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UK Commercial Space Activities

The UK space industry had a turnover of £11.8bn in 2012/13.[1] By 2030, the UK Government and industry want this to grow to £40bn.[1] In December 2015 the Government published the UK's first National Space Policy, which sets out its vision for achieving growth.[2] This POSTnote describes the UK space industry and potential barriers to growth.

Overview

- Government and industry want the UK space industry to capture 10% of the global space economy by 2030.
- The Government is developing a regulatory regime that will permit the creation of a commercial spaceport in the UK by 2018.
- The development of small satellites (weighing less than 500 kg) is reducing the cost of space operations.
- Insurance requirements, skills shortages, export controls and limited availability of orbits and transmission frequencies all need to be addressed in order to enable growth.
- It is hoped that British ESA Astronaut Tim Peake's mission to the International Space Station will inspire young people to take up careers in science, technology, engineering and mathematics.

Background

Forty years ago government was the main customer of the UK space industry. Today, the space industry provides commercial services to a vast range of sectors. Almost all television content passes through a satellite at least once before it reaches the home and the use of satellite navigation in transport is ubiquitous. In 2012/13 the space industry contributed £5.1bn to GDP (comparable to the rail transport sector) and grew by 4.1% (annual growth has averaged over 8% since 1999/2000).[3,4] Along with space-science activities, the space industry plays a key role in inspiring young people to take up scientific careers.[5,6]

In recent years, government and industry have taken steps to promote the UK space industry. The Space Innovation and Growth Strategy (IGS), was published in 2010 and updated in 2015. A key achievement of the IGS has been the setting up of the UK Space Agency to oversee all UK civil (non-military) space activities, as well as a network of bodies to promote growth (Box 1).[7] This note describes:

- the UK space industry's activities
- applications of satellite data
- different types of satellite and their main functions
- issues that need addressing in order to enable growth.

The UK Space Industry

The UK space industry's activities involve the provision of space infrastructure (mainly satellites and the associated ground-based control systems), and the exploitation of satellite data. The space industry is dominated by large multinational companies, but small and medium enterprises are expected to play a key role in its growth. Satellite technology falls into two categories. The first is technology to manage operational functions, such as maintaining its orbit. The second is the 'payload' - technology that performs a particular function. This can be telecommunications (telecoms), navigation, earth observation or space science.

The £11.8 m turnover figure can be broken down into three components. Firstly, around 8% comes from the manufacturing of space infrastructure.[8] Airbus Defence and Space is one of the main companies in this subsector. It manufactures satellites for all purposes and is a major contributor to European Space Agency missions.[9] Historically satellites have been bespoke structures, expensive to manufacture, launch and maintain. A typical communications satellite is roughly the size of a bus and can weigh over six tonnes. However the UK has played a key role in pioneering small satellites weighing less than 500 kg (Box 2).

Box 1.The Space Innovation and Growth Strategy (IGS)
The Space IGS is produced by specialists from government, academia and industry. Its aim is to increase the UK's share of the global space economy from 6.5% to 10% by 2030.[10] The IGS outlines the regulatory, policy and legal framework in which the space industry operates. It also considers factors that constrain or promote growth and provides strategic advice to the Government; it focuses on supporting SMEs and start-ups and outlines a technology strategy to direct research and development (R&D) over the next 15 years.

The original IGS report in 2010 resulted in the UK Space Agency (UKSA) being established in 2011 "to provide strategic leadership to the UK's civil space activity with a central focus on the growth of the industrial sector".[11] The UK Space Agency leads in developing UK space policy, represents the UK internationally on space matters, and regulates UK space activities to meet international obligations.[11]

The IGS also led to several other new bodies being established:
- Satellite Application Catapult (SAC): promotes development and commercialisation of space products, services and applications. SAC provides industry with access to facilities and expertise[12]
- Satellite Finance Network: works with SAC and trade association UKspace to deliver financial advice and support to its members[13]
- Space Knowledge Transfer Network: links business, academics entrepreneurs, and funders to support the development of new products and services that exploit data from satellites [14]
- Space Leadership Council: oversees delivery of the IGS and provides strategic advice to the UK Space Agency and Ministers.

Secondly, 12% of turnover comes from 'space operations' such as operating satellites and ground stations.[15] Inmarsat is one of the main companies in this subsector, and owns and operates 12 satellites that deliver services to subscribers. Thirdly, almost 80% of turnover comes from the provision of services that use satellite data directly, with satellite broadcasting (mostly from BSkyB) accounting for almost two thirds of this.[16, 17]

Telecoms, navigation and Earth-observation in combination, support activities ranging from medicine to disaster monitoring (Box 3).Satellite data plays a central role in diverse sectors, such as transport and storage, and Information Communications Technology, whose combined turnover runs to almost £400 bn.[18] It also yields benefits that are hard to quantify, such as saving money and lives by improving the accuracy of weather forecasting.[19]

Functions that satellites perform

Telecommunications

Satellites are useful for telecoms and broadcast, because they can send and receive signals over a wide area. Alphasat, Europe's largest telecoms satellite, launched in 2013 and is a joint project of ESA and Inmarsat. It has provided a platform to test new technologies, including a laser system that relays data from Earth observation satellites to ground stations so that the data can be accessed in real time. In 2014, UKSA pledged £130 million for the development of new telecoms technologies, including £57 million for a software automated (or 'smart'), low-cost, telecommunications satellite.[20] In its National Space Policy Government says it will use satellites to bridge the digital divide, where satellites are only effective means to deliver broadband to the UK population.

