the first launch from UK did not take place in summer 2022 as was originally proposed. At the time of writing, no date for a launch has been set. To ensure this launch takes place as soon as possible and that other launches follow soon thereafter, the Government must make sure that the Civil Aviation Authority (CAA), who award required licences, is appropriately resourced to issue them quickly.

Since the UK lost access to the secure Position, Navigation and Timing (PNT) provided by the European Union's Galileo system, the Government has failed to take appropriate action to ensure that the UK has access to secure PNT should the US's Global Positioning System (GPS) fail. Although a significant amount of money and time has been invested across Government into investigating and planning a UK PNT system, the Government has failed to publish the outcomes of these investigations. We urge the Government to publish a National PNT Strategy and set out what ground and space-based components will be used in a UK PNT system.

The Government's purchase of OneWeb was carried out under exceptional circumstances and it is still unclear what benefits the investment will bring to the UK public. Given the unusual investment, the Government should avoid making similar purchases. Further, given the considerable public investment, the Government should report to Parliament on the state of the Government's investment in OneWeb on a yearly basis.

To ensure the success of the space sector more broadly, interventions are required to inspire a diverse range of people to train and take up jobs within the sector. Whilst the clustering of space companies in Glasgow and at the Harwell Space Cluster has brought

many benefits to the sector, focus should be placed on spreading the success of the sector across the country. The UK should also think globally and continue its strong association with the European Space Agency, whilst seeking connections to collaborate with other allies.

1 Introduction

1. The UK space industry is a fast-growing sector, and its income has more than trebled since 2000.[1] It generates an estimated income of £16.5 billion (0.31% of UK GDP) for the UK per year and supports around 47,000 jobs across all parts of the UK.[2] The UK space sector (see Box 1 for a more detailed description of the sector) supports a range of public services—particularly through satellite data and imagery—such as telecommunications, global positioning system (GPS), weather forecasting and disaster relief. The growing global reliance on satellites and their data and the reducing cost of launching small satellites into space has driven the growth of the space sector in the UK and globally.[3]

2. Over the past five years, the Government has taken a number of steps that signal its support for the UK's space sector. In 2018, a new regulatory framework was introduced under the Space Industry Act 2018,[4] which provided the legal framework to enable commercial spaceflight in the UK. The new regulations supported the growth of the UK spaceflight programme, LaunchUK, which aimed to establish commercial vertical and horizontal spaceports in the UK from 2022.[5] Later, in June 2020, the Government invested in the satellite technology firm OneWeb,[6] and established a new Cabinet Committee on the sector termed the National Space Council which would consider issues "concerning prosperity, diplomacy and national security in, through and from Space, as part of coordinating overall Government policy".[7]

3. In September 2021, the Government published the UK's first ever National Space Strategy, which described the Government's ambitions for the UK space sector.[8] The strategy brought together the civil and defence aspects of space and set out five key goals for the UK, which it said would be achieved through the strategy's ten-point plan.

Our inquiry

4. We launched our inquiry into the UK space strategy and UK satellite infrastructure on 23 April 2021 to explore how the UK could optimise the benefits from this growing sector. Our inquiry was launched before the publication of the National Space Strategy and we sought submissions on:

- the prospects for the UK's global position as a space nation;
- the breadth of the UK space sector and what support it needed to grow;
- how the Government should ensure that the UK had resilient and future-proofed access to Position, Navigation and Timing (PNT), Earth Observation (EO), and Communication capabilities;
- and what the aims and focus of the National Space Strategy should be.

1 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p10
2 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p1
3 Morgan Stanley, Space: Investing in the Final Frontier, 24 July 2020
4 The Space Industry Act 2018
5 UK Government, LaunchUK, 18 July 2022
6 Press release: UK government to acquire cutting-edge satellite network, Department for Business, Energy & Industrial Strategy, 3 July 2020
7 Cabinet Office, List of Cabinet Committees, last updated 21 October 2021
8 HM Government, National Space Strategy, 27 September 2021

5. We have published nearly 100 written submissions and taken oral evidence from 25 witnesses, including academics, business leaders from the space industry, leaders of other country's space agencies, the CEO of the UK Space Agency (UKSA), the Civil Aviation Authority (CAA), the Executive Chair of the Science and Technology Facilities Council (STFC) and the then Secretary of State for Business, Energy and Industrial Strategy, Rt Hon Kwasi Kwarteng MP. We also visited the Harwell Space Cluster and met with companies and academics in Glasgow. Although we took written evidence before the National Space Strategy was published, we were able to gain valuable insights on its contents from the witnesses who gave oral evidence to our inquiry. We are grateful to everyone who contributed to our inquiry.

Scope of this Report

6. Whilst the National Space Strategy brought together the civil and defence aspects of space, our inquiry has mainly focussed on the civil space capabilities. Where defence aspects are mentioned, it is done so to highlight how the two aspects of space are closely linked. For more details on the defence aspects of space, please refer to the recent Defence Committee inquiry into and Report on *Space Defence*.[9]

Key space sector definitions

7. Before we begin to set out the evidence received during our inquiry, Box 1 explains some of the key terms that were integral to our understanding of the space sector.

Box 1: Key space sector definitions

Defining the space sector

The space industry is often defined by two components: 'downstream' and 'upstream':

- **Upstream** refers to space manufacturing (including satellites, launch vehicles, and ground segment equipment), testing, and launching; and
- **Downstream** describes services such as satellite operations, satellite service provision (broadcasting, communication, navigation, Earth Observation (EO), and weather forecasting) and data processing.[10]

A higher proportion of revenue and employment comes from downstream services; the 'Space Applications' sector[11] was estimated, for example, to have produced 74% of the space sector's total income in 2019/20.

9 House of Commons Defence Committee, Space Defence, Inquiry concluded on 8 March 2022; House of Commons Defence Committee, Third Report of Session 2022–23, Defence Space: through adversity to the stars?, HC 182

10 London Economics, Industry 4.0 and the Future of UK Space Manufacturing, January 2019

11 Space Applications is defined at the applications of satellite signals and data and includes direct-to-home broadcasting and communication services; BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p5

Satellite sizes

Satellites come in a large range of sizes and masses that are appropriate for their different intended functions and orbit.[12] Although there is no globally accepted classification for sizes of satellites, industry generally follows the classifications shown in the table which follows.

Classification		Mass	Orbit	Example size
Large		> 1000 kg	GEO	Bus (or larger)
Medium		500 to 1000 kg	LEO/MEO/ GEO	Small car
Small		< 500 kg	LEO	
	Mini	10 to 500 kg		Fridge
	Micro	10 to 100 kg		Beachball
	Nanosatellites	1 to 10 kg		Toaster

Due to improvements in technology, the ability to produce smaller satellites has increased, bringing with it a reduction in manufacturing and launch costs (less mass to launch means less fuel needs to be used).

Types of orbit

Geostationary Orbit

Satellites in geostationary orbit (GEO) circle Earth above the equator following Earth's rotation by travelling at the same rate as Earth turns. This results in satellites in GEO being 'stationary' over a fixed position. To perfectly match Earth's rotation, a GEO satellite must be placed at a height of almost 36,000 km to avoid distortion from Earth's gravitational pull. At this distance, one GEO satellite can see a large amount of Earth's surface so as few as three satellites can provide global coverage.[13] Telecommunication and weather monitoring satellites are often placed in GEO.

Low Earth Orbit

A low Earth orbit (LEO) is an orbit that is relatively close to Earth's surface; satellites in LEO usually orbit at an altitude of less than 1,000 km. Unlike geostationary satellites, LEO satellites do not have to follow a particular path around Earth, which means there are more available routes for satellites in LEO. This has resulted in increased popularity of companies making use of LEO. Unlike GEO satellites, a low orbiting satellite covers a limited area of Earth's surface so a constellation of a large number of similar satellites is required to provide full global coverage for any one system.[14]

12 Viasat, How big is that satellite? A primer on satellite categories, 27 April 2021; NASA, What are SmallSats and CubeSats?, 26 February 2015

13 ESA, Types of orbits, accessed 9 March 2022

14 ESA, Types of orbits, accessed 9 March 2022

Types of launch

Rockets are used to launch one or more satellites into their individual orbits. The mass of the payload and the height of the target orbit, together, generate the requirement for rocket power. A rocket with more power will be required to launch a heavy payload into GEO, compared to a small satellite being launched into LEO.[15]

Vertical launch

A vertical launch is the most common type of launch and typically has between two and three stages.[16] In a three-stage rocket:

- the first launch stage is ignited and launches the rocket up vertically. When this stage runs out of fuel, it is jettisoned and falls back to Earth, then;
- the second launch stage is ignited and carries the rocket onto the next part of its journey. This second stage is also eventually discarded; and
- the third stage carries out more accurate manoeuvres to place the satellite into the required location and orbit.[17]

Vertical launches are carried out in purpose-built spaceports. Two vertical launch sites are currently being built in the UK: SaxaVord Spaceport, on Unst in the Shetland Isles and Space Hub Sutherland, in Sutherland, Scotland.

Horizontal launch

Horizontal launch, which is currently much less commonly used, can take place off an airport runway. An aircraft takes off as usual and navigates to a remote location, where a rocket is then released from underneath a wing. Once the rocket is safely away from the aircraft, it ignites and lifts into space. Horizontal launches save on fuel use as the rocket is carried into the upper atmosphere, but the use of an aircraft limits the mass of payload that can be launched. Compared to vertical launches, horizontal launches can take place from already operational airports, meaning that there is a wider range of potential launch locations available.[18] A horizontal launch site is currently being established in Newquay, Cornwall.

Aims of this Report

8. In this Report we assess the Government's National Space Strategy and make recommendations for how the Government can best support the UK space sector and ensure that the UK has secure access to critical capabilities that satellites provide:

- In Chapter 2, we explore the UK's access to core space-based capabilities such as Communications, Position, Navigating & Timing (PNT), and Earth Observation, and discuss the Government's investment in the satellite communications firm OneWeb.

15 ESA, Types of orbits, accessed 9 March 2022
16 Space centre, UK Spaceport: FAQ, accessed 1 April 2022
17 Orbital today, What Is The Difference Between A Horizontal And Vertical Launch?, 3 February 2020
18 Orbital today, What Is The Difference Between A Horizontal And Vertical Launch?, 3 February 2020

- In Chapter 3, we review progress towards the development of UK's small satellite launch sites and analyse the progress made towards establishing appropriate spaceflight regulations.
- In Chapter 4, new technologies are identified, including those that could be developed to encourage space to be exploited in a more safe and sustainable way.
- In Chapter 5, we discuss the breadth of the UK space sector and identify areas where support appears to be required to provide emerging industries with better prospects for success.
- In Chapter 6, we reflect on useful insights from overseas witnesses, and explore the benefits that international collaboration has brought to the UK and how the UK might build more partnerships in the future.
- In Chapter 7, the space skills shortage is discussed, with suggestions of what interventions need to be taken to develop the space sector workforce.
- Finally, in Chapter 8, we reflect on the targets set out in the National Space Strategy and make recommendations about the key next steps for the Government and its agencies.

2 Maintaining access to core space capabilities

9. It is estimated that over £360 billion (about 17%) of the UK's non-financial business GDP per year is dependent on satellites.[19] The range of functions provided by satellites is vast and include services such as communications, navigation, financial transactions, and weather forecasting.[20] These services are vital to the UK and provide further benefits to many industries, including agriculture, maritime, urban development, and energy. In this Chapter, we discuss the need for resilient and secure access to core services provided by satellites, namely: Communications; Position, Navigation and Timing (PNT); and Earth Observation (EO), which are critical space infrastructure.[21] We explore the consequences of leaving the European Union on the UK's participation in key space programmes and make recommendations on steps that the Government needs to take to secure access to core services, which were recognised as important in the National Space Strategy within Pillar Four: "Developing resilient space capabilities and services".[22] We also discuss the Government's investment in the communications company, OneWeb, including the Government's motivations for the purchase and the potential benefits that being a shareholder could bring to the UK.

Communications

10. Communication satellites help to provide television, radio, internet, telephone and data transfer services. The National Space Strategy defined the capabilities of satellite communications as "global, secure, and resilient communications and information exchange via satellites and ground stations for civil and defence purposes".[23] The satellite telecommunications sector is the largest contributor by value to the UK space sector;[24] in 2019/20 direct-to-home (DTH) broadcasting was estimated to make up 45% of the space industry's income.[25] This sector, which includes satellite operations and provision of services such as TV and broadband, makes a significant contribution to the economy, supporting an estimated £101 billion of GDP.[26]

11. As well as hosting world-leading expertise and capabilities in the manufacturing of communication satellite technology, through companies such as Airbus,[27] the UK hosts several top tier communication service providers such as Inmarsat and Avanti.[28] In evidence to us, Yasrine Ibnyahya, Director of Advanced Concepts at Inmarsat, explained that the company was able to source a lot of its infrastructure in the UK, with nine of its fourteen assets being manufactured in the UK.[29] However, Dr Ibnyahya expressed concern that as a procurer of technology, the supply chain available in the UK was too

19 know.space, Size & Health of the UK Space Industry 2020, May 2021, p24
20 POSTnote 514, UK Commercial Space Activities, 15 December 2015
21 Satellite Applications Catapult (SPA0037)
22 HM Government, National Space Strategy, 27 September 2021, p38
23 HM Government, National Space Strategy, 27 September 2021
24 ADS, UKspace (SPA0056)
25 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p5
26 know.space, Size & Health of the UK Space Industry 2020, May 2021, p24
27 UK Research and Innovation (UKRI) (SPA0024), Department for Business, Energy and Industrial Strategy (SPA0026), Royal Aeronautical Society (RAeS) (SPA0079)
28 Lockheed Martin UK (SPA0050)
29 Q152

limited and Inmarsat often relied on Airbus for manufacturing.[30] She also said that one of the UK's weakness was in integrating payloads into a complete system, but that there were signs that the Skynet (the Ministry of Defence's communication satellites) programme might address this issue in the future.[31]

OneWeb

12. OneWeb is a global communications company that is building a low Earth orbit (LEO) satellite constellation to deliver broadband services worldwide for civilian and military use.[32] On 27 February 2019, OneWeb successfully launched its first six satellites into low Earth orbit (LEO) from French Guiana, South America.[33] By doing so, OneWeb secured priority rights to the radio spectrum that LEO satellites use.[34] This means that OneWeb has priority status to utilise the capacity of this spectrum in order to improve connectivity access around the world. Other LEO constellation operators need to coordinate with OneWeb to avoid causing interference to OneWeb's services.

13. In March 2020, a year after its first launches took place, OneWeb filed for Chapter 11 bankruptcy protection in the US after its largest investor, Softbank, refused to provide OneWeb with the funding it required.[35] When we asked OneWeb about the bankruptcy, Chris McLaughlin, the company's Chief of Government, Regulatory Affairs, and Engagement, told us that covid-19 had played a part:

> […] at the time OneWeb had invested approximately $3.4 billion to build out its network and it was due to get a final $2 billion from the investor SoftBank. It had every prospect that it was going to get that. Just at that moment, a little thing called Covid threw the whole financial market up in the air. SoftBank had a number of challenges with other investments. We work with one of them, which hit the headlines at the time. It found itself in a situation where it could not put in the $2 billion.[36]

14. In July 2020, the UK Government led a successful bid to acquire OneWeb, alongside the Indian telecommunications company, Bharti Global Ltd, with each partner contributing $500 million.[37] The Government set out its rationale for the purchase in a press release:

> The deal will enable the company to complete construction of a global satellite constellation that will provide enhanced broadband and other services to countries around the world.
>
> […]

30 Qq152–154
31 Q152, The Skynet system is a set of sovereign satellites which provide secure communications for UK defence and NATO allies. The system, which is currently on its fifth iteration, 'Skynet 5,' is owned and operated by Airbus on behalf of the Ministry of Defence (MoD). In July 2020, the MoD contracted Airbus to carry out updates to the Skynet 5 system and launch a further satellite, Skynet 6A. Q152
32 OneWeb (SPA0008)
33 OneWeb, OneWeb Makes History as First Launch Mission is Successful, 28 February 2019
34 OneWeb, OneWeb Secures Global Spectrum Further Enabling Global Connectivity Services, 7 August 2019
35 Space News, OneWeb files for Chapter 11 bankruptcy, 27 March 2020
36 Q240
37 HM Government, UK government to acquire cutting-edge satellite network, 3 July 2020

> With a sovereign global satellite system, the UK will further develop its advanced manufacturing base, making the most of its highly skilled workforce as the hardware is further developed and equipment and services are deployed to make the most of this unique capability.
>
> OneWeb will also contribute to the government's plan to join the first rank of space nations, along with our commitment to making the UK a world leader in science, research, and development.[38]

Prior to the Government announcement, the then BEIS Acting Permanent Secretary and Accounting Officer, Sam Beckett, wrote to the then Secretary of State for Business, Energy and Industrial Strategy, Rt Hon Alok Sharma MP, seeking a Ministerial Direction for the purchase, noting the time available to review the purchase, value for money and potential non-monetary benefits.[39]

The UK Government's rationale for the OneWeb purchase

15. Throughout our inquiry, we have sought to gain a better understanding of the rationale for the Government's investment in OneWeb and why the purchase required a formal ministerial direction. In his evidence, Chris McLaughlin, OneWeb's Chief of Government, Regulatory Affairs, and Engagement, told us that after SoftBank had been unable to provide OneWeb with the funds that it required, OneWeb had sought a "covid loan" from the UK Space Agency (UKSA) in the order of a "couple of hundred million pounds". UKSA refused this loan on the basis that OneWeb's constellation was incomplete and its services were not yet operational.[40] Later in the session Mr McLaughlin explained that OneWeb then approached the UK Government, asking them to consider providing a "commercial loan on commercial terms."[41] Mr McLaughlin said that the Government became interested in investing in the company, rather than providing a loan, due to it being a "unique asset" which would give the UK priority access to the spectrum that OneWeb had secured by launching its first set of satellites:

> I cannot speak for the Government perspective, but, looking at it as an outsider, the evolution of it was: here is the asset, OneWeb, with global spectrum and global orbital opportunity, and it is to be sold in a process through the New York courts and someone will have it. Three of those were the Chinese; a couple of them could be American; another could be Canadian; and there could almost certainly be a European option as well. Was it content? That was something the Government had to weigh up in their own right, but the option was that it is going to be sold.[42]

16. As it had previously been reported that the then Prime Minister's (Rt Hon Boris Johnson MP) former adviser, Dominic Cummings, had persuaded the Government to

38 HM Government, UK government to acquire cutting-edge satellite network, 3 July 2020
39 BEIS, Letter to the Secretary of State from the Acting Permanent Secretary and Accounting Officer, 26 June 2020
40 Q240
41 Q240
42 Q214

invest in OneWeb, we asked Mr McLaughlin to confirm Mr Cummings' involvement in the transaction.[43] He told us that he had never met Mr Cummings, and that he could not "shine any light on" Mr Cummings' motivation.[44]

17. When we asked the then Secretary of State for Business, Energy and Industrial Strategy (Rt Hon Kwasi Kwarteng MP) to confirm what had motivated the Government to make this $500 million investment in OneWeb (£374 million), he simply referred to a letter written by his predecessor in response to Sam Beckett's request for a ministerial direction.[45] The letter, dated 26 June 2020, confirmed that the then Secretary of State for BEIS, had taken advice from officials at HMT, BEIS, UKSA and the Cabinet Office and was happy to support the purchase of OneWeb.[46] The letter described the potential benefits that Ministers predicted HMG's investment in OneWeb would bring to the UK in the following terms:

> […] OneWeb, a UK-based company, represents an opportunity for UK interests globally. As you say, it would be the first mega-constellation operator, if it succeeds, and would have the potential to connect millions of people, in particular those in remote, rural locations without broadband access. There are also broader potential benefits that could be realised beyond global broadband. lf OneWeb is successful, the UK would have a share in a global space platform, including through possible future research and development, and potentially bringing future manufacturing to the UK. There could be wider, less quantifiable benefits of signalling UK ambition and influence on the global stage.[47]

Hugo Robson, Chief Negotiator for BEIS, explained to us that a ministerial direction was needed as the department was concerned with the speed at which the transaction took place and the lack of time available to carry out the normal due diligence for such a significant investment.[48] Mr Robson said that the reason for seeking a ministerial direction was a "process issue":

> The view taken was that, although it could be justified from a commercial point of view, we were unable to demonstrate at that point value for money against the alternative options that might have been available at the time. As I say, the main reason for the direction was a process issue.[49]

18. Views within the space sector on the Government's investment in OneWeb varied. Some stakeholders thought that the deal gave the UK an important technical asset and signalled that the Government had great ambitions for the UK space sector.[50] Dr Jonathan Eastwood, Director of the Space Lab Network of Excellence, commented that the decision to invest in OneWeb "strategically places the UK as the first major European player in the

43 The Times, OneWeb - Dominic Cummings' £400m moonshot, 12 July 2020; BBC News, OneWeb: UK rejects Russian demand to sell share in satellite firm, 2 March 2022
44 Q271, Q277
45 Q460
46 BEIS, Letter to the Acting Permanent Secretary and Accounting Officer from the Secretary of State, 26 June 2020
47 BEIS, Letter to the Acting Permanent Secretary and Accounting Officer from the Secretary of State, 26 June 2020
48 Q481
49 Q482
50 Satellite Applications Catapult (SPA0037), techUK (SPA0042), Jacobs (SPA0073), Fujitsu Ltd (SPA0091)

constellation-based communications market".[51] In her evidence to us, Rebecca Evernden, Director for Space at BEIS, confirmed that the investment decision was made due to the global strategic asset it provided to the UK and the future opportunities it could bring to the UK.[52]

19. Having said this, concerns were raised that there was a lack of due diligence surrounding the investment,[53] suggesting that investment in OneWeb was prioritised over providing money to other space companies. A number of stakeholders suggested that the Government needed to provide clarity on the long-term strategy regarding OneWeb and how it would be used to support the rest of the UK space sector.[54] When we asked the then Secretary of State if he was working to ensure that the rest of the sector understood the Government's rationale for its investment, he told us:

> We have to be very clear about what the nature of our investment means. There was a suspicion among the sector that somehow we would prioritise OneWeb, or we would be biased in favour of OneWeb, and we have been very strict about that. We very clearly want to have a competitive, diverse sector. We do not want the Government's stake in OneWeb to prejudice competition or tilt the playing field in a highly competitive market.[55]

When asked to confirm whether he thought that the approach used to purchase OneWeb could be used elsewhere, the then Secretary of State claimed that the investment was a "unique opportunity," but that it was " … not something that I think is usual, and I would not want it to be a usual, day-to-day occurrence that governments take equity stakes—ultimately, taxpayers' money—in businesses that were bankrupt".[56]

20. Since the UK's rescue package of $500 million, in a 50:50 deal[57] with Bharti Global Ltd, OneWeb has attracted further investments from SoftBank, Eutelsat (a French satellite operator), and Hanwha Systems (a South Korean technology conglomerate).[58] This has resulted in the UK's investment being diluted, with the UK owning 19% of the company in February 2022.[59] Despite the dilution, we heard from OneWeb and BEIS, that the UK had a "golden share," giving it control over OneWeb's operation and allowing the UK to appoint three non-executives directors to its board.[60] Although we did not gain any further clarity about what additional benefits the UK's "golden share" provided, a letter from the then Permanent Secretary at the Department for BEIS to the Chair of the Public Accounts Committee stated that the UK's special share could be "exercised to protect national security interests".[61]

51 Dr Jonathan Eastwood (Director, Space Lab Network of Excellence and Senior Lecturer, Dept. of Physics at Imperial College London) (SPA0035)
52 Q464
53 Dr Thomas Cheney (Lecturer in Space Governance at AstrobiologyOU, The Open University) (SPA0015); The Times, OneWeb - Dominic Cummings' £400m moonshot, 12 July 2020; SkyNews, OneWeb: Dominic Cummings and the £400m public bailout to rescue an imperilled satellite internet firm, 22 March 2021
54 ADS, UKspace (SPA0056), Thales (SPA0060), AstrobiologyOU, The Open University (SPA0072), Jacobs (SPA0073), Athena (SPA0083)
55 Q462
56 Q472
57 HM Government, UK government to acquire cutting-edge satellite network, 3 July 2020
58 Q254
59 Q464
60 Q255, Q464, Letter to Chair of PACAC, OneWeb, Company, accessed 11 March 2022
61 Letter to Chair of PACAC

21. After our inquiry finished taking evidence, on 26 July 2022, the UK Government announced that a merger of OneWeb and Eutelsat was planned.[62] The new business would be 50/50 owned by shareholders in both companies.[63] The Government framed this merger as "positive news for UK taxpayers" and said that the UK Government would retain its "special share," which gave exclusive rights in relation to OneWeb, including:

- a range of national security rights, including over security standards of the OneWeb network and use of the OneWeb network for national security purposes;
- the UK remaining the preferred location for future OneWeb launches; and
- OneWeb preferring businesses in the UK for future procurement for manufacturing on a commercial basis.[64]

The Government also said that the deal would be subject to UK and international regulatory approvals, including through the National Security and Investment Act, as well as approval of Eutelsat's shareholders. It is expected that the merger will complete in the first half of 2023.[65]

22. Having said this, concerns were raised about the merger, with former Science Minister George Freeman MP commenting:

> The UK's golden share in LEO satellite constellation OneWeb is a key part of the UK's commercial Space Industry Strategy. Unless our rights are protected this sale to France's Eutelsat will hand over another key industrial asset to UK competitors.[66]

The Chair of the Business, Energy and Industrial Strategy Committee also wrote to BEIS to express his concern that the then Secretary of State was both the Government lead for the UK's share of OneWeb and lead decision maker for the National Security and Investment Act scrutiny. The BEIS Chair also highlighted that the Chinese government (through China Investment Corporation) currently held minority shares in Eutelsat. He asked the then Secretary of State to confirm how he would manage this conflict of interest and how he would address the issue of the Chinese government having a minority shareholding in Eutelsat.[67] The Government response to this letter stated that, if required, decision-making would be delegated to prevent conflicts of interest. In relation to the Chinese government investment, the response pointed out that China Investment Corporation had never been represented on the Eutelsat board and that its Eutelsat shareholding was less than 4%, which would be diluted by the deal.[68]

Potential benefits of the OneWeb investment

23. During our inquiry we tried to gain an understanding of what benefit OneWeb might bring to the UK. Mr McLaughlin, public affairs chief at OneWeb, said that OneWeb would be supplying internet connectivity to users across the world through telecoms operators;

62 BEIS, OneWeb merger with Eutelsat, 26 July 2022
63 OneWeb, Eutelsat and OneWeb to combine: a leap forward in satellite connectivity, 25 July 2022
64 BEIS, OneWeb merger with Eutelsat, 26 July 2022
65 BEIS, OneWeb merger with Eutelsat, 26 July 2022
66 Tweet by George Freeman MP
67 BEIS Committee, Letter to the Secretary of State for BEIS from the Chair, 29 July 2022
68 BEIS, Letter from Secretary of State to Chair of BEIS Committee, 12 August 2022

OneWeb already had, for example, an agreement in place with BT who had begun testing connectivity using OneWeb services and would begin rolling these out during 2022.[69] Ms Evernden, Director of Space at BEIS and Dr Bate, CEO of UKSA, also confirmed that a potential benefit of OneWeb was that it aimed to offer satellite broadband to rural communities and people who found it difficult to access good connectivity in the UK.[70] We also heard that OneWeb might be able to provide accurate timing to the UK through its Gen1 constellation and that Position, Navigation and Timing (PNT) capabilities might be provided through its Gen2 network.[71] This opportunity is discussed further later in this Chapter.

24. We were told that another possible positive outcome of the OneWeb deal could be that it moves its satellites manufacturing process to the UK, thus stimulating the UK space sector.[72] The Gen1 satellites are currently manufactured in Florida, on a production line that can produce two satellites a day that cost around $1.2 million each.[73] Chris McLaughlin told us that it was not possible to move any of the Gen1 manufacturing to the UK, but that OneWeb was looking to manufacture its Gen2 in the UK from around 2024–25.[74] After Mr Mclaughlin had appeared before us, and in contradiction to his evidence, Sunil Bharti Mittal, Chair of Bharti Enterprises, told the Financial Times that it was not certain that the Gen2 satellites would be built in the UK and the choice would depend on the capabilities available and associated costs of manufacturing in the UK.[75]

25. In March 2022, OneWeb was due to carry out its 14th launch which would add a further 36 satellites to its network. OneWeb had already launched 428 LEO satellites, around two-thirds of the total planned for its Gen1 satellite constellation.[76] The launch—scheduled to take place from Baikonur cosmodrome in Kazakhstan using a Russian Soyuz rocket—was cancelled due to conflicts with the Russian space agency, Roscosmos, related to Russia's invasion of Ukraine.[77] Two days before the planned launch, Roscosmos Chief, Dmitry Rogozin, said that the launch would not take place unless Russia received guarantees that the satellites would not be used for military purposes and the UK Government sold its shares in the company.[78] Shortly after this demand was made, OneWeb's board unanimously voted to suspend all launches from Baikonur.[79] It was therefore necessary for OneWeb, through Arianespace, to seek new options for launching its satellites as quickly as possible. In a House of Commons Defence Committee evidence session on Space Defence on 8 March 2022, Rebecca Evernden explained launch capabilities in the UK would have limited capacity, noting that when vertical launch capabilities were established in Scotland, it would only be possible to launch six satellites at once, compared to the 36 (or more) that could be launched on the Soyuz rocket.[80] On 21 March 2022, OneWeb announced that it had entered an agreement with SpaceX, a US-based launch

69 Q247 and Q267
70 Q480 and Q419
71 Q258
72 Q264
73 Q261
74 Qq262–265
75 Financial Times, UK stake in OneWeb no guarantee production will shift from US, big shareholder says, 1 March 2022
76 OneWeb, OneWeb Confirms Successful Launch of 34 Satellites, Delivering Ongoing Momentum at the Start of 2022, 10 February 2022
77 The Times, OneWeb is facing its toughest mission after loss of Russian Soyuz rockets, 7 March 2022
78 New Scientist, OneWeb 'surprised' by Russian demands over satellite launch, 2 March 2022
79 OneWeb, Statement from OneWeb, 3 March 2022
80 Q224, Space Defence, HC 271, Oral evidence taken before the Defence Committee, 8 March 2022

provider run by Elon Musk, that would enable OneWeb to launch to the rest of its satellite constellation.[81] Later, on 20 April 2022, OneWeb announced another launch deal with New Space India Limited, which is the commercial arm of the India Space Research Organisation.[82] On 23 October 2022, OneWeb announced that 36 of its satellites had been launched by New Space India Limited from Satish Dhawan Space Centre in Sriharikota, India and were now operational.[83]

26. **We understand that, once fully launched, the OneWeb low Earth orbit constellation will provide broadband coverage, via broadband providers such as BT, to people in the UK and elsewhere, including those in remote areas. However, it is not clear to us what other benefits the Government's purchase of OneWeb will bring to UK citizens and whether the purchase represents value for money for UK taxpayers. Given that the Government purchased OneWeb from bankruptcy, we believe its investment in OneWeb is unusual. This is exemplified by the purchase requiring a ministerial direction. We were pleased to hear the then Secretary of State confirm that this model of investment is unlikely to be used in the future. Further, it remains to be seen what the UK will gain from the investment compared to other nations who have not invested in OneWeb.** ***As a considerable amount of taxpayers' money was used to complete the purchase of OneWeb, the Government should report to Parliament on the state of the Government's investment in OneWeb on a yearly basis. This should include information on how the company is contributing to scientific and technical advancements in the UK space industry. This unusual investment approach should be treated as exceptional and avoided in the future.***

27. **Since the UK's purchase of OneWeb, the number of shareholders has continued to grow. Although the Government has provided assurances that the proposed merger with Eutelsat will not affect the UK's shares and involvement in OneWeb, uncertainty remains over how the continued changing ownership will affect its management.** ***The proposed merger with Eutelsat must be subject to proper scrutiny under the National Security and Investment Act and the Government must provide assurance that OneWeb's operations in the UK will not be affected by the merger. Further, if the merger goes ahead, the National Audit Office should consider carrying out an assessment of the how well the taxpayer's investment has been protected to date and review the economic viability of continuing to hold shares in OneWeb.***

28. **We acknowledge that OneWeb could bring additional benefits to the UK if it carried out satellite manufacturing for its Gen2 constellation in the UK, which would stimulate the UK space sector and create new jobs. However, where the Gen2 constellation will be manufactured is not yet confirmed.** ***The Government must obtain assurances that OneWeb will manufacture its Gen2 constellation in the UK so that the UK space sector can benefit as fully as possible from the Government's investment in OneWeb.***

Position, Navigation and Timing

29. Position, Navigation and Timing (PNT) services enable the movement of goods and people and ensure the safe operation of telecommunications, energy provision,

81 OneWeb, OneWeb to resume satellite launches through agreement with SpaceX, 21 March 2022
82 OneWeb, OneWeb agrees satellite launch programme with New Space India, 20 April 2022
83 OneWeb, 36 OneWeb satellites successfully launched by ISRO/ NSIL from Sriharikota, 23 October 2022

financial services, transport systems, and emergency services (see Box 2 for examples of applications that PNT services support).[84] Fundamentally, all PNT services are based on signals received from orbiting satellites by devices—from smartphones and satnavs to air traffic control centres—which are used to determine their location and time.[85] In its written submission, BEIS described PNT services as key "enablers of Critical National Infrastructure (CNI) sectors" that "underpin our national security and defence interests as well as a wide range of other economic activities".[86] PNT services not only support vital functions but also make a significant financial contribution to the economy. A 2017 study commissioned by Innovate UK and the UK Space Agency, *The Economic Impact on the UK of a Disruption to GNSS*, estimated that the negative financial impact of losing access to global navigation systems could be as high as a £5.2 billion for a five day disruption.[87]

Box 2: Examples of Critical National Infrastructure sectors that depend on accurate PNT signals

Emergency services: satellite navigation services are used to locate and travel to incidents.

Energy networks: the national grid uses satellite timing services for electricity delivery.

Financial transactions: highly accurate timestamps are required for trading and audit purposes.

Food and farming: satellite navigation is used in food distribution and automated agricultural vehicles.

Transport: road, rail, air and sea transport all rely heavily on satellite navigation signals.

Communications: mobile phone networks, internet services and broadcasting use satellite networks.

Research: data from satellite-based sensors help to monitor air quality and changes in climate.

30. The European Union (EU), Russia, China and the United States own and operate sovereign PNT systems.[88] The UK currently relies on the US-owned Global Positioning System (GPS) and Galileo,[89] the EU's global navigation satellite system (GNNS), for PNT services. The UK left the Galileo programme after withdrawing from the European Union: the UK no longer plays any part in the programme's development; and UK-based businesses, academics and researchers cannot bid for related contracts.[90] The UK can still

84 Government Office for Science, Satellite-derived Time and Position: A Study of Critical Dependencies, 30 January 2018

85 UK Space Agency, UK space sector wins over £2 million to help develop options for a national position, navigation and timing space system, 28 May 2021

86 Department for Business, Energy and Industrial Strategy (SPA0026)

87 London Economics, The economic impact on the UK of a disruption to GNSS, June 2017

88 Q10

89 Galileo is part of the European GNSS programme, which also supports the European Geostationary Navigation Overlay System (EGNOS). EGNOS is a satellite based augmentation system (SBAS) which increases the accuracy of GNSS systems (such as GPS and Galileo) over Europe.

90 Q155

access Galileo's 'open' PNT services (in a similar way to the UK having access to the US's GPS services),[91] but not the more resilient encrypted Public Regulated Service (PRS), intended for military and emergency services use.[92]

31. The Government has invested around £1.2 billion into the Galileo programme, more than 10% of Galileo's total budget,[93] and a UK-based company, Surrey Satellite Technology (SSTL), a subsidiary of Airbus, manufactured all 34 of Galileo's current payloads.[94] Professor Martin Sweeting, Founder and Chairman of SSTL, told us that although Europe would be able to continue the Galileo programme without the UK, he expected that the timescale and cost of future missions would be affected.[95]

32. During discussions on the UK's continuing involvement in Galileo, the EU Commission decided to bar the UK from full participation in the programme, setting out that even if the UK applied to have third-party access to the PRS, it would no longer be involved with any research and development aspects of the Galileo system. As a result, the UK decided to not participate in the programme, and announced plans to establish its own secure PNT services.[96]

33. In August 2018, the Government invested £92 million in an 18-month study that looked at the design and development of a British Global Navigation Satellite System.[97] At the end of the 18-month UK Global Navigation Satellite System (GNSS) Programme, the Government decided against developing a sovereign sat-nav constellation.[98] It instead announced the Space-Based Positioning Navigation and Timing Programme (SBPP),[99] which would look at "new and alternative ways that could be used to deliver vital satellite navigation services to the UK," adding that the programme would "consider collaboration with international allies to share satellite navigation services, costs and technology". This announcement came just two months after the UK Government invested $500 million in OneWeb,[100] and suggested that OneWeb's LEO constellation could play a role in supplying PNT services to the UK.

34. In May 2021, the SBPP awarded a share of £2 million funding to Airbus, CGI, Sirius Analysis, GMV NSL, Inmarsat, and QinetiQ for them to "develop system design and operation, signals and algorithms, resilience, assurance, and cost modelling" for new national space-based PNT systems.[101] With a view to reducing a reliance on satellites for PNT capabilities, £36 million was awarded by the Government for the development of a National Timing Centre (NTC), led by the National Physics Laboratory (NPL), which aimed to develop a terrestrial alternative to satellite time infrastructure.[102]

91 Q8 and Q480
92 HM Government, UK involvement in the EU Space Programme, 31 December 2020
93 Guardian, UK may never recover £1.2bn invested in EU Galileo satellite system, 30 November 2018; Financial Times, Britain quits military side of Galileo satellite system, 30 November 2018
94 Q155
95 Q156
96 HM Government, UK to tell EU it will no longer seek access to secure aspects of Galileo, 1 December 2018
97 HM Government, Space sector to benefit from multi-million pound work on UK alternative to Galileo, 29 August 2018
98 See, for example: Politico, UK scraps Brexit alternative to EU's Galileo satellite system, 24 September 2020, or: Space News, U.K. to revise strategy for satellite navigation system, 25 September 2020
99 HM Government, Government to explore new ways of delivering 'sat nav' for the UK, 24 September 2020
100 HM Government, UK government to acquire cutting-edge satellite network, 3 July 2020
101 HM Government, UK space sector wins over £2 million to help develop options for a national position, navigation and timing space system, 28 May 2021
102 HM Government, World's first timing centre to protect UK from risk of satellite failure, 19 February 2020

35. Dr Paul Bate, Chief Executive of the UK Space Agency (UKSA), told us that UKSA had reviewed the best options for the space-based elements that could be used to deliver secure PNT services for the UK and provided this analysis to the Government in November 2021 to inform its strategy.[103] Professor Mark Thomson, Chair of the Science and Technology Facilities Council (STFC), described work funded by UKRI that was developing ground-based PNT signals, telling us:

> The correct answer for the UK will be some combination of space-based timing and potentially very resilient ground-based timing distribution.[104]

Several submissions to our inquiry agreed with this sentiment, stating that PNT in the UK should be achieved by using a system of systems approach,[105] in order to improve reliability, integrity and resilience.[106] This is especially interesting, considering it was recently reported that attacks on GPS satellite signals were becoming more frequent. For example, Russian forces have used jamming systems to target GPS signals in Ukraine.[107] Speaking in the House of Lords on 26 April 2022, Lord West (a retired Royal Navy Admiral who acted as security adviser to Prime Minister Gordon Brown) explained that GPS signals could be "intercepted and adjusted very easily". He queried the planned approach to PNT and suggested that a terrestrial system, that was less susceptible to jamming should be part of the system of systems.[108]

36. When giving oral evidence, the then Secretary of State for Business, Energy and Industrial Strategy described to us his vision for UK-based PNT, saying that the UK could deliver PNT services outside of Galileo and that OneWeb would help to achieve this:

> My view—and I know that people have different views on this—is that positioning, navigation and timing capability, which Galileo is all about, is something that we could do ourselves. Some people said we cannot do this, there is no way that we could deliver PNT outside Galileo. I do not happen to agree. Our strategic stake in OneWeb, which we may talk about, gives us a possibility for future capability in PNT. Given our commitments in space, when people look at our space strategy, we are seen as a credible medium-sized player. That is why I do not think that participation in Galileo was really the be-all and end-all. In fact, looking at it, we felt that we were not getting our bang for our buck in what our companies and supply chain were getting from it. That is my view on this.[109]

37. In its written and oral evidence, OneWeb told us that its Gen1 satellite constellation, which was currently in the process of being launched and manufactured, had the potential to provide the UK with an "enhanced, resilient timing service," but could not provide full PNT services.[110] OneWeb said that its Gen2 satellites would offer full PNT

103 Q409
104 Q414
105 A system of systems is "a collection of systems, each capable of independent operation, that interoperate together to achieve additional desired capabilities;" Mitre, Systems Engineering Guide: Systems of Systems, accessed 9 May 2022
106 See, for example: The Space academic Network (SPA0009), UK Research and Innovation (UKRI) (SPA0024), techUK (SPA0042), Airbus (SPA0081)
107 The Times, Russia takes battle into space and targets GPS in Ukraine, 11 May 2022
108 HL Deb 26 April 2022, c121
109 Q450
110 OneWeb (SPA0008), Q258

services by 2026.[111] The then Secretary of State seemed to be suggesting a more ambitious schedule in his evidence. He expected the UK to: "have at least as good a service in PNT and communications as people in EU countries" and, while unable to provide an exact timeframe, he said he would: " … want to see it in the next two or three years, probably sooner."[112]

38. Several submissions to our inquiry suggested that the Government was developing a national PNT strategy.[113] In March 2021, Lord Callanan, Lord's Parliamentary Under-Secretary for BEIS, told the House of Lords that this would be published imminently.[114] After our oral evidence concluded, we received two pieces of follow-up evidence that shed further light on the status of this national PNT strategy.[115] Andy Proctor, Director of RethinkPNT and John Owens, Director of Border Consulting Ltd., and previously an auditor of the GNSS and SBPP programmes, highlighted the critical importance of the UK having access to secure PNT signals, and suggested that there was an unpublished Government review that estimated that the cost to the UK of economy of the loss of GNSS services had increased to £1.5 billion per day (compared to £1 billion per day that was estimated by the Blackett review back in 2017).[116]

39. Mr Proctor gave an account of the work that he contributed to whilst employed as an innovation lead for space and PNT at InnovateUK. He described the work that was carried out under the GNSS programme in detail, including that a secure UK PNT system that used medium Earth orbit satellites had been designed, with significant input from industry, and alongside a detailed budget and implementation plans.[117] Mr Proctor and Mr Owens expressed significant concern that this programme, which had a budget of around £65–70 million, had been abandoned in September 2020 and replaced with the UKSA's SBPP, which continued to seek options for a space-based PNT system for the UK.[118] Mr Owens thought that this decision was made because the Government was planning to explore how the UK could use the OneWeb LEO system (which was purchased around the same time) to provide the UK with PNT services and suggested that the Satellite Applications Catapult, a company that helps UK organisations to realise the potential of space-based infrastructure,[119] had conducted research on how the OneWeb system could be used to provide precise timing services to the UK.[120] Mr Owens, however, stated in his evidence that there were "numerous technical reasons that LEO satellites are not optimum" for providing PNT, including: high power consumption, a complex ground monitoring system, less easy to predict orbits then MEO or GEO satellites, and increasing amounts of space debris in LEO.[121]

40. Mr Proctor went on to explain that he had also contributed to the development of the UK PNT strategy. He was loaned to the Cabinet Office for this work, which involved consulting with over 85 experts from industry and academia and creating an evidence-based document that built on 20 years of evidence. The strategy included a wide range

111 OneWeb (SPA0008)
112 Q480
113 Surrey Satellite Technology Ltd (SPA0023), techUK (SPA0042), Lockheed Martin UK (SPA0050), Airbus (SPA0081)
114 HL Deb, 10 March 2021, c1610
115 RethinkPNT (SPA0100), Border Consulting Ltd (SPA0103)
116 RethinkPNT (SPA0100), Border Consulting Ltd (SPA0103)
117 RethinkPNT (SPA0100)
118 RethinkPNT (SPA0100), Border Consulting Ltd (SPA0103)
119 Satellite Applications Catapult, About us, accessed 12 May 2022
120 Border Consulting Ltd (SPA0103)
121 Border Consulting Ltd (SPA0103)

of technical recommendations on the UK's approach to PNT and included a costed implementation plan. Mr Proctor and Mr Owen both suggested that as well as detailed plans that had already been drafted within Government, the UK had the technical knowhow to establish its own PNT systems, with strong expertise and manufacturing capabilities being available within its industry. After receiving Mr Proctor's evidence, we wrote to the then Secretary of State for Business, Energy and Industrial Strategy to ask him to confirm whether a PNT strategy had been drafted and when it would be published.[122] The then Secretary of State confirmed that a Cabinet Office team had reviewed the UK options for PNT but that the draft strategy did not "represent an agreed cross-government position".[123] He explained that BEIS was in the process of establishing cross-government coordination mechanisms so that the UK's PNT requirements could be reviewed. In relation to the previous work and documents that had already been drafted, he added:

> Once this cross-government coordination is established, I expect the team to review the documents produced by the Cabinet Office team and reassess options for both sector-specific mitigations and a system of systems to improve resilience. The useful outputs from the UK GNSS Programme, the subsequent Space-Based PNT Programme (SBPP) and the Cabinet Office work on use cases will all feed into the plans. Together with relevant teams across departments, we will consider which documents should be published.[124]

41. **The UK has access to 'open' Position, Navigation and Timing (PNT) services, supplied through the US GPS system and the EU Galileo system, meaning that most users are not affected by the UK leaving the Galileo programme. The UK currently relies on the US GPS system for its secure PNT services that can be used for defence and critical national infrastructure purposes. The reliance on foreign systems is concerning due to the potential for the UK to be blocked from using them in the future. Reliance on space-based systems is also not advisable as these can be disrupted through jamming attacks or adverse space weather. The loss of PNT services would be detrimental to the UK, with power distribution, financial transactions, and transport systems all seriously affected, and the UK's national security put at severe risk. Although the UKSA, UKRI and BEIS, told us that work is underway to evaluate options for the UK's approach to gaining access to resilient and secure PNT, we understand that a significant amount of work, using large amounts of public funds, has already been carried out but a strategy is yet to be published.**

42. **We are concerned that the Government seems to be progressing towards plans to use OneWeb's low Earth orbit (LEO) satellite constellation to provide PNT services in the future, despite suggestions from experts that there are many technical issues surrounding using LEO satellites for PNT signals. Ambiguity also remains about the development schedule for full PNT services from OneWeb and whether such services could be provided in a way that is appropriate for sovereign military and critical national infrastructure purposes.**

122 Correspondence from the Chair to Kwasi Kwarteng MP, Secretary of State for Business, Energy and Industrial Strategy, regarding the National Position, Navigation and Timing (PNT) Strategy, 23 March 2022

123 Correspondence from Kwasi Kwarteng MP, Secretary of State for Business, Energy and Industrial Strategy, relating to the national PNT strategy, 31 March 2022

124 Correspondence from Kwasi Kwarteng MP, Secretary of State for Business, Energy and Industrial Strategy, relating to the national PNT strategy, 31 March 2022

43. **Considering the importance of developing secure access to PNT services, we are disappointed that the Department for Business, Energy and Industrial Strategy (BEIS) is delaying the finalisation and publication of the PNT strategy and therefore refusing to commit to the critical action that needs to be taken. Although BEIS is in the process of establishing cross-government strategy on PNT, we believe the responsibility for PNT should lie outside of any one Department.** ***The Government should establish the National Security Adviser (NSA) as having overall responsibility for the UK's access to secure PNT capabilities. The NSA should ensure that the importance of developing secure PNT systems is understood throughout Government and take responsibility for developing a programme and budget for the work that needs to be carried out. The NSA should take guidance from work that has already been undertaken within Government and publish the National PNT Strategy no later than the end of February 2023, including details of the space- and ground-based components that will be used to ensure the UK has sustained, resilient and secure access to PNT services. If the strategy includes the use of the OneWeb LEO Gen2 constellation, the solutions to the technical challenges drawn out in our evidence should be addressed and the Government should provide clarification on why LEO satellites have been chosen over other, more commonly used, space-based PNT systems. In summary, the strategy should set out:***

a) ***the updated review and estimate of the impact of loss of PNT services on the economy;***

b) ***the results of the Global Navigation Satellite System (GNSS) programme, and details of which aspects of the proposed system will be taken forward;***

c) ***the UK Space Agency's analysis of the space-based elements of PNT and details of which of these will be taken forward; and***

d) ***how secure PNT services can be delivered through LEO and the technical challenges that will need to be overcome to achieve this.***

Earth observation

44. Earth observation (EO) is the collection of information about the physical, chemical, and biological properties of the Earth's surface, oceans and atmosphere. EO data can be collected using satellites, aircrafts, drones, and ground-based monitoring,[125] although our inquiry only addressed the use of satellites. EO data is used in variety of applications such as weather forecasting, climate change monitoring, disaster risk reduction, monitoring natural resources and border security,[126] and is estimated to support £100 billion (4.7%) of annual GDP in the UK.[127]

45. The evidence we received consistently described the UK as a world leader in EO technology and data analysis,[128] with over 100 EO companies operating in the UK, the

125 OECD, Earth Observation for decision-making, March 2017

126 UK Research and Innovation (UKRI) (SPA0024)

127 Know.space, Size & Health of the UK Space Industry 2020, May 2021

128 See for example: The Space academic Network (SPA0009), The National Oceanography Centre (SPA0012), NERC SENSE Earth Observation Centre for Doctoral Training (SPA0013), Midlands Innovation (SPA0022), UK Research and Innovation (UKRI) (SPA0024), Earth Observation Network, Imperial College London (SPA0031), ADS, UKspace (SPA0056), National Centre for Earth Observation (NCEO) (SPA0084)

largest number in any one country in Europe.[129] Despite this, some witnesses, from industry and academia, suggested that a long-term EO programme backed by increased investments in EO research and development was required to ensure that the UK remained a world leader in this area.[130]

46. Although the strengths of the UK's EO sector were recognised, concerns were raised about the UK's lack of sovereign satellite EO capability.[131] UKRI said that while the UK often led on EO science, it lacked the support to be able to deploy its own EO technology:

> The UK science base is hugely influential in EO satellite missions, often leading the science teams that win missions at international level. However, it lacks the national support to deploy our next generation and novel EO technology whether on UK missions or internationally; we are forced to focus only on science data, low TRL activities and calibration. If funded, such missions would be collaborative between science and industry, thus enabling new discovery, economic growth and de-risking of leading UK-led technology in space through one action.[132]

The Royal Astronomical Society, Satellite Applications Catapult, and Earth Observation Network echoed this view, agreeing that more support was needed from the Government to facilitate EO satellite builds.[133]

47. Throughout our inquiry, we also heard about the possibility of using the UK's strength's in EO to support the Government's ambitions for achieving Net Zero.[134] For example, Midlands Innovation[135] told us that the UK could use its expertise in EO, artificial intelligence and data analysis to improve monitoring of sea temperatures, erosion, air quality, deforestation, and land use.[136] The Government's intention to use EO technologies to combat climate change was listed as point two in the National Space Strategy's ten-point plan:

> **Fight climate change with space technology**
>
> The UK will not reach its goal of net zero emissions by 2050 without a clear understanding of how climate change is impacting the Earth, to guide crucial decision-making and investments. We will strive to remain at the forefront of Earth Observation (EO) technology and know-how, including

129 UK National Quantum Technology Hub in Sensors and Timing, University of Birmingham; UK Quantum Technology Hub Sensors and Timing (SPA0011)

130 Midlands Innovation (SPA0022), Surrey Satellite Technology Ltd (SPA0023), UK Research and Innovation (UKRI) (SPA0024), Plymouth Marine Laboratory (SPA0039)

131 Surrey Satellite Technology Ltd (SPA0023), ADS, UKspace (SPA0056), Airbus (SPA0081), National Centre for Earth Observation (NCEO) (SPA0084)

132 UK Research and Innovation (UKRI) (SPA0024)

133 Royal Astronomical Society (SPA0047), Satellite Applications Catapult (SPA0037), Earth Observation Network, Imperial College London (SPA0031)

134 Midlands Innovation (SPA0022), UK Research and Innovation (UKRI) (SPA0024), Surrey Satellite Technology Ltd (SPA0023), Planet (SPA0071)

135 Midlands Innovation is a strategic partnership of eight research-intensive universities in the Midlands (Aston University, University of Birmingham, Cranfield University, Keele University, University of Leicester, Loughborough University, University of Nottingham and University of Warwick).

136 Midlands Innovation (SPA0022)

> by participating in Copernicus, the world's leading global EO programme and working with partners in ESA on the TRUTHS mission to deliver a 10-fold improvement in accuracy.[137]

In support of these ambitions, UKSA announced in November 2021 a joint project with the UN Office for Outer Space Affairs (UNOOSA) that would review existing activity on climate action where space technology was used. The aim of the review was to develop a strategic view of these activities to enable increased policy coherence at an international level.[138]

48. Copernicus is the European Union's publicly-funded EO programme, which aims to provide the EU with "autonomy and leadership in high-quality environmental monitoring, emergency management and support for border and maritime security".[139] The key mission statement for Copernicus is "Looking at our planet and its environment for the benefit of Europe's citizens," and the programme provides free, accurate, timely and easily accessible EO data to a range of stakeholders across the world, including citizens, businesses and policy makers.[140] The EU invested €4.3 billion in Copernicus from 2014–2020,[141] and the European Council has agreed to spend a further €5.4 billion on the programme between 2021 and 2027.[142]

49. The Copernicus programme is broken up into six Sentinel missions, with each mission launching a pair of satellites that provide increased spatial coverage of the Earth's surface and measuring different environmental factors such as the composition of the atmosphere, air quality and sea levels.[143] Data from the satellites is received by local ground stations, one of which is located in Harwell in Oxfordshire.[144] Eight satellites have been launched so far and further launches are planned as part of the Sentinel missions.[145] In support of Copernicus, the European Space Agency (ESA) is developing a further six missions that will support Copernicus services, focusing on challenges such as "urbanisation, food security, rising sea levels, diminishing polar ice, natural disasters, and climate change".[146]

50. The UK has contributed to the Copernicus programme, through building instruments for the Sentinel satellites and by carrying out data dissemination and processing.[147] In his oral evidence Dr Josef Aschbacher, Director General of ESA, told us that the UK was "a very active member in Copernicus".[148] The UK has made an agreement-in-principle to participate in Copernicus for 2021 to 2027,[149] and has set aside €750 million (around 10%

137 HM Government, National Space Strategy, 27 September 2021; TRUTHS is a climate mission that is led by the UKSA and delivered by ESA that aims to help improve: the accuracy of measurements of energy hitting the Earth from the Sun; and the understanding of global warming. The programme is being funded by the UK, Switzerland, the Czech Republic, Romania and Greece and will be launched in 2026–2028.
138 UK Space Agency, UK and UN join forces in using space tech to tackle climate change, 10 November 2021
139 European Commission, EU budget: A €16 billion Space Programme to boost EU space leadership beyond 2020, 6 June 2018
140 European Commission, Copernicus Europe's eyes on Earth, 2015
141 ESA, Copernicus operations secured until 2021, 28 October 2014
142 European Commission, EU budget: A €16 billion Space Programme to boost EU space leadership beyond 2020, 6 June 2018; Research Professional News, Incoming Esa boss worried about Copernicus budget shortfall, 15 January 2021
143 European Commission, Copernicus: The EU Earth Observation and Monitoring Programme, April 2019
144 ESA, UK joins Sentinel Collaborative Ground Segment, 19 March 2015
145 ESA, The Sentinel missions, accessed 7 March 2022
146 ESA, Copernicus Sentinel Expansion missions, accessed 7 March 2022
147 Royal Aeronautical Society (RAeS) (SPA0079)
148 Q289
149 HM Government, UK involvement in the EU Space Programme, 31 December 2020

of the programme's total required funding for the 2021–2027 period)[150] for its contribution to the programme.[151] Full participation would allow UK-based businesses, academics and researchers to participate fully in the programme, including the ability to bid for contracts through the EU.[152] The UK's participation in Copernicus remains uncertain due to ongoing negotiations between the UK and the EU on implementing other parts of the withdrawal agreement.[153] This has resulted in UK businesses being unable to bid for Copernicus contracts tendered through the EU and concerns over the data available to the UK in the interim, with advice from the Department for Business, Energy and Industrial Strategy stating:

> Until the agreement is finalised and implemented, some UK users may lose the right to high-bandwidth access to the standard data from Copernicus Sentinels. Some UK users may also lose access to data sourced by Copernicus from Contributing Missions. UK users will not have access to data deemed security sensitive. UK-based Copernicus data users should consider the impact that losing access to any data or information not sourced under the free and open data policy may have on their operations.[154]

51. In evidence to us, Jon Styles, Director of Assimila, an EO data analysis company, explained that the Copernicus open access data policy was vital to Assimila's work:

> There is a lot of space data that is openly accessible. Much of it comes from the Copernicus programme, and that has been a game-changing advance in the availability of open data. We are going in the right direction. The Government have always supported, at least in our discussions regarding Copernicus, the open data policy of Copernicus. That has been an important thing. Most of the applications that we deliver could not function without access to the datasets that I have mentioned.[155]

Although Mr Styles did not express any concern about ongoing access to the data supplied by Copernicus, other witnesses told us that they were concerned that not participating in Copernicus could lead to UK users having delayed access to data, with Professor Iain Woodhouse, Professor of Applied Earth Observation at the University of Edinburgh, telling us:

> At the moment the agreement says that non-members will get the data slightly later, so anybody who is doing rapid services will be disadvantaged by that. Who is to say that in a few years' time they don't change it again, so that in fact you don't get it until a week later? We will have no say or contribution to how that goes forward.[156]

52. **We understand that the UK space sector has significant concerns about the current and future access to data currently supplied by EU's Copernicus programme, especially if the UK cannot remain a member. *BEIS and UK Space Agency (UKSA) must ensure that they communicate clearly with the space sector to ensure that there is a***

150 Research Professional News, Incoming Esa boss worried about Copernicus budget shortfall, 15 January 2021
151 Q410
152 HM Government, UK involvement in the EU Space Programme, 31 December 2020
153 Q289
154 HM Government, UK involvement in the EU Space Programme, 31 December 2020
155 Q241
156 Q523

good understanding about any impact on the UK's access to data from Copernicus if the UK does withdraw from the programme. BEIS and UKSA must conduct a consultation of how the space sector expects to be impacted if participation is not possible, with a particular focus on loss of access to data. The results of this consultation should be made public. Further, the UK Government should seek assurances from the EU, that if the UK does associate and invest the planned €750 million, its access rights will remain the same as all other countries participating in the programme.

53. The UK space sector was in favour of the UK's participation in Copernicus, recognising the benefit of the UK's involvement in a substantial and unique international programme where large costs are shared.[157] Josef Aschbacher, Director General of ESA, also expressed his desire for the UK to fully participate in Copernicus,[158] saying that he was "proposing architectures and an implementation mechanism for Copernicus that allow the UK to stay on board," and explained that talks between the UK and Brussels were ongoing:

> Certainly, we as programme implementers are making sure from a technical engineering implementation point of view that the UK can stay on board even if the signature does not happen today. The deadline passed on 30 November, but we would like to keep the options open for the UK to participate at a later stage. This is really between Brussels and the UK, and ESA is not a direct party to the negotiations of the UK participation in Brussels.[159]

Dr Aschbacher clarified that the UK was already able to participate in parts of the Copernicus programme that ESA funds, which amounted to around a third of the programme, and that contracts for the ESA-funded part were separable from the EU-funded side and that these contracts were "being put in place every day".[160]

54. Rebecca Evernden, Director of Space at the Department for Business, Energy and Industrial Strategy, told us that the Government's "Plan A" was to continue to participate in Copernicus.[161] Dr Paul Bate, CEO of UKSA, explained that UKSA was preparing for both scenarios (UK participation being confirmed, as well as the UK's withdrawal from the programme) and said that, in either case, the UK was "building up and continuing to build up the national capability in Earth observation".[162] He added that if the UK left Copernicus, the money set aside for participation (€750 million) would be available for establishing a national EO capability.[163] The then Secretary of State for Business, Energy and Industrial Strategy was also confident that the UK could establish EO capabilities outside of Copernicus and Rebecca Evernden told us that most of the data from Copernicus would still be available to the UK even if it did not remain a full member of the programme.[164] She went on to explain that BEIS was looking to maximise the sources of data that the UK space sector would have access to:

157 The National Oceanography Centre (SPA0012), Surrey Satellite Technology Ltd (SPA0023), UK Research and Innovation (UKRI) (SPA0024), Royal Aeronautical Society (RAeS) (SPA0079)
158 Q289
159 Q290
160 Qq291–292
161 Q455
162 Q409
163 Q410
164 Qq454–456

> There is a real opportunity for the UK to do more around data analytics. There are very many sources of space data, not just Copernicus. One of the things we are looking at is how we maximise all those sources of data so that companies can develop innovative applications and come up with commercially savvy ways of using the data.
>
> It is a combination of the essential data—what Copernicus can provide around that and what we need to supplement potentially with domestic alternatives—and how we use data from other sources, which is already being gathered.[165]

55. After our evidence sessions concluded, the Government published a policy paper setting out the approach it would take to developing a new R&D programme if the UK was unable to associate with Horizon Europe, Copernicus and Euratom.[166] The announcement did not provide any detail on if and how it would establish an alternative to Copernicus.

56. Several stakeholders told us that they were concerned about the UK's data infrastructure, with UKRI calling for "dedicated infrastructure for data processing" to ensure that the EO sector can efficiently exploit EO data and develop new applications for the data.[167] This was echoed by Professor Woodhouse who said that he would like to see less reliance on offshore data services, such as Amazon, Google, and IBM and that the Government should support the establishment of more data centres and infrastructure in the UK.[168] He told us that the Edinburgh city deal had invested in the Edinburgh International Data Facility, which was helping researchers to gain better control over their data.[169]

57. **The UK is world-leading in Earth Observation (EO) science and technologies. The EO sector and the Government have recognised that these strengths can also be used to support other UK ambitions such as Net Zero.** ***Taking guidance from the UK Space Agency and UN Office for Outer Space Affairs (UNOOSA) joint review into how space technologies can be used to tackle climate change, the Government should set out detailed actions for how EO will be used to support the transition to Net Zero. This should include a package of financial support to ensure the UK remains a world leader in this area.***

58. **The UK space sector remains strongly in favour of maintaining the UK's participation in the EU's Copernicus Earth observation programme, for which the UK Government has set aside €750 million. Despite this, it is imperative that the UK stands ready to adapt if an agreement with the European Union cannot be reached.** ***The Government should publish a 'Plan B' no later than the end of December 2022 which defines what actions it will take if an agreement with the EU cannot be reached over UK membership of the Copernicus programme and how the €750 million currently set aside for participation would then be spent.***

165 Q497
166 BEIS, Supporting UK R&D and collaborative research beyond European programmes, 20 July 2022
167 UK Research and Innovation (UKRI) (SPA0024)
168 Q522
169 Q521

3 Development of UK launch

59. Several launch sites for small satellites are currently being developed in the UK, including a horizontal launch site in Cornwall and two vertical launch sites in Scotland. This Chapter explores the status of these spaceports, considering what support these sites might need and whether the UK's spaceflight regulatory regime is fit for purpose.

Development of UK launch sites

60. Over the past ten years there has been a significant reduction in the cost of producing and launching satellites and increasing interest in the development of large constellations of small satellites.[170] The reduction in cost has primarily been due to improvements in electronics which have meant that much smaller satellites can be manufactured.[171] These satellites are therefore lighter (less than 600 kg) so multiple satellites can be launched simultaneously, for the same or reduced cost. Improvements in rocket technologies have also been made, which have led to further reductions in launch costs.[172] This shift in cost is predicted to allow a wider range of companies and organisations to launch satellites. Some of the companies that are currently launching satellite constellations are shown in Box 3.

Box 3: Companies that are launching satellite constellations.

A range of companies are currently launching their own satellite mega-constellations. These consist of a large number of satellites in LEO that will provide internet coverage across the globe, including to remote areas. Four companies launching constellations are:

- Space-X's Starlink—plans to create a mega-constellation of up to 42,000 small satellites to deliver the world's largest LEO broadband constellation.[173]
- OneWeb—plans to launch 650 small satellites to provide high speed broadband coverage to 95% of the Earth's surface.[174]
- Amazon's Project Kuiper—plans to launch a constellation of 3,236 LEO satellites to provide affordable broadband, to "make a difference for unserved and underserved communities".[175]
- Telesat's Lightspeed—partnered with Thales Alenia Space to form a fleet of 298 satellites.[176]

61. Due to the substantial decreases in launch costs that have occurred over the past decade and the UK being well-placed geographically to host LEO small satellite launches,[177]

170 Deloitte Perspectives, The decline of commercial space launch costs, accessed 14 March 2022; Satellite mega-constellations are networks of many (hundreds or thousands) small satellites in low Earth orbit (LEO), described in more detail in Chapter 1: Introduction
171 The Conversation, How many satellites are orbiting Earth?, 17 September 2021
172 Deloitte Perspectives, The decline of commercial space launch costs, accesses 14 March 2022
173 Space.com, Starlink: SpaceX's satellite internet project, 7 January 2022
174 OneWeb, Network, accessed 14 March 2022
175 Amazon, Amazon marks breakthrough in Project Kuiper development, 16 December 2020
176 Telesat, Telesat Lightspeed, accessed 14 March 2022
177 Royal Aeronautical Society, The magnificent seven, 16 April 2021

the UK Government has endorsed the development of UK launch capability.[178] The Government's Spaceflight Programme, Launch UK, aims to establish commercial vertical and horizontal small satellite launch sites by 2022 so that the UK can be home to the first satellite launch from European soil.[179] The programme, originally initiated in July 2018, set out the locations of seven prospective spaceports across the UK, from Newquay in Cornwall to Shetland in Scotland. Although seven spaceports were proposed, only three are expected to be operational from 2022–23, the details of which are set out in Table 1.

Table 1: Details of the UK launch sites

Launch site	Type of launch	Partners	Funding	Status
Space Hub Sutherland[180]	Vertical, 12 per year.	Orbex, a UK launch provider, have received £5.5m from UKSA.[181]	£17.3m: £2.5m from UKSA, £9.8m from Highlands and Islands Enterprises, £5m being sought from the Nuclear Decommissioning Authority.[182]	Planning permission granted in August 2020,[183] and land use change granted in September 2021.[184]
SaxaVord Spaceport[185]	Vertical, 30 per year.[186]	Lockheed Martin,[187] headquartered in the US, have received £13.5m from UKSA and have contracted Californian-based ABL systems to provide launch vehicles;[188] and Skyrora, a launch company headquartered in Edinburgh.	Privately funded, around £100m.[189]	Planning permission granted in February 2022.[190] Submitted its licence application to the CAA on 10 March 2022.[191]

178 UK Government, How we are promoting spaceflight from the UK, 1 October 2020
179 UK Government, LaunchUK, 18 July 2022; HM Treasury, Budget and Spending Review–October 2021: What you need to know, 27 October 2021
180 Highlands and Islands Enterprise, Space Hub Sutherland, accessed 14 March 2022
181 UK Government, Lockheed Martin and Orbex to launch UK into new space age, 16 July 2018
182 Q113
183 BBC, Sutherland Space Hub secures planning permission, 19 August 2020
184 The Times, UK's first spaceport Space Hub Sutherland promises lift-off for Highland economy, 15 September 2021
185 SaxaVord, SaxaVord, the UK's Pathfinder Space Port, accessed 14 March 2022
186 SaxaVord, SaxaVord Spaceport agrees multi-launch deal with Skyrora, 12 October 2022
187 The Times, How the remote Shetland island of Unst rocketed to centre of the British space race, 18 October 2021
188 Lockheed Martin, Lockheed Martin Selects ABL Space Systems Rocket To Power First UK Vertical Satellite Launch, 8 February 2021
189 Qq102–103; SaxaVord, Work set to begin on UK's first vertical launch spaceport in Shetland, 28 February 2022
190 SaxaVord, Work set to begin on UK's first vertical launch spaceport in Shetland, 28 February 2022
191 SaxaVord, Licence applications submitted to regulator, 10 March 2022

Launch site	Type of launch	Partners	Funding	Status
Spaceport Cornwall	Horizontal	Virgin Orbit, US based launch provider.[192]	£12m from Cornwall Council,[193] £7.3m from UKSA and £2.5m from Virgin Orbit.[194]	No runway extension was required at Newquay airport, licence application was submitted in October 2021.[195]

Benefits of establishing UK launch

62. During our inquiry, we received a large amount of evidence in favour of the establishment of UK spaceports. In its written submission, the Department for Business, Energy and Industrial Strategy said that improving the UK's launch capability would help to grow the UK's world leading small satellite industry.[196] A number of international and UK-based companies agreed with this and advocated for the development of UK-based launch.[197] Skyrora, a company that manufactures rockets, described the lack of homegrown launch facilities as a key weakness of the UK space sector and said that the Government and industry needed to work together to ensure the success of the UK's commercial launch sector.[198]

63. During our oral evidence sessions, we gained further insight into the benefits that establishing commercial launch in the UK might bring. Alan Thomson, Head of Government Affairs at Skyrora, proposed that one of the key benefits was increased proximity to launch sites, which had the potential to reduce lead-in times for satellite manufacturers, reduce shipping costs and remove export controls.[199] Professor Sir Martin Sweeting, Founder and Chairman of a small-satellite manufacturing company, Surrey Satellite Technologies Ltd, agreed with Mr Thomson's view, asserting that, as a satellite manufacturer, in the absence of UK launch facilities he had to spend a lot of time procuring launch services from different countries.[200]

64. Witnesses also suggested that the new spaceports could bring wider benefits to the UK. Nik Smith, Regional Director for UK and Europe at Lockheed Martin Space (a satellite and spacecraft manufacturer) told us that companies might move to the UK to be closer to launch sites, which would create economic benefits and new jobs.[201] Melissa Thorpe, Head of Spaceport Cornwall, agreed with this, saying that Spaceport Cornwall was trying to establish a new space cluster.[202] In order to attract satellite manufacturers to the local area, Spaceport Cornwall was developing a £5.6 million Centre for Space Technologies, which would enable the assembly and testing of satellites, integration of launcher stages and

192 Virgin Orbit, Technology, accessed 15 March 2022
193 Qq100–101
194 HM Government, UK Space Agency confirms £7.35 million funding to support small satellite launch from Cornwall, 5 November 2019
195 Q129
196 Department for Business, Energy and Industrial Strategy (SPA0026)
197 See, for example: Lockheed Martin UK (SPA0050), Airbus (SPA0081), OneWeb (SPA0008), ADS, UKspace (SPA0056)
198 Skyrora Limited (SPA0064)
199 Q53
200 Q162
201 Q54
202 Q112

mission control.[203] Pete Guthrie, Senior Programme Manager at Space Hub Sutherland, also pointed out that the new spaceports could create jobs in regions where it was otherwise difficult to do so.[204]

Spaceport funding models

65. In our oral evidence session with leading players in the launch industry, we heard that spaceports had taken different approaches to accessing public funding and, therefore, to their resulting business models. Nik Smith, Regional Director for UK and Europe at Lockheed Martin Space told us that he thought Government support was vital for the success of a spaceport:

> I am not aware […] of any spaceport anywhere in the world that does not have some level of direct or indirect ongoing Government support, either as a role as an anchor customer or maybe even more directly by providing things like range services or support to the spaceport itself, because, coming to the point about these being infrastructure, there is a recognition that it is important to support these systems for the long term so that they can be globally competitive. The reality is that we will be competing with spaceports that have quite substantial direct Government support.[205]

On the contrary, Scott Hammond, Deputy Chief Executive Officer at SaxaVord Spaceport explained that SaxaVord spaceport was funded privately, via "high-net-worth individuals around the world",[206] and that grant-funded projects did not always lead to sustainable businesses.[207] Although Space Hub Sutherland had received around £17 million of public funding to allow the spaceport to be built, Pete Guthrie, Senior Programme Manager at Space Hub Sutherland, explained that he expected the spaceport to be commercially successful and to not need ongoing public subsidies.[208] Likewise, Melissa Thorpe expected that Spaceport Cornwall would start generating income by its fifth year of operation.[209] She said that revenues would be returned to Cornwall Council and used to support the wider business of Cornwall airport.[210]

Launch providers

66. As shown in Table 1, the three UK spaceports have partnered with a range of launch providers. We heard that spaceports were looking to expand their customer base and hoped to attract both UK and international companies to use their facilities. To establish the first launches of small satellites from Space Hub Sutherland, Highlands and Islands

203 UKSpace, The acceleration of Cornwall Space – built on a pioneering history, 15 October 2021
204 Q107; In September 2021, the North Highland and Moray Space Cluster strategy estimated that a Northern Space Cluster in the Highlands and Islands, due to the establishment of Sutherland spaceport, could create up to 740 jobs and boost the regional economy by £56 million per year by the end of the decade; Jacobs, Caithness Chamber of Commerce and UpNorth! Community Trust, North Highland and Moray Space Cluster strategy, September 2021
205 Q56
206 Q102
207 Q104
208 Qq113–114
209 Q115
210 Qq115–117

Enterprises have partnered with Orbex, a UK-based launch vehicle company.[211] Elsewhere, Lockheed Martin, is responsible for developing launch operations at SaxaVord spaceport[212] on Unst in the Shetlands after relocating operations there from the Sutherland Hub in 2020.[213] When we asked Nik Smith, Regional Director for UK and Europe at Lockheed Martin Space, about the move, he told us that the transfer of operations was due to issues with Sutherland hosting two launch operators on one site:

> … these are complex capital programmes to build a spaceport. We were working with Sutherland alongside Orbex. The reality is that to try to satisfy both our different needs there was increasing risk in trying to put all those facilities in one place.[214]

Mr Smith concluded that a decision was made that the best way of maximising the chance for both operators to have the opportunity to launch was for Lockheed Martin to make a move.[215]

67. In addition to the plans for Lockheed Martin to establish launch operations at SaxaVord, Skyrora, a company headquartered in Edinburgh, has signed a deal with the Shetland-based spaceport to launch multiple rockets over the next decade.[216] In March 2022, Skyrora opened a new engine testing facility, the largest of its kind in the UK, and announced that it planned to be the first UK firm to carry out a launch from UK soil.[217] In his oral evidence, Scott Hammond, Deputy Chief Executive Officer of SaxaVord Spaceport, told us that it was looking to host a variety of launches of different sizes and was talking to a wide variety of launch companies to secure customers:

> We are working with Skyrora, a UK manufacturer, and ABL, an American manufacturer. In addition, we are talking with HyImpulse, a German manufacturer. They have done some engine tests already with us. There are two other German manufacturers, Rocket Factory Augsberg being one of them, which also comes to us. We are talking to C6, a Canadian launch company. We talked to Polish launch companies, French launch companies and some Israeli launch companies.[218]

68. Virgin Orbit is currently Spaceport Cornwall's primary launch partner. Virgin Orbit's small-satellite launch system is made up of a modified Boeing 747 (Cosmic Girl) which carries a rocket (Launcher One).[219] With a view to widening their customer base, Spaceport Cornwall have signed a memorandum of understanding with US company

211 UK Government, Lockheed Martin and Orbex to launch UK into new space age, 16 July 2018; In 2020, Orbex secured six launch contracts and further funding ($24 million) from two investment companies, Orbex, Orbex Secures $24 Million Funding Round for UK Space Launch, 10 December 2020; and in March 2021, Orbex won €7.45 million through the European Space Agency's (ESA's) "Boost! Commercial Space Transportation Services Programme," which will support its development of a sustainable launch vehicle, Orbex, European Space Agency Awards Orbex €7.45 Million, 24 March 2021

212 Letter from Minister for Science, Research & Innovation to the Chair of the Science and Technology Committee, 16 March 2022; PQ HL5303 [Lockheed Martin and Virgin Orbit], 25 January 2022

213 The Times, How the remote Shetland island of Unst rocketed to centre of the British space race, 18 October 2021

214 Q76

215 Q76

216 BBC, Rocket launch deal signed for Unst space centre, 12 October 2021

217 Skyrora, Skyrora opens the UK's largest rocket engine testing facility to take the lead in the British orbital launch race, 15 March 2022

218 Q111

219 Virgin Orbit, Technology, accessed 15 March 2022

Sierra Nevada, which plans to land its reusable space plane in the spaceport.[220] Melissa Thorpe, Head of Spaceport Cornwall, also confirmed that the facility planned to be a multi-user spaceport, and was looking to work with UK-based companies in the future.[221]

69. **The Government and the UK space sector have made significant steps towards developing a UK launch capability, with the establishment of a horizontal launch site at Spaceport Cornwall and two vertical launch sites: SaxaVord Spaceport on Unst in Shetland and Space Hub Sutherland. Although spaceports have taken different financing approaches, we commend the UK Space Agency (UKSA) for the funding it has provided for the establishment of spaceports and launch systems and recognise that the development of the UK space sector would not have been possible without these initial injections of public funding. Having said this, further investment may be required to ensure that the UK launch sector is successful and sustainable. *The Government should continue to examine where further and continued funding may be required to secure the success of the UK launch industry.***

Development of launch regulation

70. In 1967, the UN Outer Space Treaty was introduced to place obligations on Governments to:

- Maintain a register of objects sent into space;
- Ensure safety of operations for such space activities; and
- Bear ultimate liability for costs arising from accidental damage to 3rd parties from UK space activities.[222]

In response, the UK Government introduced the Outer Space Act 1986 (OSA) which provided the legal basis for the regulation of activities in outer space carried out by persons connected with the United Kingdom, thereby implementing the UK's obligations under the UN Space Treaties.[223] In 2017, the Government considered that neither international aviation nor space law were suitable to regulate the risks to safety and security posed by commercial spaceflight activities in the UK and a new bill was proposed by the Department for Transport.[224] The Space Industry Act 2018 created the high-level legal framework for UK spaceflight, including the requirements for the grant of operator, spaceport and range control licences.[225] The detailed regulatory framework for spaceflight, the Space Industry Regulations 2021,[226] were later approved by Parliament, on 1 July 2021. Parliament also approved two associated statutory instruments relating to the investigation of accidents and an appeals process.[227]

220 BBC, Spaceport Cornwall signs agreement with US company, 9 June 2021
221 Q112
222 United Nations Office for Outer Space Affairs, UN Outer Space Treaty, 19 December 1966
223 The Outer Space Act 1986
224 Department for Transport, Statement UIN HCWS471, 9 February 2017
225 Space Industry Act 2018; The Outer Space Act 1986 now only applies to space activities carried out by UK entities overseas.
226 Space Industry Regulations 2021
227 The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021, The Space Industry (Appeals) Regulations 2021

71. The new regulations have largely been welcomed by the space sector, but some stakeholders said that the Government needed to take an agile approach to the regulations and ensure that they were regularly reviewed and updated. In its written evidence, OneWeb said:

> Although the recent Space Industry Act 2018 is welcome and paves the way for space launch in the UK, it should not be seen as 'job done'. It will be essential to keep UK space legislation and regulations under constant review to ensure they are keeping pace as new technologies come on-line and other countries rapidly increase their space capabilities and ambitions.[228]

Some companies also told us that the length of time taken to publish the regulations had adversely affected their businesses. Alan Thompson, Head of Government Affairs at Skyrora, said:

> in 2012 the Federal Aviation Authority gave a copy of its regulations to HMG, and it has taken until now to get those regulations recreated. I believe that what we finally got in UK society with the [Civil Aviation Authority] is a good basis for world-leading regulation for space flight based on our experience in health and safety, but it has taken a lot of time. Time is the one thing that we do not have, and we need Government to polarise, to be clear what that case is, why we are behind it, why we are backing it and how it needs to work.[229]

He later added that Skyrora had been ready to launch its vehicle since May 2020 but had been unable to do so due to lack of UK spaceflight regulation:

> We have a suborbital vehicle that has been ready to launch since May of last year, but because of the absence of regulations and the set-up we have not been able to secure permission to do that. This vehicle is currently in Iceland because we hoped that the Icelandic [regulatory regime] would be able to provide us with a non-objection to make that happen, but because of the weather, unfortunately, we are unable to make that happen until spring of next year. That will demonstrate our capability of space flight. By the end of next year, we have a prototype of our orbital go-to-market vehicle that will be ready to launch in quarter 4 of 2022.[230]

Civil Aviation Authority

72. The regulations appointed the Civil Aviation Authority (CAA) to undertake regulatory functions. Previously, the UK Space Agency (UKSA) issued licences, but it also had responsibility for promoting the space sector, which the Government deemed to be a conflict.[231] The CAA was charged with overseeing "licence conditions, eligibility criteria, prescribed roles, liability and insurance, enforcement, international obligations and security against the policy framework established by Government".[232] Its work will involve issuing the following types of licence:

228 OneWeb (SPA0008)
229 Q62
230 Q64
231 Explanatory Memorandum to the Space Industry Regulations 2021
232 UK Civil Aviation Authority (SPA0014)

- Orbital—a licence that allows a person or organisation to: procure a launch for an object, operate an object in orbit, or conduct other activity in outer space;
- Launch and return—a licence that allows a person or organisation to launch a launch vehicle or carrier aircraft and launch vehicle;
- Spaceport—allows a person or organisation to operate a spaceport;
- Range control—authorises a person to provide particular range control services in support of licensed spaceflight activities at a designated range; and
- Air Navigation Order rocket—allows an operator to carry out activity with a rocket that is not capable of exceeding the stratosphere.[233]

73. In its evidence, the CAA told us that it was committed to engaging with the industry and had established two working groups, one with the sector and one with the Department for Transport, as a way to allow continued dialogue on how the regulations were functioning.[234] Overall, stakeholders were optimistic about the approach that the CAA had taken so far and the support they had received on their licence applications.[235] Having said this, the space sector still had a number of ongoing concerns.

74. The issue of operators facing unlimited liability was raised on a number of occasions throughout our inquiry.[236] The Space Industry Act 2018 placed a liability on a person carrying out spaceflight activities (whether this be for a launch activity or the operation of a single satellite) to indemnify the Government or listed person or body for any claims brought against them for loss or damage caused by those activities.[237] The new regulations provided for a limit on the amount of the operator's liability, which would be specified in the licence (licences and therefore liability are applied per satellite), but the regulations do not state a value for this limit. Representatives from launch companies (Nik Smith and Alan Thomson) were worried that the value was not stated in the primary legislation, and suggested that the Government should consider setting it to €60 million.[238] Skyrora also pointed out that, in contrast to the UK's approach, most other nations (where launch operations existed) had a fixed liability cap.[239] Nik Smith, Regional Director for UK and Europe at Lockheed Martin Space, said that compared to other countries the UK was attempting to take a more agile approach to setting the value of the liability cap. He believed that although this approach was more flexible and aimed to reduce the liability that companies were responsible for, it could increase uncertainty for companies who are trying to develop business cases for launch.[240] However, in the longer term, once the

233 CAA, Types of licence, accessed 30 September 2022
234 Q345
235 Q88
236 The explanatory memorandum to the regulations explained the background to liabilities: Under the UN Convention on International Liability for Damage Caused by Space Objects ("the UN Liability Convention") a launching state is ultimately liable to pay compensation to other states for any damage to another state's nationals caused by its space activities. To mitigate this liability on the Government, the 2018 Act requires operator licence holders to indemnify the Government for any claims brought against it. Section 34(2) places a strict third-party liability on spaceflight and satellite operators for damage their activities cause in the UK.
237 Explanatory Memorandum to the Space Industry Regulations 2021
238 Qq89–90
239 Skyrora Limited (SPA0064)
240 Q92

industry became more familiar with the processes involved, both Mr Smith and Scott Hammond, of SaxaVord Spaceport, suggested that the UK's approach could bring benefits in the future.[241]

75. On 23 June 2022, after our evidence sessions had concluded, the Government published the results of a consultation that it had undertaken to inform its orbital liability and insurance policy.[242] In this publication the Government revealed that it was exploring options for amending the Space Industry Act "to make clear in legislation that all operator licences must specify a limit on the amount of the licensee's liability." This change would provide legislative certainty that no operator faces unlimited liability. The Government also said that it would look to move to a variable liability limit approach, where licences would be placed in a limited number of liability bands with "a minimum value of zero and maximum recommended of £50m." The then Minister for Science, Research and Innovation, George Freeman MP, also set out in his foreword that the new approaches to policy on liability and insurance would be developed with sustainability in mind; incentives would be given to satellite operators who took precautions to minimise the risk of debris creation and long-term impacts on orbital sustainability, whilst the trackability and manoeuvrability of satellites was maximised. The Government said that it would conduct another consultation on these new proposals "later in 2022 or early 2023," adding that it had established a working group which "includes representatives from the satellite sector and academia to develop the safety and sustainability approach to setting orbital operator liability".[243]

76. **We understand that the Civil Aviation Authority (CAA) is considering changes to its approach to setting liability caps for orbital licences, including changing to a variable liability limit approach, where liability bands are defined and the maximum value is recommended to be £50m. We believe this approach will be welcomed by the industry, who want further certainty on the liability caps that will be applied to their operations. *The Government should develop proposals for the variable liability approach as quickly as possible, opening the consultation on these by the end of December 2022. To ensure that the required certainty is brought to the space industry and that the UK's launch sector begins to flourish, it should seek to implement the proposals by June 2023.***

77. Most players in the UK launch sector, including spaceport owners, launch vehicle operators and satellite operators, were concerned about the length of time that it might take the CAA to process their licence applications.[244] The CAA had forecast it taking 6–12 months to process a spaceport operator licence application, and 9–18 months for a launch operator's licence. Scott Hammond, Deputy CEO of SaxaVord spaceport, said that the length of this timescale was "a threat to the whole programme".[245] There were a few occasions during the CAA's representatives' testimony where it appeared that the Authority was placing the onus for a successful licence application primarily on the applicant. Tim Johnson, Director of Strategy and Policy at the CAA, stated that "the key

241 Q135
242 HM Government, Government response: Call for evidence to inform orbital liability and insurance policy, 23 June 2022
243 HM Government, Government response: Call for evidence to inform orbital liability and insurance policy, 23 June 2022
244 OneWeb (SPA0008), AAC Clyde Space (SPA0020), Lockheed Martin UK (SPA0050), Skyrora Limited (SPA0064), Q128
245 Q128

driver of the timetable will be the quality of the applications and the evidence presented".[246] When we asked the CAA to clarify what support it was providing to companies applying for licences, Mr Macleod said:

> As the independent regulator in a safety case model, we cannot write the safety case for them, but various guidance has been published, statutory and otherwise. There are about 1,000 pages of guidance that help applicants to understand what the system is. On safety cases, we have been developing workshops where we engage either with the industry as a whole or specifically with the company on its specific application and risks to try to help them understand the methodology, if they are not within the UK.[247]

78. Witnesses were also concerned about the adequacy of the CAA's resources. Pete Guthrie, Senior Programme Manager at Space Hub Sutherland, praised the CAA's adaptive approach but questioned whether it would be able to manage and process the growing number of spaceport and launch licence applications that were likely to be submitted in the coming years.[248] The CAA's spaceflight regulation team consists of about 35 people, whilst the total staff of the CAA numbers about 1,200 people. When asked whether they thought the team would be able to handle a "mass of parallel" applications, Mr Johnson responded on behalf of the CAA:

> Yes. We have built some additional flexibility into that model. We have the FAA secondee; we have a number of contracts with third parties who can assist us particularly with some of the technical evaluations—with the European Space Agency, for example. We have built the model with flexibility for a potentially changing workflow, and if we need to increase the size of the team we will do so.[249]

When we put these concerns about the CAA's capacity to the then Secretary of State for BEIS he told us that, although the CAA was new to the regulation of space launches, he expected that it would "reflect this growing market in its personnel, recruitment and staffing".[250]

79. **We were pleased to hear that the Civil Aviation Authority (CAA) has been working with spaceports, satellite manufacturers, and launch suppliers to ensure that the spaceflight regulations and licence application processes are fit for purpose. However, we are concerned that the CAA is not providing enough support for applicants which could cause delays in the licensing process. *The Department for Transport (DfT) should ensure that the CAA is suitably resourced to be able to provide an effective liaison service for each licence applicant to support them with navigating the application process.***

80. **The Government must take steps to ensure that the CAA is appropriately resourced to meet the demands of processing increasing numbers of licence applications. *Quarterly review meetings should be held by the CAA and DfT to review whether the***

246 Q346
247 Q372
248 Q129
249 Qq360–366
250 Q486

CAA's staffing complement is sufficient and further funding should be provided by the Government to the CAA if required and in good time to allow induction and training of such staff.

Countdown to a first launch

81. The timeline for the first UK launch received much speculation throughout our inquiry. On 27 October 2021, a press release following the Spending Review, set out the UK Government's aim to have the first launch take place in 2022:

> Funding for the UK to become the first country to launch a rocket into orbit from Europe in 2022, with the aim of becoming a leader in commercial small-satellite launch, as set out in the National Space Strategy.[251]

In addition, on 14 January 2022, the then Minister for Science, Research and Innovation, George Freeman MP, wrote in a tweet that he was working closely with the UK Space Agency and Virgin Orbit to "bring launch to the UK this year".[252] However, when representatives from the Civil Aviation Authority (CAA) were asked in oral evidence about a launch in 2022, Tim Johnson, Director of Strategy and Policy, did not directly answer the question and instead said:

> We absolutely share the Government's and the industry's enthusiasm and commitment to this task. We are open for business and are processing applications. The key driver of the timetable will be the quality of the applications and the evidence presented.[253]

Despite being pressed for an answer,[254] Mr Johnson would only say that the CAA was doing everything that it could to support the Government's ambitions by processing licence applications in a timely manner.

82. Seeking some clarity on this matter, we also asked the then Minister for Science, Research and Innovation, George Freeman MP, to confirm whether a launch would take place in 2022.[255] He said that a horizontal launch was predicted to take place in the summer of 2022, but it was uncertain whether a vertical launch from Scotland would take place this year. The Minister later followed up in writing, setting out that SaxaVord's first launch was planned for December 2022 and had been delayed due to issues with the launch system that ABL Space Systems was providing. The letter said:

> ABL are urgently seeking to correct the cause of failure and assess if they can recover any time lost. Their preliminary estimate is that this will delay the UK launch date from September to December 2022.

251 HM Treasury, Budget and Spending Review – October 2021: What you need to know, 27 October 2021
252 Twitter, George Freeman MP, 14 January 2022
253 Q346
254 Qq347–353
255 Oral evidence taken on 2 February 2022, HC (2021–22) 606, Qq268–274 [the then Minister George Freeman]

83. Since this letter was published, SaxaVord have announced another deal with launch providers Astra Space, with the first launches expected to begin in 2023.[256] Concerning Sutherland, Mr Freeman wrote that a launch was not expected to take place until "early 2023," and depended on how quickly development of the spaceport progressed.[257]

84. The then Secretary of State for Business, Energy and Industrial Strategy confirmed in a subsequent evidence session that his department was working closely with the spaceport and launch providers to ensure that the first UK launch took place as soon as possible.[258] He also told us that the then Secretary of State for Transport, who is responsible for the CAA, was working to expedite the licensing process "without any impediment to safety or impairment of the integrity of the process".[259]

85. In October 2022, Virgin Orbit announced that preparations were underway for its first launch from UK soil,[260] with the UK Government explaining that the mission was on track for a November launch from Spaceport Cornwall.[261] Despite this announcement, as of 26 October 2022 Virgin Orbit had not received its licence from the CAA for the launch.[262] It had, however, received its maritime licence from the Marine Management Organisation on 24 October 2022.[263]

86. **We are disappointed that a launch from the UK has not yet been achieved, especially as we were assured on several occasions that the first horizontal launch would take place in summer 2022.** ***The Department for Business, Energy and Industrial Strategy and the Department for Transport must prioritise working towards achieving the first launch from UK soil as soon as possible.***

87. **We are concerned that the delay in achieving the first UK launch is partly due to the Civil Aviation Authority (CAA) being unable to process licence applications in a timely manner.** ***For this initial set of licence applications, the Department for Transport must provide additional resource to the CAA to ensure that the licensing process does not impede the feasibility of a launch this year. After this, we expect that the application process will become streamlined and therefore the timeline for processing licence applications should be reduced to 3–6 months for all licences by 2024.***

88. **The publication of the Space Industry Regulations in July 2021 was a vital step that set out the licensing processes for launch activities, including establishing the Civil Aviation Authority as the regulator.** ***The Civil Aviation Authority, with the support of the Department for Transport and the Department for Business, Energy and Industrial Strategy, should continue to take guidance from other authorities such as the Federal Aviation Authority on how to best operate the licensing process.***

256 SaxaVord, Astra Space looks to expand launch capacity with SaxaVord UK Spaceport, 10 May 2022
257 Letter from Minister for Science, Research & Innovation to the Chair of the Science and Technology Committee, 16 March 2022
258 Q485
259 Q486
260 Virgin Orbit, Virgin Orbit's Next Rocket Read for Cornwall, 5 October 2022
261 UK Space Agency, Start Me Up: Countdown to first UK satellite launch, 11 October 2022
262 Space News, Virgin Orbit awaiting license for first UK launch, 6 October 2022
263 Marine Management Organisation, Marine licence issued for Virgin Orbit satellite launch project, 24 October 2022

4 Growing new technologies

89. During our inquiry, we heard about several challenges that the space sector is facing, and new technologies being developed to tackle these. This Chapter discusses some of these technologies and identifies Government interventions that will be required to ensure their success.

Space debris

90. We received a wealth of evidence that highlighted that space debris was a critical issue for the space industry and that means of its cost-effective removal were a priority. Allied to the development of technical solutions, the regulatory regime around such debris, and the hazards arising, also needed to be improved. (See Box 4 for key definitions relating to space debris.)[264]

Box 4: Definitions relating to space debris

- **Space debris**—includes human-made objects that orbit the Earth but are no longer functional, such as satellites that are no longer active, abandoned launch vehicle stages, and fragmentation debris. Space debris encompasses both natural and human-made objects, while "orbital debris" refers to artificial debris that is orbiting Earth.[265]
- **Space Situational Awareness (SSA) or Space Domain Awareness (SDA)**—refers to keeping track of objects in orbit and predicting where they will be at any given time.[266] SDA is more often associated with military aspects of space exploitation. For clarity, we will refer to these capabilities as SSA/SDA.
- **Space Traffic Management (STM)**—the management of space traffic, ensuring that objects are safely launched, operated, and returned to Earth without colliding with space debris.[267]

91. As of 3 March 2022, the European Space Agency's Space Debris Office regularly tracks 29,860 pieces of debris and estimated that there could be up to 36,500 objects in orbit greater than 10cm in size, 1 million objects between 1–10cm and 130 million objects between 1mm–1cm.[268] Space debris is an issue of concern as collisions can occur, which have the potential to cause damage to active spacecraft.[269] As space has become increasingly congested, particularly with space debris and satellites in low Earth orbit (LEO), the ability to operate in space safely has been threatened and an increased focus has been placed on tracking debris or avoiding its creation in the first place.[270]

264 See, for example: UK Research and Innovation (UKRI) (SPA0024), Dr Jonathan Eastwood (Director, Space Lab Network of Excellence and Senior Lecturer, Dept. of Physics at Imperial College London) (SPA0035), The Royal Society (SPA0049), ADS, UKspace (SPA0056), Airbus (SPA0081)

265 NASA, Space Debris and Human Spacecraft, 26 May 2021

266 Jacobs (SPA0073)

267 Dr Jonathan Eastwood (Director, Space Lab Network of Excellence and Senior Lecturer, Dept. of Physics at Imperial College London) (SPA0035)

268 European Space Agency, Space debris by the numbers, 3 March 2022

269 Q288

270 The Royal Society (SPA0049), Q288

92. Nations across the world are looking to improve their Space Situational Awareness (SSA) capabilities to ensure their assets in space are protected. The European Space Agency (ESA) has its own SSA/SDA programme which aims to "provide Europe and its citizens with complete and accurate information on objects orbiting Earth, on the space environment and on threats coming from space".[271] Dr Yamakawa, President of the Japan Aerospace Exploration Agency (JAXA), told us that JAXA had been tracking space debris for twenty years and that it had a memorandum of understanding in place with the US Department of Defence to share SSA/SDA services and information. He went on to say that the Japanese Ministry of Defence was responsible for the development of the Japanese Government's SSA system and that JAXA contributed scientific and technical support to this programme.[272] The importance of an effective SSA/SDA system is recognised in the UK National Space Strategy; it is listed as one of the high-growth areas that the UK should look to develop leadership in,[273] and as one of key civil and defence capability priorities.[274] In addition, UKSA recently launched a "Monitor Your Satellites" pilot service, which will provide operators of UK-licensed satellites with information, via an online platform, with information about upcoming potential collision events.[275] The UK Defence Space Strategy, published on 1 February 2022 after the National Space Strategy, also lists SSA/SDA as one of its seven priorities. The defence strategy says:

> The Defence SDA programme, which will be boosted by an addition of over £85M over the next 10 years, will augment and contribute to existing allied and commercial data sources using assured sensor capabilities required for national object classification and attribution. We will coordinate information and intelligence across all domains to build a richer understanding of the environment we see ourselves operating in, enhancing this using innovative and emergent technology that can also be used by our partners across government. We will ensure that the Defence SDA programme works in conjunction with the civil Space Surveillance and Tracking programme, led by the UKSA, to bring together the best possible data and analysis from civil, commercial and classified sources.[276]

With commitments made in both strategies, it was unclear how the responsibilities for the SDA capability would be allocated within Government between civil and defence authorities—UKSA and MoD. On 9 February 2022 (after the publication of the Defence Space Strategy), we asked the then Secretary of State for Business, Energy and Industrial Strategy about efforts to ensure that MoD investments in space domain awareness capabilities benefited (i.e. augmented and contributed to) the UKSA's space surveillance and tracking programme. The then Business Secretary suggested this was a matter for the MoD as there was "[…] a dual capability […] a civil capability, for which we are responsible, and a defence capability". However, he added that BEIS was talking to the MoD "all the time" and that the two departments were "trying to integrate the two [capabilities] and work out how we can synergise both approaches".[277]

271 ESA, Space Situational Awareness, accessed 23 March 2021
272 Q342
273 HM Government, National Space Strategy, 27 September 2021, p15
274 HM Government, National Space Strategy, 27 September 2021, p40
275 UK Space Agency, Monitor Your Satellites, 10 May 2022
276 Ministry of Defence, Defence Space Strategy, 1 February 2022, p30
277 Q489

93. **Although we believe that UK Space Agency (sponsored by BEIS) and the Ministry of Defence are both right to commit to improving their abilities to track and recognise objects in orbit (Space Situational Awareness /Space Domain Awareness), the two departments appear to be developing these capabilities independently, despite the previous Secretary of State for Business, Energy and Industrial Strategy's claims about efforts to integrate and find synergies. We believe a joint approach to serving civil and military needs from these capabilities should be established. *The Government should bring UKSA and MoD Space Situational Awareness/Space Domain Awareness services under one roof to maximise the use of knowledge, technology, and resources. The UK Space Command would be a perfect candidate for this as it already works alongside the UK Space Agency and Ministry of Defence to deliver joint national space capabilities.***

94. Witnesses thought that the UK was taking a leading role on the international regulation of space.[278] In January 2021, the UK signed an agreement with the UN Office for Outer Space Affairs (UNOOSA), which provided £85,000 to support international efforts to promote the sustainable use of space.[279] UNOOSA acts as secretariat to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) which, in 2019, adopted the Guidelines for the Long-Term Sustainability of Outer Space Activities (LTS guidelines), which provides a framework aiming to encourage the safe and sustainable use of space.[280] The UK has been a member of COPUOS since it was established in 1958.[281] Dr Paul Bate, CEO of UKSA, told us that UNOOSA had identified the UK as a leader in the area of space regulation at a recent G20 meeting.[282] Rebecca Evernden, Director of Space at BEIS, told us that the UK would continue to lead on this area by working with the United Nations to develop "global norms and rules with other like-minded countries" on the secure and sustainable use of space.[283] When we asked Ms Evernden to clarify the status of talks within the United Nations, she told us:

> The key is to work closely with like-minded states in order to create a critical mass to influence the wider debate. That is our starting point. We are working up a regulatory road map internally that will set out the steps we wish to take to get to that point of a consensus.[284]

95. **We commend the Department for Business, Energy and Industrial Strategy's approach to promoting the sustainable and safe use of space by developing a "regulatory road map" for the sustainable use of space and working with like-minded nations to promote the safe use of space. *The Department should publish this roadmap no later than the end of February 2023 and include what steps it will take to try and establish the "critical mass" required to form a consensus on the sustainable and safe use of space.***

96. The international witnesses that we spoke to agreed that the management of space debris was an international matter.[285] Dr Yamakawa, President of the Japan Aerospace Exploration Agency, told us that there needed to be an international code-of-conduct

278 ADS, UKspace (SPA0056), EMEA Satellite Operators Association (ESOA) (SPA0068), Q16
279 UK Space Agency, UN and UK sign agreement to promote space sustainability, 26 January 2021
280 UK Space Agency, UN and UK sign agreement to promote space sustainability, 26 January 2021
281 United Nations Office for Outer Space Affairs, Committee on the Peaceful Uses of Outer Space: Membership Evolution, accessed 23 March 2022
282 Qq426–427
283 Q490
284 Q491
285 Qq341–342

for the use of low Earth orbit to reduce the chance of problematic collisions that might damage active satellites.[286] On 18 April 2022, after we concluded taking evidence, the US announced a ban on missile tests against satellites, with US Vice-President Kamala Harris stating that such tests were reckless due to the space debris that they create. The Vice-President called on all nations to make the same commitment.[287] On 3 October 2022, the UK Government announced that it would follow suit, committing not to "destructively test direct ascent anti-satellite missiles".[288]

97. On 23 June 2022, after our evidence had concluded, the then Minister for Science, Research and Innovation, George Freeman MP, announced a new package of measures to drive the UK's sustainable use of space.[289] He set out the Government's plans to work with industry to establish a new Space Sustainability Standard, which would "aim to incentivise companies to adopt best practice in space sustainability and officially recognise those who take steps to minimise their footprint on the Earth's orbit."

98. **We commend the Government's latest announcements which will encourage the UK space industry to use space sustainably.** ***As space is global in nature, the Government should set out how it intends to work with international partners to establish an International Space Sustainability Standard, rather than focusing on UK only interventions.***

Space debris removal

99. As well as taking a lead on the regulation of space, we heard that the UK's space industry was leading on the development of technology required to remove debris from space.[290] We visited Harwell space cluster which hosts three companies (D-Orbit, Astroscale and ClearSpace) who were developing space debris removal technologies,[291] and had previously received financial support from the UK Space Agency (UKSA).[292] Astroscale had also received €800,000 from ESA to develop technologies that would accurately predict when collisions in space were going to occur and then calculate and implement the required evasive manoeuvres so that collisions were avoided.[293] In the new package of space sustainability measures announced on 23 June 2022,[294] the Government announced that it would undertake a regulatory review to "incentivise sustainable practises, investment and growth" and promote the use of state of the art technologies such as Active Debris Removal (ADR). £5 million was also confirmed for the Government's ADR programme. Later, on 26 September 2022, UKSA awarded £4 million to ClearSpace and Astroscale to

286 Qq342–344; Dr Yamakawa also explained that JAXA was due to launch a space debris removal satellite in 2022, Q315

287 The White House, Remarks by Vice President Harris on the Ongoing Work to Establish Norms in Space, 18 April 2022

288 Foreign, Commonwealth & Development Office, Responsible space behaviours: the UK commits not to destructively test direct ascent anti-satellite missiles, 3 October 2022

289 HM Government, Government announces package of new measures to drive space sustainability, 23 June 2022

290 Q15

291 Q426

292 Q426; UK Space Agency, UK working with global partners to clear up dangerous space debris, 26 October 2021; UK Space Agency, New funding to support sustainable future of space, 31 January 2022

293 Astroscale, Astroscale Awarded 800K Euro ESA Contract to Boost Collision Avoidance Maneuver Capability on Congested Orbital Highways, 10 March 2022

294 HM Government, Government announces package of new measures to drive space sustainability, 23 June 2022

design missions to remove existing pieces of space debris.[295] The announcement of this funding said on completion of their design, the companies could receive further funding to launch the UK's first space debris removal mission in 2026.

100. **The Government has taken positive steps towards supporting the establishment of space debris removal missions and we look forward to seeing further work in this area, especially on ensuring that regulation of these activities is fit for purpose.** ***Space debris removal missions should remain a clear focus of Government support and facilitation for the foreseeable future.***

In-orbit manufacturing

101. To date, almost all spacecrafts, including satellites, are manufactured, and assembled on the ground and then launched into space.[296] This results in restrictions on the size and design of the payloads, as they have to fit into rockets for launch. In-orbit (or on-orbit) manufacturing refers to the potential to build and assemble components in space as opposed to on the ground. The use of in-orbit manufacturing means that larger structures could be built in space, structures might be repaired, recycled and updated in space, and cost-savings and debris reduction could be made.[297] The Satellite Applications Catapult published a report in May 2021 on the UK's In-Orbit Servicing Capability.[298] Commissioned by UKSA and written alongside industry and the trade body, UKSpace, the report aimed to set out the UK's opportunity to become a world leader in the in-orbit services and manufacturing (IOSM) market. IOSM includes not just the manufacture and servicing of infrastructure in space, but the removal of space debris from orbit. The report identified that the UK had the capability to become a leader in IOSM and that technologies such as "large scale communication and observation systems, in-space laboratories and space-based power stations" could be developed if the Government committed to investment in this area. The report recommended that in the short-term the UK should support a multi-target space debris removal mission and in the longer-term it should support the in-orbit manufacture of a "space bench".[299]

102. UK businesses have already made significant steps towards developing IOSM capabilities. The Cardiff-based company, Space Forge, will have its first satellite, ForgeStar, launched on the first horizontal launch by Virgin Orbit from Cornwall Spaceport.[300] ForgeStar was the first satellite to be manufactured in Wales and is a new type of returnable vehicle that will be used to carry out IOSM in the future.[301] Space Forge is one of the only businesses developing IOSM capabilities in Europe and its technology is world leading.[302] The development of IOSM capabilities was also listed in the National Space Strategy as one of the priority areas in which the UK should improve its capabilities:

295 UK Space Agency, UK builds leadership in space debris removal and in-orbit manufacturing with national mission and funding boost, 26 September 2022
296 Institute of Defence Analyses, On-Orbit Manufacturing and Assembly of Spacecraft, January 2017
297 Q14, Institute of Defence Analyses, On-Orbit Manufacturing and Assembly of Spacecraft, January 2017
298 Satellite Applications Catapult, Astroscale and FAIR-SPACE, UK In-Orbit Servicing Capability, 27 May 2021
299 Satellite Applications Catapult, Astroscale and FAIR-SPACE, UK In-Orbit Servicing Capability, 27 May 2021, p18–19
300 Virgin Orbit, Virgin Orbit to launch first Welsh satellite from Spaceport Cornwall, 9 March 2022
301 The first launch for ForgeStar will test the return from space technology.
302 Space Forge Ltd (SPA0097)

> The UK will explore advanced in-orbit debris removal servicing, refuelling and assembly technologies nationally and in partnership with others, including ESA. In time, we will be able to build and repair satellites in orbit, conduct commercial activities including producing fuel and materials in space to support robotic and crewed space activity, and conduct defence operations to protect and defend our interests in and from space.[303]

103. **Research has already shown the UK has the potential to be a world leader in the growing in-orbit services and manufacturing (IOSM) market. The Government should seize this opportunity.** ***The Department for Business, Energy and Industrial Strategy and UK Space Agency (UKSA) should work with organisations and companies such as the Satellite Applications Catapult and Space Forge who have already set out the steps that the UK needs to take to maintain leadership in this area. UKSA should set out which parts of the Catapult's proposals it plans to take forward and should set a budget for this work.***

Space-based solar power

104. Although currently theoretical, we heard that the development of space based solar power (SBSP) could support the UK's transition to Net Zero.[304] In follow-up correspondence provided after our oral evidence sessions had concluded, the then Secretary of State for Business, Energy and Industrial Strategy set out how SBSP works:

> [Space-based solar power] functions by collecting solar energy using a satellite placed in geo-stationary orbit with a large-scale photovoltaic panel(s) which beam the electricity using radio technology to a fixed point on the Earth. Its main advantages over wind and terrestrial solar energy are the ability to deliver clean, baseload electricity, day and night throughout the year and in all weather conditions since the satellite is placed into an orbit where there is no night.[305]

In September 2021, the Government published an independent study that explored the technical feasibility, cost and economics of SPBP.[306] The study concluded that it would be technically feasible to develop SBSP capability for the UK and that this could be completed before 2050 (the date of the Net Zero target). The then Secretary of State laid out what the expected costs for producing power through these systems was estimated to be:

> The Levelised Cost of Energy (LCOE) of SBSP is estimated to be between £35-£80/MWh (central cost £50/MWh) for a nth-of-a-kind system commissioned in 2040. This is comparable to BEIS projections for other renewable technologies such as offshore wind (£40/MWh) and biomass with carbon capture & storage (£193/MWh). There are broader economic benefits for the UK to pursue the development of SBSP, with a favourable GDP multiplier and benefit-cost ratio. In addition, the development could lead to substantial spill-over benefits.[307]

303 HM Government, National Space Strategy, 27 September 2021, p16
304 Qq14–15
305 Department for Business, Energy and Industrial Strategy (SPA0101)
306 Frazer Nash Consultancy, Space Based Solar Power: De-risking the pathway to Net Zero, 27 September 2021
307 Department for Business, Energy and Industrial Strategy (SPA0101)

He went on to say that his department was creating a small-scale innovation programme to support the development of the technologies that SBSP required. He also noted that his department and the Department for International Trade were members of the Space Energy Initiative (established 10 March 2022), which aimed to bring together government, academia, and industry to coordinate a programme that would establish SBSP in the UK.[308] SBSP had also attracted attention elsewhere. ESA have recently funded 13 projects relating to SBSP and had also commissioned a cost-benefit analysis study of the technology.[309] Japan's work on SBSP technology is at a more mature stage of development, with JAXA expecting to have operational SBSP in the 2030s.[310]

105. **Although the technology is at a relatively early stage of development, Space Based Solar Power (SBSP) has the potential to become a useful supply of green energy by 2050, helping the UK to reach its Net Zero goals. We commend the announcement by BEIS of plans to create an innovation programme that will seek to develop the technologies required to achieve SBSP.**

308 Space Energy Initiative, Space Based Solar Power, accessed 25 March 2022
309 ESA, ESA reignites space-based solar power research, 10 January 2022
310 JAXA, FAQ about the SSPS, accessed 25 March 2022

5 Supporting the UK space sector

106. A survey conducted in 2021 found that the UK was home to 1,293 organisations that were part of the space sector.[311] All parts of the UK are home to space organisation headquarters, but sites are concentrated in South East England (450), London (317), South West England (215), and Scotland (144).[312] During our inquiry, we made visits to Harwell space cluster and Glasgow, two key areas where space organisations are concentrated. Although the UK clearly has a thriving space sector, we heard that it required more support to continue to grow and flourish. This Chapter examines the key support mechanisms that the sector told us needed to be put in place.

Multi-year funding agreements

107. We received evidence to suggest that space organisations in academia and industry would benefit from a multi-year funding settlement (three years as a minimum),[313] and that the late arrival of Government budgets in recent years had damaged the progress of research and development.[314] Stakeholders said that funding for multi-year space programmes was necessary for effective project planning, technology development, attracting private investment and recruiting and training employees.[315] The lack of funding for R&D being carried out at low Technology Readiness Levels (TRLs)[316] was also recognised.[317] This was attributed to the lack of long-term funding agreements; short-term funding was often provided to high-TRL levels, where commercially valuable outputs were more likely to occur quickly.[318] Dr Paul Bate, CEO of UKSA, and Professor Mark Thomson, Chair of the Science and Technology Facilities Council, also confirmed that the past two years (financial years 2020–21 and 2021–22) of single-year funding settlements had caused difficulties with the grant-funding process and that the three-year settlement would allow their organisations to provide multi-year grants in turn.[319] The Department for Business, Energy and Industrial Strategy announced a multi-annual funding settlement on 14 March 2022, which set out the allocations for UKRI and UKSA for the next three years.[320]

108. **Space-based projects, including fundamental research and development of new and especially wholly novel technologies, generally occur on long timescales and therefore require long-term funding. We were pleased to see the announcement of a**

311 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p10

312 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p15; note that values include multiple sites for some organisations; the total number of sites was 1,815.

313 AAC Clyde Space (SPA0020), University of Leicester (SPA0021), Surrey Satellite Technology Ltd (SPA0023), UK Research and Innovation (UKRI) (SPA0024), Space Hub Yorkshire (SPA0027), UKSA Space Exploration Advisory Committee Membership (SPA0043), Royal Astronomical Society (SPA0047), Thales (SPA0060), Spire Global UK (SPA0092)

314 University of Leicester (SPA0021), Airbus (SPA0081)

315 University of Leicester (SPA0021), AWE (SPA0046), Q174

316 Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest; NASA, Technology Readiness Level, 28 October 2012

317 Applied Space Technology Laboratory, University of Strathclyde (SPA0029); University of Leicester (SPA0021), techUK (SPA0042), Airbus (SPA0081), National Centre for Earth Observation (NCEO) (SPA0084)

318 Applied Space Technology Laboratory, University of Strathclyde (SPA0029)

319 Qq402–408

320 BEIS, BEIS research and development (R&D): partner organisation allocation 2022/2023 to 2024/2025, 14 March 2022

three-year budget for the Department for Business, Energy and Industrial Strategy for 2022–23—2024–25 which should bring some certainty to the sector. *The Government should reflect on the consequences of the recent one-year settlements on the space sector and provide a commitment to deliver at least three-year budget settlements to facilitate a more strategic approach to the allocation of public support for these technologies of the future.*

Support for SMEs

109. We heard that, although the space sector was home to a growing number of start-ups,[321] more support was required to enable SMEs to grow into larger enterprises.[322] The 2021 space sector survey showed that the industry was dominated by a few large organisations, with just 13 organisations accounting for 82% of the sector's total income (in 2018/19).[323] AAC Clyde Space, a medium-sized enterprise, argued that this was because current funding mechanisms offered more support to early-stage organisations through grants and large organisations through large-scale ESA-led programmes.[324]

110. UKRI agreed with this suggestion,[325] explaining that the UK Innovation and Science Seed Fund was well-suited to launching new-start-ups but that funding models needed to be put in place to support businesses at different stages.[326] These could include investor partnerships, where grant funding was matched with private investment; and innovation loans, where affordable loans were offered to R&D projects that were likely to become commercially viable.[327] Jon Styles, CEO of Assimila, and Professor Iain Woodhouse, Professor of Applied Earth Observation at the University of Edinburgh, both highlighted the importance of the UK growing its domestic market for space technologies and services, explaining that although receiving grant money allowed companies to develop technologies and services, these companies required customers to whom they could sell their product in order to become commercially viable and grow.[328]

111. We also heard that it would be helpful if the Government acted as a customer, using contracts rather than grants to support the development of new services and to drive private investment or attract other customers.[329] The potential for the UK Government to strengthen and support the space sector by acting as a procurer was also identified in the 2021 UK space sector survey,[330] and in our oral evidence sessions. Dr Lucy Edge from the Satellite Applications Catapult, for example, said that procurement could be used to drive the growth of SMEs, as it could also solve the issue of current funding not facilitating the scaling-up of SMEs.[331]

321 Q178
322 AAC Clyde Space (SPA0020)
323 know.space, Size & Health of the UK Space Industry 2020, May 2021, p13
324 AAC Clyde Space (SPA0020)
325 UK Research and Innovation (UKRI) (SPA0024); See also: Satellite Applications Catapult (SPA0037), Q179
326 UK Innovation & Science Seed Fund, accessed 29 March 2022
327 UK Research and Innovation (UKRI) (SPA0024)
328 Qq219–221, Q507
329 Q174, Q193, Q507
330 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p19
331 Q29

112. In addition to increasing the Government's role as an anchor customer, Professor Iain Woodhouse, Professor of Applied Earth Observation at the University of Edinburgh, proposed that the current procurement system would need to be changed if smaller companies were going to benefit from the Government becoming a customer:

> I know a lot of companies who won't bid for UK Government or Scottish Government contracts, largely because they want to keep all the IP. Start-up companies are not going to give you all their IP, so they have to look elsewhere. If you can change the procurement system so that these companies can get more clients and customers, that is how you will grow.[332]

Whilst the topic of procurement was not discussed in detail during our ministerial session, Rebecca Evernden, Director of Space at BEIS, told us that the department was working alongside the Ministry of Defence to identify how both departments could use procurement to develop dual-use capabilities in the future.[333]

113. **The current procurement systems are limiting the growth of the UK space sector and SMEs require further support to access new customers and expand. *The Government should further consider how procurement could be used to support businesses and leverage further private investment. The Department for Business, Energy and Industrial Strategy should work with the Ministry of Defence to establish improved procurement mechanisms.***

Clusters

114. During our inquiry, we learned that companies which were engaged with the space industry could be found across the whole of the UK, but certain areas were home to large clusters of space companies. We visited Harwell Space Cluster, which was part of the Harwell Science and Innovation Campus in Oxfordshire and was home to over 100 space organisations, ranging from start-ups to large multinationals.[334] We perceived great benefits to be realised from the co-location of companies which supported opportunities for collaboration,[335] including with the European Space Agency (ESA), who had an office on the campus. The Satellite Applications Catapult, established in 2013, played a vital role at the space cluster by providing smaller companies with access to testing facilities that they would otherwise have to spend their limited funds on.[336] Harwell was also home to the UKRI-funded National Satellite Test Facility (NTSF).[337] Costing over £100 million, the NTSF was the UK's first purpose built large-scale test facility for spacecraft and space payloads.[338] Professor Martin Sweeting, described the benefits that this facility brought:

> Having that test capability means that there is a one-stop shop for industry to be able to go to these test facilities. The test facilities are very expensive to implement, so it is not practical for every industry player to have their own. Having a central capability is important. One industry does not need

332 Q507
333 Q448
334 Harwell Space Cluster (SPA0090)
335 Professor David Southwood (Senior Research Investigator at Imperial College London) (SPA0040)
336 Q28
337 UKRI, National Satellite Test Facility, accessed 29 March 2022
338 UK Research and Innovation (UKRI) (SPA0024)

> to have one of those and use it every day, so having a central one makes a great deal of sense. Having a really modern test facility will simulate and help industry to be competitive in the UK.[339]

The Catapult also coordinated collaboration between industry, academia, UKSA, ESA, the Government and international partners to establish new projects and draw in investment.[340]

115. Although space-related activity is largely concentrated in the South East of England, Scotland is home to 144 space organisations,[341] with Glasgow said to produce more satellites than any other city in Europe.[342] Proportionally, Scotland employs over twice as many people in the space sector as the rest of the UK, 8,440 in total (as of 2019/20). In comparison, the South East of England, the region with the most space organisations in the UK, employed 9,880 people.[343] As part of our inquiry, we visited Glasgow and met with satellite manufacturers and space academics. In support of its thriving space sector the Scottish Government has established:

- The Scottish Space Leadership Council, which brought together key stakeholders from industry, academia and government with the aim of promoting the Scottish space sector;[344]
- The Scottish Space Academic Forum, which was established in 2021 and aims to promote the Scottish Space Higher Education Institution sector;[345] and
- A Strategy for Space in Scotland, published in October 2021 after the National Space Strategy was released, contains some specific aims for the Scottish space sector.[346]

116. To gain further insights into the Scottish space sector, we conducted a visit to two satellite manufacturing companies in Glasgow city centre, AAC Clyde Space and Spire Global Ltd., and took evidence from academics engaging with the space sector. Professor Malcolm Macdonald, Chair of Applied Space Technology at the University of Strathclyde and Professor Iain Woodhouse, Professor of Applied Earth Observation at the University of Edinburgh, highlighted that being situated close to a range of space companies facilitated collaboration.[347] Professor Macdonald also told us that the Scottish Space Leadership Council had successfully brought together the whole of the Scottish space sector which had resulted in its strong engagement with the Scottish Government.[348] In comparison to Harwell Space Cluster, where funding from the Government has played a large role in attracting space companies to Harwell campus, we found that the clustering of space companies in Glasgow and the surrounding areas had occurred more organically and had been driven by an increasing concentration of skills, technology and knowledge in the area.

339 Q194
340 Q17
341 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p15
342 The Scotsman, Scotland plan unveiled to become global leader in space development, 20 October 2021
343 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p16
344 Space Scotland, accessed 30 March 2021
345 Scottish Government, A Strategy for Space in Scotland, October 2021
346 Scottish Government, A Strategy for Space in Scotland, October 202
347 Qq500–501
348 Q502

117. Although the insights we gained during our visits exemplified the benefits that clusters have brought to the UK's space sector, we also received evidence that suggested that too much support was being directed to the South East of England,[349] and that more needed to be done to support the growth of space activity in other regions.[350] The UK Space Agency announced in February 2022, £600,000 of funding for the development of new space clusters across the UK, including in the Midlands, Cornwall, the North West of England, the West of England, Northern Ireland and Wales.[351]

118. **Clusters, such as those in Harwell and Glasgow, can be established in different ways and clearly bring benefits to the UK space sector. We welcome UK Space Agency's (UKSA's) announcements of at least some funding for the establishment of further clusters, and we particularly commend any such innovation outside the South East of England and London. However, the funding provided to support these new clusters was very limited and is therefore likely to prevent new clusters developing at pace.** ***The UKSA should set out in response to this Report its plans for each of the new clusters, what support it plans to provide and what outcomes it is aiming at, including how many companies it aims to attract to each region and how many jobs it aims to create.***

119. **The Satellite Applications Catapult has been instrumental in securing the establishment and development of space sector SMEs and driving the growth of Harwell space campus.** ***The Government should provide further support to the Satellite Applications Catapult, which will in turn stimulate the growth and success of space companies. Given that the Government's levelling up white paper says that "the Department for Business, Energy and Industrial Strategy will aim to invest at least 55% of its total domestic R&D funding outside the Greater South East by 2024–25", we would encourage the Government to be even more ambitious. Support for space R&D undertaken outside of Harwell should be in line with the proportion of the UK population living outside of the Greater South East. This would promote the growth of new space clusters and expand the space sector's reach.***

349 Applied Space Technology Laboratory, University of Strathclyde (SPA0029)

350 University of Birmingham, UK Quantum Technology Hub Sensors and Timing, West Midlands Regional Economic Development Institute (SPA0016), AAC Clyde Space (SPA0020), University of Leicester (SPA0021), Midlands Innovation (SPA0022), The Manufacturing Technology Centre (MTC) (SPA0041), Royal Aeronautical Society (RAeS) (SPA0079), Buckinghamshire Local Enterprise Partnership (SPA0080)

351 UK Space Agency, Boost for space clusters across the UK, 2 February 2022

6 International considerations

120. The success of the UK space sector to date, and indeed the development of national capabilities, would not have been possible without international collaboration.[352] International partnerships, whether bi- or multi-lateral, have allowed the UK to share knowledge, as well as the costs associated with carrying out R&D and developing new technologies.[353] The UK's main route to collaboration remains through the European Space Agency (ESA), but a UK-Australia Space Bridge was established in 2021 which aims to "increase knowledge exchange and investment across the two countries' space sectors".[354] This Chapter looks at the UK's main routes to international collaboration, including discussing the advantages of the UK's participation in ESA, and explores how establishing further collaboration could benefit the UK space sector.

European Space Agency (ESA)

121. Established in 1975 and headquartered in Paris, the ESA is an international and intergovernmental agency with 22 member states, including the UK.[355] ESA's remit is to:

> provide for, and to promote, exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems.[356]

Although ESA is not an EU organisation and the UK's membership has not been affected by its departure from the EU, ESA does coordinate the EU Space Programme, which includes the Galileo and Copernicus programmes, and is funded by the EU.[357] ESA's total budget for 2022 was €7.15 billion—with €4.81 (64.3%) of this from member state contributions.[358] The four largest contributors to the funding from member states were from: France (€1,178m, 24.5%), Germany (€1,018m, 21.1%), Italy (€680.2m, 14.1%) and the UK (€437.9m, 9.1%).[359] ESA's programmes are classed as either mandatory or optional; the contribution to the mandatory programmes accounts for around 20% of the budget and is calculated according to each country's gross national product, whereas contribution to the optional programme is decided by each country.[360] In 2022, the UK's mandatory contribution (to the budget supplied by member states) was 14% and its optional contribution was 9%. When we asked about the UK's contribution to ESA, its Director General, Dr Josef Aschbacher, told us that the UK was a very strong member state, but he hoped its contribution to optional programmes would increase in the future.[361]

352 UK Research and Innovation (UKRI) (SPA0024)
353 Open Geospatial Consortium (SPA0045)
354 UK Government, 'Space Bridge' across the world will help UK and Australia get ahead in global space race, 23 February 2021
355 ESA member states include: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom.
356 ESA, ESA's purpose, accessed 31 March 2022
357 European Commission, EU Space Programme, accessed 31 March 2022
358 28.4% of the budget was supplied by the European Union, 2.4% from Eumetsat and 4.9% from other sources.
359 ESA, ESA budget 2022, 18 January 2022
360 Qq283–284
361 Qq283–284

122. The benefit that participation in ESA brought to the UK was widely recognised by the UK space sector,[362] and it has been estimated that for every £1 that the UK invests in ESA, up to £11.80 is returned to the UK economy.[363] Airbus said that the UK's long-term membership of ESA had allowed the UK to "punch above its weight in space".[364] The advantages that ESA brought to the UK were well expressed by the University of Strathclyde:

> The UK enjoys a position of global leadership in the space sector, secured through our membership of the European Space Agency (ESA). Through ESA we gain access to many of the programmes that make space high-profile; from the Astronaut programme and the International Space Station, to conducting truly exceptional and exquisite science. ESA offers access to a depth and breadth of skills that the UK could not sustain within the current public spending settlement, and so is a vital part of the UK's global position as a space nation.[365]

123. Although the evidence we received throughout our inquiry was strongly in favour of the UK's continued participation in ESA, stakeholders suggested that participation in ESA programmes should be linked more firmly to the aims of the UK's National Space Strategy and that a stronger national programme should be developed.[366] Some, such as the Royal Aeronautical Society, the National Centre for Earth Observation and Lockheed Martin UK, thought that the UK investment in national space R&D programmes should be at the same level as its contribution to ESA.[367] Doing so would mean that the overall budget for space would need to increase substantially—for example, in 2019/20 UKSA spent £334.2m on ESA membership and just £59.4m on national programmes,[368] with the latter receiving more support and advocacy from most industrial and academic institutions.[369] Overall, the UK's level of public and private investment in space (both through national and ESA programmes) was a concern and many submissions highlighted that the UK lagged behind other nations, such as Germany, Japan, Italy, and France, who had similar sized economies.[370]

124. **The UK's involvement in the European Space Agency (ESA) has brought a wide range of benefits to the UK and its space sector, but there is a need to re-address the balance between funding for ESA programmes and funding for national space**

362 University of Leicester (SPA0021), Applied Space Technology Laboratory, University of Strathclyde (SPA0029), Open Geospatial Consortium (SPA0045), Northumbria University (SPA0048), UCL, Department of Space and Climate Physics (SPA0059), London Institute of Space Policy and Law (SPA0067), Royal Aeronautical Society (RAeS) (SPA0079), Airbus (SPA0081)

363 UK Space Agency, £15 million investment in satellite communications from UK Space Agency, 17 October 2022

364 Airbus (SPA0081)

365 Applied Space Technology Laboratory, University of Strathclyde (SPA0029)

366 UK National Quantum Technology Hub in Sensors and Timing, University of Birmingham; UK Quantum Technology Hub Sensors and Timing (SPA0011), University of Leicester (SPA0021), Royal Astronomical Society (SPA0047), Lockheed Martin UK (SPA0050), FAIR-SPACE Hub (SPA0057), UCL, Department of Space and Climate Physics (SPA0059), Royal Aeronautical Society (RAeS) (SPA0079), National Centre for Earth Observation (NCEO) (SPA0084)

367 NERC SENSE Earth Observation Centre for Doctoral Training (SPA0013)

368 UK Research and Innovation (UKRI) (SPA0024)

369 Midlands Innovation (SPA0022), Satellite Applications Catapult (SPA0037), techUK (SPA0042), Skyrora Limited (SPA0064)

370 University of Leicester (SPA0021), Midlands Innovation (SPA0022), UCL, Department of Space and Climate Physics (SPA0059) Skyrora Limited (SPA0064), Jacobs (SPA0073), Royal Aeronautical Society (RAeS) (SPA0079)

programmes. ***The Government should not diminish its funding via ESA but should increase its investment in national space programmes; and both funding streams should reflect and focus on the objectives of the National Space Strategy as far as possible.***

International collaboration outside of Europe

125. Outside of its collaboration with ESA, the UK has set up the UK-Australia Space Bridge.[371] As a world first, the 'Bridge' was established in February 2021 to help develop opportunities for UK and Australian governments and companies to collaborate on space-related activities, and aims to unlock "improved access to trade, investment and academic research opportunities, better advice to businesses and innovative bilateral collaborations".[372] The creation of this agreement received support in our evidence and witnesses hoped that a similar approach could be taken to foster collaboration with other countries.[373] In December 2021, Dr Hina Khan, Senior Project Manager and UK Stakeholder Engagement at Spire Global Limited, and Dr Jon Styles, Director of Assimila, told us that the companies that they represented had already received contracts from the Bridge, which demonstrated to us that agreements such as this could harness quick benefits for the UK space industry.[374]

126. The UK Space Agency signed a Memorandum of Cooperation with the Japanese Aerospace Exploration Agency (JAXA) in June 2021, which sought to boost collaboration on space between the UK and Japan.[375] In his evidence to us, Dr Yamakawa, President of JAXA, set out his view on this agreement:

> Under that memorandum of co-operation, implementing arrangements were signed to co-operate with the UK Defence Science and Technology Laboratory, DSTL, for space debris collaboration. This kind of bilateral collaboration is the key for maximising the output of space missions.[376]

127. The UK is also contributing to the NASA-led Artemis programme, which aims to facilitate human exploration of the Moon and Mars.[377] The UK National Space Strategy said that the UK's contribution to the programme would "provide essential support that delivers new UK science, technical skills and inspires the next generation".[378] The UK has also signed the Artemis Accords, which are a set of non-binding principles, to promote cooperative, peaceful civil exploration of outer space.[379]

371 UK Government, 'Space Bridge' across the world will help UK and Australia get ahead in global space race, 23 February 2021

372 UK Government, 'Space Bridge' across the world will help UK and Australia get ahead in global space race, 23 February 2021

373 Surrey Satellite Technology Ltd (SPA0023), The Royal Society (SPA0049), Skyrora Limited (SPA0064), Airbus (SPA0081), Qq223–225

374 Qq223–225

375 UK Space Agency, Strengthening space ties between the UK and Japan, 25 June 2021

376 Q335

377 NASA, NASA's Lunar Exploration Program Overview, September 2020

378 HM Government, National Space Strategy, 27 September 2021, p33

379 NASA, Artemis Accords, 13 October 2020. The Accords were first established in October 2020 when they were signed by: Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, UK, and the US. Since, Ukraine, South Korea, New Zealand, Brazil, Poland and Mexico have also signed.

Supporting further international collaboration

128. In addition to these agreements, the UK Space Agency runs an International Partnership Programme (IPP), which uses space technology to deliver "sustainable economic, societal and/or environmental benefits to developing countries".[380] Since 2016, the IPP has funded 43 projects in 47 countries across Africa, Asia-Pacific and Latin America tackling challenges such as food security, climate resilience and disease forecasting.[381] The Satellite Applications Catapult called for the expansion of the IPP scheme as a way to establish further international partnerships, with AAC Clyde Space adding that further development of the IPP should be carried out in consultation with industry.[382] UKSA has also used its National Space Innovation Programme to establish international collaboration and has funded projects with NASA and JAXA through this mechanism.[383]

129. The majority of witnesses advocated further international agreements and programmes to be developed. Several stakeholders noted that due to the UK's reduced involvement with some EU space programmes, the UK should look outside of Europe to form future partnerships.[384] Although the National Space Strategy stated that "collaborating internationally" would be key to success of the UK space sector,[385] concerns were raised about how this would be achieved. Space Academic Network, who represent space-related researchers in the UK, told us that although the UK space R&D sector was often asked to participate in bilateral arrangements, UK programmes and UK R&D institutions lacked the funding to be able to participate in these collaborations.[386] While many stakeholders were in favour of developing new international partnerships, some stipulated that new bi- or multi-lateral agreements must:

- be in line with the aims set out in the National Space Strategy;[387]
- provide a route to future commercial opportunities;[388]
- prioritise the Five Eyes nations (US, UK Australia, Canada and New Zealand), as they had "similar technological capability, a common language and close business and legal processes";[389] and
- provide the UK with at least an equal value for money to that which it invests.[390]

130. **The UK has already benefited from new international agreements that have been established outside of the European Union, such as with the US on the Artemis Accords and the UK-Australia Space Bridge. More needs to be done to ensure that the UK increases its international reach and benefits from the skills and technologies**

380 UKSA, International Partnership Programme, last updated 7 April 2021
381 UKSA, International Partnership Programme, last updated 7 April 2021
382 Satellite Applications Catapult (SPA0086)
383 UKSA, Call for proposals: National Space Innovation Programme - International, 1 October 2020; UKSA, National and international project and grant recipients, 9 November 2021; HM Government, National Space Strategy, 27 September 2021, p32
384 London Institute of Space Policy and Law (SPA0067), Athena (SPA0083), Q223
385 National Space Strategy, 27 September 2021, p32
386 The Space academic Network (SPA0009)
387 UK Research and Innovation (UKRI) (SPA0024), ADS, UKspace (SPA0056), UCL, Department of Space and Climate Physics (SPA0059)
388 AAC Clyde Space (SPA0020)
389 Surrey Satellite Technology Ltd (SPA0023), ADS, UKspace (SPA0056), Jacobs (SPA0073), Airbus (SPA0081)
390 UK Research and Innovation (UKRI) (SPA0024), Mango Space Ltd (SPA0075)

being developed in other countries. ***The UK should focus on forming new bi-lateral and multi-lateral agreements, like the UK-Australia Space Bridge, that support the UK's aims for space and provide access to new trade opportunities, collaborative R&D projects, and access to new technologies.***

7 Addressing the skills shortage

131. In 2019/20 the space sector directly supported 46,994 jobs (0.14% of total UK employment), with a further 190,000 jobs supported across the UK supply chain.[391] The number of people employed in the space industry has seen significant growth over the last twenty years and this growth continues, especially within downstream activities (see Box 1), where 67% of the workforce is employed. The space industry workforce is also "exceptionally skilled," with 73% of employees holding at least a primary degree—higher than any other ONS-defined sector.[392]

132. The growth of the UK space sector and the demand for highly-qualified employees has placed significant strain on the space sector workforce.[393] In 2018/19 a third of space companies said that recruitment of staff was a barrier to their growth.[394] UKRI highlighted that if the skills shortage continued it might "hinder research and economic growth of the sector".[395] In 2020, UKSA's Space Sector Skills Survey found that the sector was struggling to recruit suitable employees because it set very high expectations for the qualifications and experience it expected candidates to have. The survey also found that the sector's approach to recruitment was very 'inward,' with companies showing preference for candidates with significant experience.[396] Evidence from our witnesses showed that there was a particular shortage of workers with software-based skills, including in computer science, artificial intelligence, data science and cyber-security.[397] This Chapter looks at the UK space sector's skill shortage, exploring the causes and identifying interventions that could be made to tackle the issue.

Skills challenges

Inspiring the next generation

133. We heard that to increase the number of prospective space sector employees, young people needed to be inspired by the idea of working in the space sector. Space Hub Yorkshire (SHY) told us that outreach programmes for primary and secondary pupils on the topic of space should be used to encourage young people to study STEM subjects. When taking evidence in Glasgow, we heard about the University of Strathclyde's Scottish Space School, which is an outreach programme hosting a hundred 15–16-year-olds annually at a week-long school programme of space-related lectures, labs, and workshops. Professor Malcolm Macdonald, Chair of Applied Space Technology at the University of Strathclyde, told us that the school actively targeted students who were not considering studying a STEM subject at university and that, after attending the school, 65–85% of them went onto apply to study a STEM subject.[398] The school has previously hosted NASA astronauts as a way of

391 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p8
392 BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p9
393 City REDI Blog, University of Birmingham, Meeting the Skills Needs of the Space Sector, 15 September 2021
394 Know.space, Size & Health of the UK Space Industry 2020, May 2021, p20
395 UK Research and Innovation (UKRI) (SPA0024)
396 UK Space Agency, Space Sector Skills Survey 2020, 25 February 2021
397 Q199
398 Q503

inspiring its attendees but Professor Macdonald agreed, at our suggestion, that the school should consider hosting guests who were more tangible role models for the students, such as employees from local companies.[399]

Training the next generation

134. Once people choose to study a space-related discipline at university, it is not certain that they will be training in the most relevant skills. UKSA's Space Sector Skills Survey found that there was "a mismatch between what skills the industry needs and what skills the UK Higher Education system produces," including a perception that higher education did not keep up with advancing technologies or industry needs.[400] Space Hub Yorkshire (SHY) explained that it was not possible for one single university to carry the expertise of the entire space sector and therefore cross-university institutions should be established that could signpost modules and training courses and work with industry to provide the most relevant training to undergraduates.[401] The Royal Aeronautical Society thought that investment would be required to ensure that the delivery of Higher and Further Education teaching on space had the "right knowledge, equipment and people to support learning".[402] The Society, alongside other witnesses, such as the UK Solar Physics Council, also suggested that increasing undergraduate access to internships in industry would improve their future employability.[403] With respect to postgraduate training, we received evidence that suggested that the UK should increase access to postgraduate training, including creating new doctoral training centres.[404]

135. Outside of university education, the Royal Aeronautical Society (RAeS) praised the establishment of the new Level 4 and 6 Space Engineering Technician Apprenticeship Standards,[405] proposing that these would help more people enter the industry. RAeS said that the Government and UKSA should work towards developing new apprenticeship standards to meet sector needs. In oral evidence, representatives from Spire Global Ltd. and Inmarsat confirmed that apprenticeships were used to train 16- and 17-year-olds and this had kick-started their career.[406]

Recruiting experienced employees

136. When we spoke to representatives from industry, they said that, although graduate schemes were often oversubscribed, recruiting people with experience was often challenging.[407] Professor Lucy Berthoud, Co-Chair of the Space Universities Network, told us that despite growing numbers of students taking up undergraduate courses in space-related topics, the space sector had a shortage of people with 5+ years of experience.[408]

399 Q505
400 UK Space Agency, Space Sector Skills Survey 2020, 25 February 2021, p8
401 Space Hub Yorkshire (SPA0027)
402 Royal Aeronautical Society (RAeS) (SPA0079)
403 Dr Peter Shaw (Senior Lecturer in Astronautics at Kingston University London) (SPA0003), Space Hub Yorkshire (SPA0027), UK Solar Physics Council (SPA0034), Royal Aeronautical Society (RAeS) (SPA0079)
404 The Space academic Network (SPA0009), The National Oceanography Centre (SPA0012), NERC SENSE Earth Observation Centre for Doctoral Training (SPA0013), UK Solar Physics Council (SPA0034), Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (SPA0082)
405 Royal Aeronautical Society (RAeS) (SPA0079)
406 Q204; Q230
407 Q201
408 Lucy Berthoud (Co-Chair at Space Universities Network, Professor of Space Systems Engineering at University of Bristol) (SPA0088)

Various representatives from industry confirmed that this was a key issue. For example, Hina Khan, Senior Project Manager and UK Stakeholder Engagement at Spire Global, a satellite manufacturer and operator, suggested that this could be due to the short-term nature of funding available to the space sector, which made employing experienced workers preferable to spending time training and upskilling new employees.[409] The Atomic Weapons Establishment (AWE), a Ministry of Defence research facility, found that the space sector was a desirable sector for graduates to work in, with hundreds of graduates applying for one role, but that retaining these graduates was difficult.[410] Professor Sir Martin Sweeting, Founder and Executive Chairman of Surrey Satellite Technologies Ltd. (SSTL), agreed with this, saying that SSTL had received 150 applications for 12 graduate positions.[411] He suggested that graduates who SSTL trained often left the company to work for space sector start-ups or SMEs offering much higher salaries.[412] Yasrine Ibnyahya, Director of Advanced Concepts at Inmarsat, confirmed that the larger primes were not as attractive to graduates as smaller companies but that Inmarsat tried to use its graduate programme to overcome this—by providing training and rotations into different departments.[413] Overall, larger companies did not appear to have an issue with recruiting graduates but seemed to struggle to recruit the more experienced personnel they desired.

Competition with other sectors

137. We heard that another key issue regarding skills was competition with other tech-related sectors that offered higher levels of pay. Surrey Satellites Technology Ltd. said that employees often had expertise that overlapped with other industries and that this could result in skilled workers leaving the space industry to use their skills elsewhere.[414] The Satellite Applications Catapult agreed with this and identified that competition with comparable industries which had similar skill requirements, such as machine learning, often led to people leaving the space industry.[415] A survey by the Space Skills Alliance, based on 2020 data, revealed that tech companies were paying considerably more for equivalent level roles than the space sector.[416] When we spoke to leaders of space agencies in other countries, Dr Phillipe Baptiste, President of the centre national d'études spatiales (CNES, French National Space and Research Centre) said that although other industries which required similar skills offered higher salaries, CNES did not struggle with recruitment because working for the space sector was "something people love," suggesting that inspiration had a role to play.[417] This point was borne out by the Space Skills Alliance survey finding that less than 1% of respondents cited pay as a reason for joining the space sector (the vast majority liked the topic or found the work interesting).[418]

409 Q229
410 AWE (SPA0046)
411 Q201
412 Q203
413 Q198
414 Surrey Satellite Technology Ltd (SPA0023)
415 Satellite Applications Catapult (SPA0037)
416 Space Skills Alliance, Pay in the UK space sector, Accessed 18 March 2022
417 Q333
418 Space Skills Alliance, Pay in the UK space sector, para69, accessed 18 March 2022

Re-skilling workers from other sectors

138. Through written and oral testimonies, we heard that re-training and up-skilling skilled employees from other sectors was key to addressing the skills shortage.[419] In oral evidence, Dr Khan described how Spire Global brought in talent from the oil and gas industries as these were sectors which used skills that were relevant to the space sector.[420] The Royal Aeronautical Society highlighted that apprenticeships could be used for the re-skilling or up-skilling of staff and that employees could be drawn from industries such as civil aerospace manufacturing and aviation, where reduced numbers of roles were available due to the pandemic.[421]

A lack of diversity

139. Research conducted by the Space Skills Alliance indicated that the space sector workforce lacked diversity. Women were significantly under-represented (29% of the workforce despite making up over 50% of the working age female population), which matched trends seen in similar workforces such as tech, physics and engineering.[422] Other under-represented groups were identified as:

- Carers (6% vs 15% in the wider workforce);
- Ethnic minorities (11% vs 14% in the population at large); and
- Disabled people (8% vs 13% in the wider workforce).[423]

In addition, people from higher socio-economic backgrounds were over-represented, with people who attended private schools over-represented by a factor of 2.2 and selective school attendees over-represented by a factor of 4.6, while those attending comprehensives (non-selective schools) being under-represented by a factor of 0.7.[424] A more detailed report into women in the UK space sector discussed the demographics, education, pay and experiences of 452 woman who were surveyed as part of the 2020 space census. It stated that 41% of women in the space sector had experienced discrimination (compared to 10% of men), that women were consistently paid less than men, and that they were less likely to be promoted into senior roles.[425] A number of witnesses called for more to be done to increase the diversity of the space industry's workforce,[426] including Dr Khan, from Spire Global, who suggested that both the Government and industry had a role to play:

> What the Government can do to help to resolve some of that is important. I do a lot of work in schools as a STEM ambassador. Girls are very excited about being in space and technology. It is a fun thing to be involved in, but as

419 Q200, The Manufacturing Technology Centre (MTC) (SPA0041), Royal Aeronautical Society (RAeS) (SPA0079), Lucy Berthoud (Co-Chair at Space Universities Network, Professor of Space Systems Engineering at University of Bristol) (SPA0088)
420 Q211
421 Royal Aeronautical Society (RAeS) (SPA0079)
422 Space Skills Alliance, Demographics of the UK space sector, 9 March 2021, Figure 2
423 Space Skills Alliance, Demographics of the UK space sector, 9 March 2021, Summary
424 Space Skills Alliance, Demographics of the UK space sector, 9 March 2021, Figure 27
425 Space Skills Alliance, Women in the UK space sector, 6 October 2021
426 Dr Thomas Cheney (Lecturer in Space Governance at AstrobiologyOU, The Open University) (SPA0015), AAC Clyde Space (SPA0020)

> they go through secondary school and university there is a little movement away and space is very much high-tech with rockets and engineering, so there is a little bit of a disconnect.
>
> It is important that as a sector—there is an onus on our side as well as on Government—we extend the information on what it means to be in the sector. There is so much more than just the technology side; there is storytelling, business, the legal aspect and medical science. There are all sorts of things that are non-traditional space aspects that people may not have visibility of.[427]

140. Although the Royal Astronomical Society called on the Government to publish a plan to address issues of diversity,[428] the National Space Strategy did not describe how the Government planned to increase the diversity of the space workforce. Having said this Dr Bate, CEO of UKSA, suggested that UKSA was undertaking work on the theme of skills and diversity:

> There is quite a range of activities that we are trying to corral, measure and demonstrate what the opportunities are. That goes as far as for small and medium enterprises for developing skills and a diversity strategy so that they can take that themselves rather than having to work everything out from scratch.[429]

We are currently conducting an inquiry into Diversity and Inclusion in STEM which explores these issues in much greater detail.[430] Our forthcoming Report will provide detailed conclusions and recommendations on this topic.

Government action

141. The National Space Strategy contained a section on employment and skills issues, called "Nurturing Talent", which described how the Government would support the space sector workforce, including by:

- working with employers to improve access to relevant and quality training to build in-demand skills;
- partnering with employers to help more young people access apprenticeships and work placements; and
- using the 'wonder of space' to inspire the next generation into STEM careers.[431]

Nonetheless, Professor Anu Ohja, Director of the National Space Academy, who spoke to us after the strategy had been published, said that the plan for skills was lacking:

> […] where the strategy, unfortunately, is really lacking, is not because of our lack of expertise but because of skills. Underpinning us teching our way out of the challenges we face now using space, people are key. There is a

427 Q231
428 Royal Astronomical Society (SPA0047)
429 Q429
430 Science and Technology Committee, Diversity and Inclusion in STEM, opened 22 November 2021
431 HM Government, National Space Strategy, 27 September 2021

> broad spectrum on skills development, from the inspiration programme—a really overused word in my opinion—all the way up to the really focused skills development programmes. Some of them are broad, for millions of people. Some of them are for smaller numbers of people and much deeper in depth.[432]

142. Professor Thomson, Chair of Science and Technology Facilities Council (STFC), told us that work was underway to develop an implementation plan that would support the delivery of the new strategy and that UKRI had taken a leading role in a workstream related to skills (see Chapter 8 for more details).[433] He went on to say that STFC was looking to expand its apprenticeship and graduate programmes to ensure that the space industry had access to candidates with the correct skills.[434]

143. After our evidence sessions concluded, the then Secretary of State for Business, Energy and Industrial Strategy wrote to us to confirm the work his department was carrying out to address the space skills shortage. He told us that:

- UKSA had convened a Space Skills Advisory Panel (SSAP) that brought together academia, industry and government and aims to create solutions to the skills shortage. The panel was developing a national skills strategy and had commissioned a space census that would be used as a benchmark against which any improvements could be measured;
- UKSA, alongside Industry Trailblazer Groups, had established two space engineering apprenticeships and were in the processes of developing a third;
- the Government was supporting the establishment of two new centres, one at Goonhilly in Cornwall and one at the University of Bradford, that would aim to develop "higher-level space Artificial Intelligence (AI) related skills;"
- in 2019, UKSA, the European Space Education Resource Office UK and STEM Ambassadors had established a 'One Million Interactions' programme that pledged to deliver one million interactions per year with young people that emphasised the importance and excitement of space; and
- UKSA had invested over £600k per year for three years in measures to support space education and skills.[435]

144. **The space sector is suffering from a skills shortage, with experienced employees and those with skills such as programming being particularly hard to find. Higher Education institutions struggle to provide training that keeps pace with technical advancements happening in the sector's industries. *The UK Space Agency's newly convened Space Skills Advisory Panel (SSAP) should look to establish a working group, including representatives from Higher Education institutes, Doctoral Training Centre's, and industry, who should develop joint training programmes that address the skills gap and allow future space employees to gain experience in the most advanced technologies.***

432 Q37
433 Q379
434 Q431
435 Department for Business, Energy and Industrial Strategy (SPA0102)

145. **Companies often find it difficult to recruit employees with considerable experience, but we think companies are also hesitant to invest money and time into training staff. This is partly due to the short-term nature of grant funding, creating a need for companies to have immediate access to the correct expertise. Further, space organisations fear that they will lose early career workers through competition with similar sectors, such as the tech sector, which require similar skills but often offer higher salaries.** ***Industry players should move away from requiring applicants to have years of experience and should instead strengthen their early career training programmes, including the use of apprenticeships so that not all applicants require a degree. The Government should make it easier for businesses to do this, by offering multi-year grants which allow companies to plan and offer employees longer contracts.***

146. **If the UK is to address the space skills shortage it is currently facing, then it will need to inspire future generations to take up a career in space. Although the UK Space Agency has programmes in place that are seeking to do this, we believe there is a disconnect between what the UK space sector does and how the wider population perceives it. Most associate space with space exploration and may not associate it with the range of vital services that it provides.** ***The UK Space Agency should ensure that its "inspiration" programme addresses the breadth of the UK's activities in space and uses local role models who reflect this.***

8 Conclusions and next steps for the National Space Strategy

147. This final Chapter explores the contents of the National Space Strategy, bringing together concerns raised by industry and academia, and considers what steps must be taken by the Government to ensure the success of its approach to the space sector.

National Space Strategy

148. On 27 September 2021, the Government published its National Space Strategy (NSS) which described the Government's ambitions for the UK space industry, including five key goals:

- Grow and level up our space economy
- Promote the values of Global Britain
- Lead pioneering scientific discovery and inspire the nation
- Protect and defend our national interests in and through space, and
- Use space to deliver for UK citizens and the world.[436]

The details of the strategy were set out under four pillars:

- Pillar One: Unlocking growth in the UK space sector—this pillar covered creating trade partnerships, spreading growth across the UK, having modern regulation, access to private and public finance, nurturing UK talent, and making use of government procurement.
- Pillar Two: Collaborating internationally—this covered building international partnerships and using diplomacy to promote the safe use of space.
- Pillar Three: Growing the UK as a science and technology superpower—the main plan described here was to use the UKSA's National Space Innovation Programme to support collaborations between industry and academia.
- Pillar Four: Developing resilient space capabilities and services—covering securing civil and military access to satellite-based Communications, Earth Observation (EO), Position Navigation and Timing (PNT), launch facilities, Space Domain Awareness and In Orbit Servicing and Manufacturing (IOSM).

In addition to these four pillars, the strategy included a Ten Point Plan which described areas that the Government would initially focus on to "pursue the highest impact opportunities and the critical cross-cutting enablers that will lay the groundwork for a thriving future in space."[437]

149. The strategy did not include reference to any increase in public spending for the civil space sector but stated that the Autumn 2021 Comprehensive Spending Review

436 HM Government, National Space Strategy, 27 September 2021
437 HM Government, National Space Strategy, 27 September 2021, p41

"would set budgets for government space activities into the coming years." In spite of this, no further details of funding for space were included within the Autumn Budget and Spending Review 2021 and Spring Statement 2022.[438] The lack of funding associated with the strategy was criticised by aerospace policy and technical experts alike.[439]

150. The NSS received mixed reviews from the space sector, with many commenting that it was more of a vision document than a detailed plan and arguing that it did not identify specific areas where future funding would be focused.[440] Concern was also raised about whether the current organisational structures would allow for effective coordination of space activities and the lack of measurable aims.[441] The following sections address these points in more detail.

Implementation plan

151. Throughout our inquiry, experts from the sector told us that although the overall aims of the strategy were promising, the details of how these aims would be achieved were lacking.[442] In our first session, Professor Washington Yotto Ochieng, Chair in Positioning and Navigation Systems at Imperial College London, told us:

> All the right words are there—what we should be and what we should be doing as a country. What is missing is how we do it and how we actualise it. That is what I cannot find.[443]

Professor Anu Ohja echoed Professor Ochieng's comments and said that he thought that a strategic delivery plan needed to be developed.[444]

152. With this in mind, we were pleased to hear that the Government, UKSA and UKRI were in the process of developing an implementation plan that would set out further details on how the strategy would be delivered.[445] Dr Paul Bate, CEO of UKSA, informed us that the development of this implementation plan was being carried out by a national space board which was co-chaired by the Ministry of Defence (MoD) and the Department for Business, Energy and Industrial Strategy (BEIS). Professor Mark Thomson, Chair of the Science and Technology Facilities Council, added that this work was incredibly important and was "bringing all the partners together in a coherent manner".[446] Despite hearing this evidence, there is no detailed information about this board available on the UKSA or government websites, including details of the co-chairs or others participating in the board.

153. As well as creating a more detailed delivery plan for the strategy, some witnesses thought that the strategy remained too broad and that the Government needed to choose some key areas where work and funding should be focused.[447] Dr Ibnyahya told us that

438 HM Treasury, Autumn Budget and Spending Review 2021, 27 October 2021; HM Treasury, Spring Statement 2022, 23 March 2022
439 Aerospace Technology, UK national space strategy reliant on private sector for many of its goals, 18 October 2021; Policy Exchange, UK's space strategy: the boost is yet to come, 1 October 2021
440 Qq19–20, Q26, Q35, Q37, Q508
441 Qq19–20, Q26, Q35, Q37, Q508
442 Qq19–20, Q26, Q35, Q37, Q508
443 Q19
444 Q37
445 Q375, Q378
446 Q379
447 Q147

the Government needed to identify which programmes and initiatives it would fund. She added that this would be "very hard" but that it was "extremely important to identify what not to focus on [and] what we want to be the leaders on".[448] However, a number of other witnesses also confirmed that choosing a specific direction would be a difficult undertaking.[449]

154. Dr Bate explained to us that he had been working with industry to find out what the UKSA's focus should be over the coming months and years. He had identified three key areas:

- Catalysing investment into the UK space sector—he pointed out that, the UK's investment of public money in space was low compared to France, Germany or Japan and hoped for increases in investment from private sources, saying that the UK had to be "clever" about how it brings "in private capital and contracts internationally as well as domestically".[450]
- Strengthening the UKSA's delivery capability—UKSA would oversee the development and delivery of further science missions, UK launch, and capabilities relating to space sustainability.[451]
- Championing space—UKSA would aim to communicate the benefits of space to the general population and non-space sectors, and work to make STEM subjects accessible to underrepresented groups.[452]

155. Further to this, Rebecca Evernden, Director for Space at BEIS, explained that the 10-point plan laid out in the NSS was the "main mechanism for identifying priorities for funding," and described some of the key priorities that the department had so far picked out:

> The Secretary of State has mentioned the launch ambition. I can see that continuing to be a priority. Funding innovation will also be at the heart of it. Developing the clusters-type approach to how we foster the sector in the UK will be a priority going forward. We will be looking to continue to support some of the more forward-looking, nascent technologies that we have set out in the strategy, whether that is around how we manage space debris or in-orbit servicing.[453]

156. **We welcome the publication of the National Space Strategy, which provides a good overarching vision for future civil and defence space applications. However, the strategy lacks details on how its broad aims will be achieved and does not specify on which areas the Government will focus its efforts. Additionally, the strategy does not clarify what funding will be made available to the sector to ensure the success of the strategy's initial ten-point plan.**

157. **We are reassured that the Government has set up a national space board that is developing a cross-Government implementation plan to sit alongside the National**

448 Q147
449 Q215, Qq515–517
450 Q379
451 Q379
452 Q379
453 Q447

Space Strategy. ***To ensure that the space sector understands what steps the Government is taking to support the sector, the plan should indicate which areas of space the Government intends to focus. The Government should publish its implementation plan no later than the end of February 2023. It should publish annual progress reports to show how the goals of the strategy are being met.***

158. **We share the space sector's concern that there has been no announced uplift in public funding for space to accompany the National Space Strategy and support the achievement of its objectives. This is all the more concerning given that the UK's overall investment in space lags behind comparable nations such as France, Germany or Japan.** ***The implementation plan should set out at what level, and how, the Government plans to fund the additional mechanisms and systems inherent in its ambitions for the space sector. Further, the implementation plan should set out what steps the Government will take to enable the sector to leverage increased private investment.***

Measuring success of the space sector

159. The strategy was criticised for its lack of quantitative aims.[454] Previously, the Government had committed to growing the UK space sector to 10% of the global space economy by 2030,[455] but this aim was left out of the NSS. When questioned about this at the UK Space Conference in September 2021, Rebecca Evernden, Director for Space at BEIS, explained that this omission had been deliberate, saying "It's been quite a long time since that initial 10% target was set. We concluded that we needed a more sophisticated way to measure growth in the various parts of the UK space sector." She added that Government agencies were working on creating the goals and metrics to measure progress towards them but offered no clarity on when or where these would be published.[456]

160. When we raised the topic of metrics with Dr Bate, head of UKSA, he told us that a "basket of metrics" would be developed, with one being the total investment into the UK space sector.[457] He explained that part of the reason the 10% target had been dropped, was because direct-to-home broadcasting had previously represented a large percentage of the UK space industry, but the growth of direct-to-home broadcasting was likely to stagnate in the coming years.[458] This would probably result in increases in other growing areas, such as launch or in-orbit manufacturing, being overshadowed by the shrinking of broadcasting.[459] In response to this, we asked Dr Bate to confirm if he thought that the 10% target was dropped because the UK would not be able to achieve it by 2030. He told us:

> No, I am not trying to prepare anybody for that. What I am looking at is that there has been a static 5% or so of the total global space economy within the UK. The main reason the growth in the space sector in the UK has been

454 Aerospace Technology, UK national space strategy reliant on private sector for many of its goals, 18 October 2021

455 HM Government, Space Growth Action Plan, April 2014

456 Space News, British government releases national space strategy, 28 September 2021

457 Q380

458 The UK space industry received an overall drop in real terms revenue in 2019/20 due to a reduction in direct-to-home television (DTH) and mobile satellite services revenue; BryceTech, Size & Health of the UK Space Industry 2021, 13 April 2022, p4–5

459 Qq385–387

> where it is, is that, on the one hand, we have direct-to-home broadcasting with relatively little growth, and the rest of the space sector, the growing area, growing much more quickly.
>
> In total, will we reach 10%? That is hard to believe, certainly [not] soon, but most of all it depends on a lot of other countries. I would much rather we were measuring a set of things that are the consequences of being successful in delivering the space strategy as it is set out.[460]

161. The then Secretary of State for Business, Energy and Industrial Strategy also confirmed that he thought that any targets should be realistic and that having a 10% target for the whole industry would not "reflect the variety of different technologies and different bits of the industry".[461] He added:

> We feel that we should be more targeted in our approach in terms of where we can add best value as opposed to going for a generic proportion of a global market that is growing extremely quickly.[462]

162. **While we accept that the scope of the UK space industry is quickly changing and that the Government must take an adaptable approach to measuring its success, dropping headline targets when producing strategies and plans indicates a lack of ambition. If the implementation of the new National Space Strategy is to be assessed effectively, we must be able to observe if positive changes have been achieved in the space sector against some indication of what success looks like. *The Government and UK Space Agency should publish the metrics by which the progress of the UK's space sector will be measured (including a justification for why these metrics have been chosen) and set a clear target against which the success of the sector can be judged. These should be published alongside the implementation plan.***

Dual use

163. For the first time the National Space Strategy brought together the civil and defence aspects of space. The sector saw this as a positive move and many contributors to our inquiry had previously advocated for more dual use of space capabilities in this way.[463] Having said this, there were some reservations about how this would be carried out in practice. Witnesses told us that space was inherently dual use, and that Government departments should work more closely to ensure that large scale programmes were not carried out in isolation, and instead seek to benefit civilian and defence capabilities.[464] An example of where review of dual use aspects was likely to be productive was the Skynet system (a set of sovereign satellites which provide secure communications for UK defence and NATO allies). Skynet is not currently used to supply the commercial sector with communication services, but Lockheed Martin suggested that the MoD should look to use the Skynet system to support the UK's commercial satellite communications sector,

460 Q387
461 Q441
462 Q440
463 UK Computing Research Committee (SPA0004), UK Research and Innovation (UKRI) (SPA0024), Applied Space Technology Laboratory, University of Strathclyde (SPA0029), Professor David Southwood (Senior Research Investigator at Imperial College London) (SPA0040), techUK (SPA0042), Northumbria University (SPA0048), Lockheed Martin UK (SPA0050), ADS, UKspace (SPA0056), Jacobs (SPA0073), Mango Space Ltd (SPA0075), Royal Aeronautical Society (RAeS) (SPA0079), Airbus (SPA0081)
464 ADS, UKspace (SPA0056)

ensuring the dual use of satellites wherever possible.[465] Plans to carry out upgrades to the Skynet system and to launch an extra satellite (Skynet 6A) in 2025, with funding of £5 billion to be invested over the next decade, were announced in the MoD's contribution to the Government's *Integrated Review of Security, Defence, Development and Foreign Policy, entitled, Defence in a Competitive Age*.[466]

164. Earlier in this Report, in Chapter 4, we also identified that there seemed to be significant overlap between the space awareness (SSA/SDA) capabilities provided by the UKSA and the MoD. In addition, during our evidence session with Scottish space academics, Professor Iain Woodhouse advocated the dual use of Earth Observation capabilities, explaining that in the US, contracts from the Defense department often helped to support Earth Observation businesses.[467]

165. Even though the NSS brought together the defence and civil aspects of space, a specific Defence Space Strategy was later published.[468] That strategy announced £1.4 billion to be spent on defence space technologies over the next ten years. This was in contrast to the NSS, which did not have any new public funding for space attached to it.

166. When we asked representatives from BEIS about its approach to bringing together civil and defence space capabilities, Rebecca Evernden said:

> BEIS and MOD are working ever more closely together. We have a joint approach to implementing the space strategy. We formed a joint implementation with the MOD, and I was at the launch of the Defence Space Strategy alongside my counterpart Air Vice Marshal Harvey Smyth at the event last week. One of the things that we talked about was how we continue to embed our thinking about not only how we have ideas about space but how we fund space and how we use procurement, potentially, to go down the dual-use route in the future. That is absolutely at the heart of our thinking.[469]

167. **As the National Space Strategy stressed that civil and defence capabilities would be brought together wherever possible (so called 'dual use'), more needs to be done to identify where overlapping capabilities can be brought together to exploit synergies and remove any unnecessary work and reduce costs. One example of this is considering whether the Skynet system, which is continuing to receive significant public investment, could provide civilian communication services. *The Department for Business, Energy and Industrial Strategy and the Ministry of Defence should map out the civil and defence uses and potential uses of other aspects of space and identify areas where existing and emerging capabilities could safely provide joint value. This work should be published no later than the end of February 2023, including an implementation plan of how civil and defence applications will be linked further over the next 5–10 years.***

465 Lockheed Martin UK (SPA0050)
466 Ministry of Defence, Defence in a Competitive Age, 22 March 2021
467 Qq507–508
468 Ministry of Defence, Defence Space Strategy: Operationalising the Space Domain, 1 February 2022
469 Q448

National Space Council

168. Witnesses told us that that the governance structure that would be used to deliver the space strategy needed to be clarified and that communication between Government departments needed to be improved to ensure the NSS's success.[470] Responsibility for space policy is split between several Government departments, including the Ministry of Defence (MoD) and the Department for Business, Energy and Industrial Strategy. Some evidence suggested that the Government's approach to managing space-related activities and funding was disjointed and needed to be made simpler or more transparent.[471] Funding for space related missions could come from UKRI, UKSA, MoD or ESA, amongst others. Organisations from across industry and academia, including UKRI themselves, believed that greater coordination was needed across these bodies to ensure national priorities were met. Spire Global wrote that one body should be given overall responsibility for the shaping and implementing the strategy for the UK's space sector:

> We would also like to see any body designated with the task of shaping and implementing the strategy including leadership from the UK space sector, working alongside the appropriate government officials. We believe that this can help the relevant body on track and also help facilitate a more agile, less fragmented environment, where the strategy can evolve and adapt more easily, to keep pace with industry development.[472]

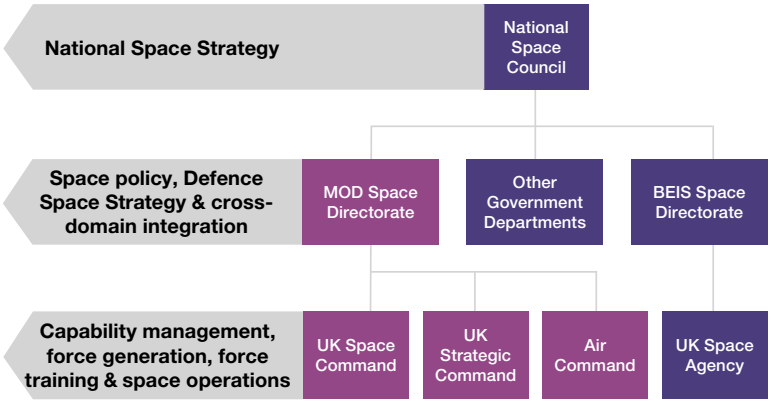
169. Professor Anu Ohja, Director of the National Space Academy, said that establishing advisory structures was necessary to ensure that Government departments used industrial and academic expertise as an input to decision-making.[473] This issue was also identified by the UK Space Exploration Advisory Committee, who shared concerns that the Department for Business, Energy and Industrial Strategy (who led the development of the NSS) had not received detailed input from research scientists and engineers.[474] Airbus also proposed that a "Space Research Advisory Board" should be created, which would report to the National Space Council and bring together organisations who were currently working on space research in isolation, to promote knowledge sharing and define future national programmes.[475]

170. The Defence Space Strategy, which was published on 1 February 2022, described the UK Government strategic organisational structure for space in a more detailed way than had been seen before (see diagram). The strategy said:

> The National Space Council, a Cabinet Committee chaired by the Prime Minister, sets direction for cross-government activity within the space domain and has approved the UK's first National Space Strategy. The resulting UK space policies are cohered collaboratively by Space Directorates within both the MOD and BEIS.[476]

470 Q36
471 The National Oceanography Centre (SPA0012), NERC SENSE Earth Observation Centre for Doctoral Training (SPA0013), UK Research and Innovation (UKRI) (SPA0024)
472 Spire Global UK (SPA0092)
473 Q37
474 UKSA Space Exploration Advisory Committee Membership (SPA0043)
475 Airbus (SPA0081)
476 Ministry of Defence, Defence Space Strategy, 1 February 2022

Figure 1: UK strategic space hierarchy and core outputs, taken from the Defence Space Strategy



Note: Lines denote governance relationships, not command structure.

171. As this diagram shows, the National Space Council, which was established in June 2020, took overall responsibility for the National Space Strategy. As the establishment of the National Space Council had been considered an important step for raising the profile of space within Government,[477] we were surprised to see that the National Space Council has been removed from the updated list of Cabinet Committees published by the Truss Government in September 2022.[478] No updated guidance on new governance arrangements has been given.

172. **Despite some potentially purposeful activity—including the establishment of the National Space Council and the National Space Board and the publication of two over-lapping high-level strategies (the National, and the Defence, space strategies)—the disbanding of the National Space Council is set to undo these efforts, with the responsibilities and interaction of the departments and agencies involved in space remaining very unclear. This is preventing the Government from making well-informed and productive decisions on space policy. *In response to this Report the Government must provide an explanation for the disbanding of the National Space Council and set out what new governance structures will be put in place and how these will ensure the success of the National and Defence Space Strategies.***

Summary of our proposals

173. Space satellite infrastructure plays a vital role in the day-to-day lives of people across the UK, bringing access to critical facilities such as navigation, weather forecasting, and communications. The UK has a flourishing small-satellite manufacturing industry and is a world leader in space data analysis. The publication of the National Space Strategy signalled that the Government has strong intentions for the UK space sector, however, our inquiry found that further interventions are required to ensure the success of the sector. We have called on the Government to publish a number of documents containing further details that will bring further clarity to industry, academia and wider space policy community. This information, along with the timeframe in which we expect them to be published, are summarised in Table 2.

477 Q26
478 Cabinet Office, List of Cabinet Committees, accessed 3 October 2022

Table 2: Documents to be published in response to this Report

Document	Should include	Publication date
Position, Navigation and Timing (PNT) Strategy	Updated review on the economic impact of the loss of PNT	No later than the end of February 2023
	The plans developed through the GNSS programme	
	The UK Space Agency's options for space-based PNT components	
	Details of how PNT services can be delivered in LEO	
Plan B for Copernicus	What actions the Government will take if an agreement with the European Union cannot be reached over the UK's membership of the Copernicus programme and how the €750 million set aside for participation would be spent	No later than the end of December 2022
Consultation on variable liability approach		Launch no later than the end of December 2022
Space sustainability regulatory roadmap		No later than the end of February 2023
National Space Strategy Implementation Plan		No later than the end of February 2023

Conclusions and recommendations

Maintaining access to core space capabilities

1. We understand that, once fully launched, the OneWeb low Earth orbit constellation will provide broadband coverage, via broadband providers such as BT, to people in the UK and elsewhere, including those in remote areas. However, it is not clear to us what other benefits the Government's purchase of OneWeb will bring to UK citizens and whether the purchase represents value for money for UK taxpayers. Given that the Government purchased OneWeb from bankruptcy, we believe its investment in OneWeb is unusual. This is exemplified by the purchase requiring a ministerial direction. We were pleased to hear the then Secretary of State confirm that this model of investment is unlikely to be used in the future. Further, it remains to be seen what the UK will gain from the investment compared to other nations who have not invested in OneWeb. *As a considerable amount of taxpayers' money was used to complete the purchase of OneWeb, the Government should report to Parliament on the state of the Government's investment in OneWeb on a yearly basis. This should include information on how the company is contributing to scientific and technical advancements in the UK space industry. This unusual investment approach should be treated as exceptional and avoided in the future.* (Paragraph 26)

2. Since the UK's purchase of OneWeb, the number of shareholders has continued to grow. Although the Government has provided assurances that the proposed merger with Eutelsat will not affect the UK's shares and involvement in OneWeb, uncertainty remains over how the continued changing ownership will affect its management. *The proposed merger with Eutelsat must be subject to proper scrutiny under the National Security and Investment Act and the Government must provide assurance that OneWeb's operations in the UK will not be affected by the merger. Further, if the merger goes ahead, the National Audit Office should consider carrying out an assessment of the how well the taxpayer's investment has been protected to date and review the economic viability of continuing to hold shares in OneWeb.* (Paragraph 27)

3. We acknowledge that OneWeb could bring additional benefits to the UK if it carried out satellite manufacturing for its Gen2 constellation in the UK, which would stimulate the UK space sector and create new jobs. However, where the Gen2 constellation will be manufactured is not yet confirmed. *The Government must obtain assurances that OneWeb will manufacture its Gen2 constellation in the UK so that the UK space sector can benefit as fully as possible from the Government's investment in OneWeb.* (Paragraph 28)

4. The UK has access to 'open' Position, Navigation and Timing (PNT) services, supplied through the US GPS system and the EU Galileo system, meaning that most users are not affected by the UK leaving the Galileo programme. The UK currently relies on the US GPS system for its secure PNT services that can be used for defence and critical national infrastructure purposes. The reliance on foreign systems is concerning due to the potential for the UK to be blocked from using them in the future. Reliance on space-based systems is also not advisable as these can be disrupted through jamming attacks or adverse space weather. The loss of

PNT services would be detrimental to the UK, with power distribution, financial transactions, and transport systems all seriously affected, and the UK's national security put at severe risk. Although the UKSA, UKRI and BEIS, told us that work is underway to evaluate options for the UK's approach to gaining access to resilient and secure PNT, we understand that a significant amount of work, using large amounts of public funds, has already been carried out but a strategy is yet to be published. (Paragraph 41)

5. We are concerned that the Government seems to be progressing towards plans to use OneWeb's low Earth orbit (LEO) satellite constellation to provide PNT services in the future, despite suggestions from experts that there are many technical issues surrounding using LEO satellites for PNT signals. Ambiguity also remains about the development schedule for full PNT services from OneWeb and whether such services could be provided in a way that is appropriate for sovereign military and critical national infrastructure purposes. (Paragraph 42)

6. Considering the importance of developing secure access to PNT services, we are disappointed that the Department for Business, Energy and Industrial Strategy (BEIS) is delaying the finalisation and publication of the PNT strategy and therefore refusing to commit to the critical action that needs to be taken. Although BEIS is in the process of establishing cross-government strategy on PNT, we believe the responsibility for PNT should lie outside of any one Department. *The Government should establish the National Security Adviser (NSA) as having overall responsibility for the UK's access to secure PNT capabilities. The NSA should ensure that the importance of developing secure PNT systems is understood throughout Government and take responsibility for developing a programme and budget for the work that needs to be carried out. The NSA should take guidance from work that has already been undertaken within Government and publish the National PNT Strategy no later than the end of February 2023, including details of the space- and ground-based components that will be used to ensure the UK has sustained, resilient and secure access to PNT services. If the strategy includes the use of the OneWeb LEO Gen2 constellation, the solutions to the technical challenges drawn out in our evidence should be addressed and the Government should provide clarification on why LEO satellites have been chosen over other, more commonly used, space-based PNT systems. In summary, the strategy should set out:*

(a) the updated review and estimate of the impact of loss of PNT services on the economy;

(b) the results of the Global Navigation Satellite System (GNSS) programme, and details of which aspects of the proposed system will be taken forward;

(c) the UK Space Agency's analysis of the space-based elements of PNT and details of which of these will be taken forward; and

(d) how secure PNT services can be delivered through LEO and the technical challenges that will need to be overcome to achieve this. (Paragraph 43)

7. We understand that the UK space sector has significant concerns about the current and future access to data currently supplied by EU's Copernicus programme, especially if the UK cannot remain a member. *BEIS and UK Space Agency (UKSA)*

must ensure that they communicate clearly with the space sector to ensure that there is a good understanding about any impact on the UK's access to data from Copernicus if the UK does withdraw from the programme. BEIS and UKSA must conduct a consultation of how the space sector expects to be impacted if participation is not possible, with a particular focus on loss of access to data. The results of this consultation should be made public. Further, the UK Government should seek assurances from the EU, that if the UK does associate and invest the planned €750 million, its access rights will remain the same as all other countries participating in the programme. (Paragraph 52)

8. The UK is world-leading in Earth Observation (EO) science and technologies. The EO sector and the Government have recognised that these strengths can also be used to support other UK ambitions such as Net Zero. *Taking guidance from the UK Space Agency and UN Office for Outer Space Affairs (UNOOSA) joint review into how space technologies can be used to tackle climate change, the Government should set out detailed actions for how EO will be used to support the transition to Net Zero. This should include a package of financial support to ensure the UK remains a world leader in this area.* (Paragraph 57)

9. The UK space sector remains strongly in favour of maintaining the UK's participation in the EU's Copernicus Earth observation programme, for which the UK Government has set aside €750 million. Despite this, it is imperative that the UK stands ready to adapt if an agreement with the European Union cannot be reached. T*he Government should publish a 'Plan B' no later than the end of December 2022 which defines what actions it will take if an agreement with the EU cannot be reached over UK membership of the Copernicus programme and how the €750 million currently set aside for participation would then be spent.* (Paragraph 58)

Development of UK launch

10. The Government and the UK space sector have made significant steps towards developing a UK launch capability, with the establishment of a horizontal launch site at Spaceport Cornwall and two vertical launch sites: SaxaVord Spaceport on Unst in Shetland and Space Hub Sutherland. Although spaceports have taken different financing approaches, we commend the UK Space Agency (UKSA) for the funding it has provided for the establishment of spaceports and launch systems and recognise that the development of the UK space sector would not have been possible without these initial injections of public funding. Having said this, further investment may be required to ensure that the UK launch sector is successful and sustainable. *The Government should continue to examine where further and continued funding may be required to secure the success of the UK launch industry.* (Paragraph 69)

11. We understand that the Civil Aviation Authority (CAA) is considering changes to its approach to setting liability caps for orbital licences, including changing to a variable liability limit approach, where liability bands are defined and the maximum value is recommended to be £50m. We believe this approach will be welcomed by the industry, who want further certainty on the liability caps that will be applied to their operations. *The Government should develop proposals for the variable liability approach as quickly as possible, opening the consultation on these by the end of*

December 2022. To ensure that the required certainty is brought to the space industry and that the UK's launch sector begins to flourish, it should seek to implement the proposals by June 2023. (Paragraph 76)

12. We were pleased to hear that the Civil Aviation Authority (CAA) has been working with spaceports, satellite manufacturers, and launch suppliers to ensure that the spaceflight regulations and licence application processes are fit for purpose. However, we are concerned that the CAA is not providing enough support for applicants which could cause delays in the licensing process. *The Department for Transport (DfT) should ensure that the CAA is suitably resourced to be able to provide an effective liaison service for each licence applicant to support them with navigating the application process.* (Paragraph 79)

13. The Government must take steps to ensure that the CAA is appropriately resourced to meet the demands of processing increasing numbers of licence applications. *Quarterly review meetings should be held by the CAA and DfT to review whether the CAA's staffing complement is sufficient and further funding should be provided by the Government to the CAA if required and in good time to allow induction and training of such staff.* (Paragraph 80)

14. We are disappointed that a launch from the UK has not yet been achieved, especially as we were assured on several occasions that the first horizontal launch would take place in summer 2022. *The Department for Business, Energy and Industrial Strategy and the Department for Transport must prioritise working towards achieving the first launch from UK soil as soon as possible.* (Paragraph 86)

15. We are concerned that the delay in achieving the first UK launch is partly due to the Civil Aviation Authority (CAA) being unable to process licence applications in a timely manner. *For this initial set of licence applications, the Department for Transport must provide additional resource to the CAA to ensure that the licensing process does not impede the feasibility of a launch this year. After this, we expect that the application process will become streamlined and therefore the timeline for processing licence applications should be reduced to 3–6 months for all licences by 2024.* (Paragraph 87)

16. The publication of the Space Industry Regulations in July 2021 was a vital step that set out the licensing processes for launch activities, including establishing the Civil Aviation Authority as the regulator. *The Civil Aviation Authority, with the support of the Department for Transport and the Department for Business, Energy and Industrial Strategy, should continue to take guidance from other authorities such as the Federal Aviation Authority on how to best operate the licensing process.* (Paragraph 88)

Growing new technologies

17. Although we believe that UK Space Agency (sponsored by BEIS) and the Ministry of Defence are both right to commit to improving their abilities to track and recognise objects in orbit (Space Situational Awareness /Space Domain Awareness), the two departments appear to be developing these capabilities independently, despite the previous Secretary of State for Business, Energy and Industrial Strategy's claims about efforts to integrate and find synergies. We believe a joint approach to serving civil

and military needs from these capabilities should be established. *The Government should bring UKSA and MoD Space Situational Awareness/Space Domain Awareness services under one roof to maximise the use of knowledge, technology, and resources. The UK Space Command would be a perfect candidate for this as it already works alongside the UK Space Agency and Ministry of Defence to deliver joint national space capabilities.* (Paragraph 93)

18. We commend the Department for Business, Energy and Industrial Strategy's approach to promoting the sustainable and safe use of space by developing a "regulatory road map" for the sustainable use of space and working with like-minded nations to promote the safe use of space. *The Department should publish this roadmap no later than the end of February 2023 and include what steps it will take to try and establish the "critical mass" required to form a consensus on the sustainable and safe use of space.* (Paragraph 95)

19. We commend the Government's latest announcements which will encourage the UK space industry to use space sustainably. *As space is global in nature, the Government should set out how it intends to work with international partners to establish an International Space Sustainability Standard, rather than focusing on UK only interventions.* (Paragraph 98)

20. The Government has taken positive steps towards supporting the establishment of space debris removal missions and we look forward to seeing further work in this area, especially on ensuring that regulation of these activities is fit for purpose. *Space debris removal missions should remain a clear focus of Government support and facilitation for the foreseeable future.* (Paragraph 100)

21. Research has already shown the UK has the potential to be a world leader in the growing in-orbit services and manufacturing (IOSM) market. The Government should seize this opportunity. *The Department for Business, Energy and Industrial Strategy and UK Space Agency (UKSA) should work with organisations and companies such as the Satellite Applications Catapult and Space Forge who have already set out the steps that the UK needs to take to maintain leadership in this area. UKSA should set out which parts of the Catapult's proposals it plans to take forward and should set a budget for this work.* (Paragraph 103)

22. Although the technology is at a relatively early stage of development, Space Based Solar Power (SBSP) has the potential to become a useful supply of green energy by 2050, helping the UK to reach its Net Zero goals. We commend the announcement by BEIS of plans to create an innovation programme that will seek to develop the technologies required to achieve SBSP. (Paragraph 105)

Supporting the UK space sector

23. Space-based projects, including fundamental research and development of new and especially wholly novel technologies, generally occur on long timescales and therefore require long-term funding. We were pleased to see the announcement of a three-year budget for the Department for Business, Energy and Industrial Strategy for 2022–23—2024–25 which should bring some certainty to the sector. *The Government should reflect on the consequences of the recent one-year settlements*

on the space sector and provide a commitment to deliver at least three-year budget settlements to facilitate a more strategic approach to the allocation of public support for these technologies of the future. (Paragraph 108)

24. The current procurement systems are limiting the growth of the UK space sector and SMEs require further support to access new customers and expand. *The Government should further consider how procurement could be used to support businesses and leverage further private investment. The Department for Business, Energy and Industrial Strategy should work with the Ministry of Defence to establish improved procurement mechanisms.* (Paragraph 113)

25. Clusters, such as those in Harwell and Glasgow, can be established in different ways and clearly bring benefits to the UK space sector. We welcome UK Space Agency's (UKSA's) announcements of at least some funding for the establishment of further clusters, and we particularly commend any such innovation outside the South East of England and London. However, the funding provided to support these new clusters was very limited and is therefore likely to prevent new clusters developing at pace. *The UKSA should set out in response to this Report its plans for each of the new clusters, what support it plans to provide and what outcomes it is aiming at, including how many companies it aims to attract to each region and how many jobs it aims to create.* (Paragraph 118)

26. The Satellite Applications Catapult has been instrumental in securing the establishment and development of space sector SMEs and driving the growth of Harwell space campus. *The Government should provide further support to the Satellite Applications Catapult, which will in turn stimulate the growth and success of space companies. Given that the Government's levelling up white paper says that "the Department for Business, Energy and Industrial Strategy will aim to invest at least 55% of its total domestic R&D funding outside the Greater South East by 2024–25", we would encourage the Government to be even more ambitious. Support for space R&D undertaken outside of Harwell should be in line with the proportion of the UK population living outside of the Greater South East. This would promote the growth of new space clusters and expand the space sector's reach.* (Paragraph 119)

International considerations

27. The UK's involvement in the European Space Agency (ESA) has brought a wide range of benefits to the UK and its space sector, but there is a need to re-address the balance between funding for ESA programmes and funding for national space programmes. *The Government should not diminish its funding via ESA but should increase its investment in national space programmes; and both funding streams should reflect and focus on the objectives of the National Space Strategy as far as possible.* (Paragraph 124)

28. The UK has already benefited from new international agreements that have been established outside of the European Union, such as with the US on the Artemis Accords and the UK-Australia Space Bridge. More needs to be done to ensure that the UK increases its international reach and benefits from the skills and technologies being developed in other countries. *The UK should focus on forming new bi-lateral*

and multi-lateral agreements, like the UK-Australia Space Bridge, that support the UK's aims for space and provide access to new trade opportunities, collaborative R&D projects, and access to new technologies. (Paragraph 130)

Addressing the skills shortage

29. The space sector is suffering from a skills shortage, with experienced employees and those with skills such as programming being particularly hard to find. Higher Education institutions struggle to provide training that keeps pace with technical advancements happening in the sector's industries. *The UK Space Agency's newly convened Space Skills Advisory Panel (SSAP) should look to establish a working group, including representatives from Higher Education institutes, Doctoral Training Centre's, and industry, who should develop joint training programmes that address the skills gap and allow future space employees to gain experience in the most advanced technologies.* (Paragraph 144)

30. Companies often find it difficult to recruit employees with considerable experience, but we think companies are also hesitant to invest money and time into training staff. This is partly due to the short-term nature of grant funding, creating a need for companies to have immediate access to the correct expertise. Further, space organisations fear that they will lose early career workers through competition with similar sectors, such as the tech sector, which require similar skills but often offer higher salaries. *Industry players should move away from requiring applicants to have years of experience and should instead strengthen their early career training programmes, including the use of apprenticeships so that not all applicants require a degree. The Government should make it easier for businesses to do this, by offering multi-year grants which allow companies to plan and offer employees longer contracts.* (Paragraph 145)

31. If the UK is to address the space skills shortage it is currently facing, then it will need to inspire future generations to take up a career in space. Although the UK Space Agency has programmes in place that are seeking to do this, we believe there is a disconnect between what the UK space sector does and how the wider population perceives it. Most associate space with space exploration and may not associate it with the range of vital services that it provides. *The UK Space Agency should ensure that its "inspiration" programme addresses the breadth of the UK's activities in space and uses local role models who reflect this.* (Paragraph 146)

Conclusions and next steps for the National Space Strategy

32. We welcome the publication of the National Space Strategy, which provides a good overarching vision for future civil and defence space applications. However, the strategy lacks details on how its broad aims will be achieved and does not specify on which areas the Government will focus its efforts. Additionally, the strategy does not clarify what funding will be made available to the sector to ensure the success of the strategy's initial ten-point plan. (Paragraph 156)

33. We are reassured that the Government has set up a national space board that is developing a cross-Government implementation plan to sit alongside the National

Space Strategy. *To ensure that the space sector understands what steps the Government is taking to support the sector, the plan should indicate which areas of space the Government intends to focus. The Government should publish its implementation plan no later than the end of February 2023. It should publish annual progress reports to show how the goals of the strategy are being met.* (Paragraph 157)

34. We share the space sector's concern that there has been no announced uplift in public funding for space to accompany the National Space Strategy and support the achievement of its objectives. This is all the more concerning given that the UK's overall investment in space lags behind comparable nations such as France, Germany or Japan. *The implementation plan should set out at what level, and how, the Government plans to fund the additional mechanisms and systems inherent in its ambitions for the space sector. Further, the implementation plan should set out what steps the Government will take to enable the sector to leverage increased private investment.* (Paragraph 158)

35. While we accept that the scope of the UK space industry is quickly changing and that the Government must take an adaptable approach to measuring its success, dropping headline targets when producing strategies and plans indicates a lack of ambition. If the implementation of the new National Space Strategy is to be assessed effectively, we must be able to observe if positive changes have been achieved in the space sector against some indication of what success looks like. *The Government and UK Space Agency should publish the metrics by which the progress of the UK's space sector will be measured (including a justification for why these metrics have been chosen) and set a clear target against which the success of the sector can be judged. These should be published alongside the implementation plan.* (Paragraph 162)

36. As the National Space Strategy stressed that civil and defence capabilities would be brought together wherever possible (so called 'dual use'), more needs to be done to identify where overlapping capabilities can be brought together to exploit synergies and remove any unnecessary work and reduce costs. One example of this is considering whether the Skynet system, which is continuing to receive significant public investment, could provide civilian communication services. *The Department for Business, Energy and Industrial Strategy and the Ministry of Defence should map out the civil and defence uses and potential uses of other aspects of space and identify areas where existing and emerging capabilities could safely provide joint value. This work should be published no later than the end of February 2023, including an implementation plan of how civil and defence applications will be linked further over the next 5–10 years.* (Paragraph 167)

37. Despite some potentially purposeful activity—including the establishment of the National Space Council and the National Space Board and the publication of two over-lapping high-level strategies (the National, and the Defence, space strategies)—the disbanding of the National Space Council is set to undo these efforts, with the responsibilities and interaction of the departments and agencies involved in space remaining very unclear. This is preventing the Government from making well-informed and productive decisions on space policy. *In response to this Report the Government must provide an explanation for the disbanding of the National Space Council and set out what new governance structures will be put in place and how these will ensure the success of the National and Defence Space Strategies.* (Paragraph 172)

Formal minutes

Wednesday 26 October 2022

Members present

Carol Monaghan, in the Chair

Aaron Bell

Tracey Crouch

Rebecca Long-Bailey

Stephen Metcalfe

Iain Stewart

Graham Stringer

UK space strategy and UK satellite infrastructure

Draft Report (*UK space strategy and UK satellite infrastructure*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 173 read and agreed to.

Summary agreed to.

Resolved, That the Report be the Second Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available (Standing Order No. 134).

Adjournment

Adjourned till Wednesday 2 November at 9.20am.

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Wednesday 3 November 2021

Professor Washington Yotto Ochieng, Chair in Positioning and Navigation Systems, Imperial College London; **Lucy Edge**, Chief Operating Officer, Satellite Applications Catapult — Q1–29

Professor Anu Ojha, Director, National Space Academy; **Professor David Southwood**, Senior Research Investigator, Imperial College London — Q30–47

Wednesday 17 November 2021

Dan Hart, CEO, Virgin Orbit; **Nicholas Smith**, Regional Director for UK and Europe, Lockheed Martin Space; **Alan Thompson**, Head of Government Affairs, Skyrora Limited — Q48–96

Melissa Thorpe, Head, Spaceport Cornwall; **Scott Hammond**, Deputy Chief Executive Officer, SaxaVord Spaceport; **Pete Guthrie**, Senior Programme Manager, Space Hub Sutherland — Q97–148

Wednesday 8 December 2021

Yasrine Ibnyahya, Director of Advanced Concepts, Inmarsat; **Professor Sir Martin Sweeting**, Founder and Executive Chairman, Surrey Satellite Technologies Ltd — Q149–206

Dr Hina Khan, Senior Project Manager and UK Stakeholder Engagement, Spire Global Limited; **Jon Styles**, Director, Assimila — Q207–235

Chris McLaughlin, Chief of Government, Regulatory Affairs, and Engagement, OneWeb — Q236–281

Wednesday 12 January 2022

Josef Aschbacher, Director General, European Space Agency — Q282–310

Dr Hiroshi Yamakawa, President, Japan Aerospace Exploration Agency; **Dr Philippe Baptiste**, President, Centre national d'études spatiales—French National Space and Research Centre — Q311–344

Tim Johnson, Director of Strategy & Policy, Civil Aviation Authority; **Colin Macleod**, Head of UK Space Regulation, Civil Aviation Authority — Q345–374

Wednesday 9 February 2022

Paul Bate, CEO, UK Space Agency; **Mark Thomson**, Executive Chair, Science and Technology Facilities Council — Q375–433

Rt Hon Kwasi Kwarteng MP, Secretary of State, Department for Business, Energy & Industrial Strategy; **Rebecca Evernden**, Director for Space, Department for Business, Energy & Industrial Strategy; **Hugo Robson**, Chief Negotiator, Department for Business, Energy & Industrial Strategy — Q434–498

Thursday 10 February 2022

Professor Malcolm Macdonald, Chair of Applied Space Technology, University of Strathclyde; **Professor Iain Woodhouse**, Professor of Applied Earth Observation, University of Edinburgh Q499–523

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

SPA numbers are generated by the evidence processing system and so may not be complete.

1 AAC Clyde Space (SPA0020)

2 ADS; and UKspace (SPA0056)

3 AWE (SPA0046)

4 Aerospace Medicine and Physiology Research Group, Centre for Human and Applied Physiological Sciences, King's College London (SPA0062)

5 Airborne Engineering Ltd (SPA0044)

6 Airbus (SPA0081)

7 Alden Legal Limited (SPA0033)

8 Applied Space Technology Laboratory, University of Strathclyde (SPA0029)

9 AstrobiologyOU, The Open University (SPA0072)

10 Athena (SPA0083)

11 Berthoud, Lucy (Co-Chair, Space Universities Network; and Professor of Space Systems Engineering, University of Bristol) (SPA0088)

12 Black Arrow Space Technologies Ltd (SPA0095)

13 Blue Skies Space Limited (SPA0054)

14 Border Consulting Ltd (SPA0103)

15 British Standards Institute (SPA0076)

16 Buckinghamshire Local Enterprise Partnership (SPA0080)

17 CFMS Services Ltd (SPA0006)

18 Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (SPA0082)

19 Cheney, Dr Thomas (Lecturer in Space Governance, AstrobiologyOU, The Open University) (SPA0015)

20 Department for Business, Energy and Industrial Strategy (SPA0101); (SPA0026); (SPA0102)

21 Deplano, Dr Rossana (Lecturer, University of Leicester) (SPA0005)

22 EMEA Satellite Operators Association (ESOA) (SPA0068)

23 Earth Observation Network, Imperial College London (SPA0031)

24 Eastwood, Dr Jonathan (Director, Space Lab Network of Excellence and Senior Lecturer, Dept. of Physics, Imperial College London) (SPA0035)

25 FAIR-SPACE Hub (SPA0057)

26 Fujitsu Ltd (SPA0091)

27 Global Partnership for Sustainable Development Data (SPA0028)

28 Hampshire Constabulary (SPA0093)

29 Harkness, Dr Patrick (Reader in Space Systems Engineering, University of Glasgow) (SPA0007)

30 Harwell Space Cluster (SPA0090)

31 Hughes Europe and EchoStar Mobile Limited (SPA0053)

32 Inmarsat (SPA0055)

33 Jacobs (SPA0073)

34 Kingston University London (SPA0061)

35 Lockheed Martin UK (SPA0050); (SPA0094)

36 London Institute of Space Policy and Law (SPA0067)

37 Matthews, Professor Sarah (Professor and Head of Solar Physics, UCL Mullard Space Science Laboratory); Professor Richard Harrison (Chief Scientist, RAL Space); Dr Jackie Davies (Head of Heliospheric Physics, RAL Space); Professor Peter Cargill (Honorary Professor , University of St Andrews); Professor Lyndsay Fletcher (Professor of Astrophysics, University of Glasgow); Dr Huw Morgan (Head of Solar System Physics, Aberystwyth University); Dr Andrzej Fludra (Head of Solar Physics, RAL Space); Professor Mihalis Mathioudakis (Professor of Astrophysics, Queen's University Belfast); Professor Robertus Erdelyi (Professor of Applied Mathematics, Sheffield University); Professor Ineke de Moortel (Professor of Applied Mathematics, University of St Andrews); and UK Solar Physics Council (SPA0034)

38 Magdrive (SPA0104)

39 Mango Space Ltd (SPA0075)

40 Met Office (SPA0058)

41 Micross Components (SPA0078)

42 Midlands Innovation (SPA0022)

43 Mulvihill, Dr Michael (Research Associate, Newcastle University); and Chloë Barker (Research Associate, Newcastle University) (SPA0038)

44 NATS (SPA0070)

45 NERC SENSE Earth Observation Centre for Doctoral Training (SPA0013)

46 National Centre for Earth Observation (NCEO) (SPA0084)

47 Northumbria University (SPA0048)

48 OneWeb (SPA0008)

49 Open Geospatial Consortium (SPA0045)

50 Pettorelli, Dr Nathalie (Senior scientist, Zoological Society of London) (SPA0001)

51 Planet (SPA0071)

52 Plymouth Marine Laboratory (SPA0039)

53 Policy Impact Partners and SpaceX (SPA0099)

54 Reaction Engines (SPA0098)

55 RethinkPNT (SPA0100)

56 Royal Aeronautical Society (RAeS) (SPA0079)

57 Royal Astronomical Society (SPA0047)

58 SKA Observatory (SPA0010)

59 Satellite Applications Catapult (SPA0037); (SPA0086); (SPA0096)

60 Shaw, Dr Peter (Senior Lecturer in Astronautics, Kingston University London) (SPA0003)

61 Skyrora Limited (SPA0064)

62 Southwood, Professor David (Senior Research Investigator, Imperial College London) (SPA0040)

63 Space Forge Ltd (SPA0097)

64 Space Hub Yorkshire (SPA0027)

65 Spire Global UK (SPA0092)

66 Surrey Satellite Technology Ltd (SPA0023)

67 Talibzade, Rahim (SPA0066)

68 techUK (SPA0042)

69 Thales (SPA0060)

70 The British Interplanetary Society (SPA0089)

71 The Manufacturing Technology Centre (MTC) (SPA0041)

72 The National Oceanography Centre (SPA0012)

73 The Royal Society (SPA0049)

74 The Space academic Network (SPA0009)

75 Thomas Keating Ltd (SPA0030)

76 Tokamak Energy Ltd (SPA0087)

77 UCL, Department of Space and Climate Physics (SPA0059)

78 UK Civil Aviation Authority (SPA0014)

79 UK Computing Research Committee (SPA0004)

80 UK National Quantum Technology Hub in Sensors and Timing, University of Birmingham; and UK Quantum Technology Hub Sensors and Timing (SPA0011)

81 UK Research and Innovation (UKRI) (SPA0024)

82 UK Space Life and Biomedical Science Association (UKSpaceLABS) (SPA0025)

83 UKSA Space Exploration Advisory Committee Membership (SPA0043)

84 University of Birmingham; UK Quantum Technology Hub Sensors and Timing; and West Midlands Regional Economic Development Institute (SPA0016)

85 University of Leicester (SPA0021)

86 Virgin Orbit (SPA0069)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website.

Session 2022–23

Number	Title	Reference
1st	Pre-appointment hearing for the Executive Chair of Research England	HC 636

Session 2021–22

Number	Title	Reference
1st	Direct-to-consumer genomic testing	HC 94
2nd	Pre-appointment hearing for the Chair of UK Research and Innovation	HC 358
3rd	Coronavirus: lessons learned to date	HC 92

Session 2019–21

Number	Title	Reference
1st	The UK response to covid-19: use of scientific advice	HC 136
2nd	5G market diversification and wider lessons for critical and emerging technologies	HC 450
3rd	A new UK research funding agency	HC 778