Box 2. Small satellites
A satellite is defined as a man-made object that has been purposefully placed into orbit around the earth (or any other planet). Small satellite development was pioneered in the 1980s by Surrey Satellites and Technology Ltd (SSTL), who have a 40% share of the global small satellite market.[21] Small satellites are made from off-the-shelf components, reducing manufacturing time and cost as well as the overheads associated with developing new space technology. Examples include:
- **TechDemoSat** (launched in 2014): This small and light satellite is roughly the size of a refrigerator. As well as testing new satellite technologies. It also carries payloads that test new air, land, sea and space-environment monitors.[22]
- **NovaSAR-S** (in development). Synthetic Aperture Radar (SAR) uses microwave pulses to monitor the Earth from space; it is a valuable tool as it can 'see' through clouds and image the Earth night or day. NovaSAR will provide such capabilities at around 20% of the cost of existing radar satellites.[22]

Satellites can be even smaller than these examples. 'CubeSats' are only one litre in volume. They are built to a standard format and can be combined to make larger satellites. Their small size limits their capabilities,[23] but because of their simplicity and low price, they are opening up new markets and opportunities. Between 2011 and 2015, an estimated 217 Cubesats were launched, mainly by the USA.[24] According to some estimates the annual number of launches could increase to over 300 by 2016.[25] Although a manufacturer of CubeSats, the UK has only launched three to date.[26] One of these, UKube-1, was launched by the UKSA and Clyde Space for testing technologies, facilitating outreach and performing scientific experiments.

Navigation

A Global Navigation Satellite System (GNSS) allows an individual to pinpoint their location using satellite signals (POSTnote 150). GNSS satellites also provide a highly accurate timing signal that is used in applications such as financial transactions. The European Union is in the process of developing the 'Galileo' GNSS. In combination with the US Global Positioning System (GPS), Galileo will deliver more accurate and reliable navigation data than is currently available.[27] Unlike GPS, which is under military control, Galileo will be under civil control, which expands its potential range of applications. Ten of a total of 30 satellites are already in orbit and the rest will follow over the next five years.[28,29] The UK will build the payloads for all of these.[30]

Earth Observation

Images of the Earth are obtained from satellites equipped with sensors that detect either natural or artificial electromagnetic radiation across a wide range of frequencies. The joint EU/ESA multi-billion euro 'Copernicus' programme will be the largest civilian Earth observation programme to date, providing information that is intended to help society manage the environment, tackle climate change and respond to disasters.[31] It will consist of six types of satellite, with different types of observational sensors and orbital paths. These will work in combination with ground-based sensors and other satellites. Two satellites are in orbit and the rest will follow by 2020. [32,33] The UK is providing technology and instruments for these satellites.[10] For weather forecasting, the UK subscribes to the European Meteorological Satellite programme.[34]

Box 3. Examples of applications of satellite data

Satellites can be used to provide new services or can improve existing ground-based services, for example by increasing the efficiency of such services, or reducing their cost. Some examples include:

- **Agriculture:** Satellite data can be used to improve knowledge of pest breeding grounds and crop health. This can then be used to refine the application of fertilizers, water and pest control.[35]
- **Marine activity:** The Automated Identifying System (AIS) is a standardised tracking system with which ships and port authorities can monitor ships in their vicinity. Satellites have extended the reach of this system. Even when ships do not have AIS they can still be tracked using Earth observation satellites.[36]
- **Machine-to-machine (M2M) services:** Multiple devices communicating over the internet can be used to perform automated tasks (POSTnote 423). Communications satellites can increase the potential of M2M – for example they are used with 'smart energy meters' to allow customers to monitor their energy usage constantly and to send meter readings to their suppliers.[37]
- **Smart Government:** Space services can make government more efficient and effective. For example, during the 2013-14 UK floods the Environmental Agency used satellite disaster-monitoring data to assess flood extent and damages.[38] The National Health Service use GPS to improve the efficiency of ambulance response.[38]
- **Search and rescue**: SOS alerts from remote locations can be communicated via satellite and assistance can be targeted more accurately using GPS and earth observations.[39]

Space science

The UK is involved in space science missions through ESA. These can involve telescopes and robotic space probes, as well as satellites. For example the UK is taking the lead in developing the Mars rover for ESA's 'ExoMars' mission to Mars in 2018. Although space science directly contributes only about 2% of UK space turnover, knowledge and technology derived from space science research often lead to commercial applications.[40] Space science is also useful for encouraging engagement with science. For example, FUNCube-2 (a payload on UKube-1, Box 2) has allowed schools to work with data from the satellite.[41]

Enabling future growth

The U.K.'s first National Space Policy, published in December 2015, reiterates the IGS ambition for the turnover of the UK space industry to grow to £40bn by 2030. It is widely accepted that growth in telecoms (which dominates the space sector) will not, on its own, be enough to meet the 2030 targets. Other areas will need to expand, for example Earth observation and navigation, which are expected to grow substantially as applications of satellite data develop. The Space Applications Catapult (Box 1) is working to drive such development. For example, it will encourage exploitation of freely available data from the Copernicus and Galileo programmes.[42] Small-satellite operations can also help growth by reducing costs and increasing the availability of data (Box 2).[43] However, there will need to be innovation in storing, processing, and visualising the increasing volumes of data to make it useful to the end customer.

The IGS points out that space services will need to out-perform ground-based alternatives in order to achieve the desired growth. Work is underway to develop the technologies needed to achieve this vision, through various UKSA-funded national space programmes (such as the National Space Technology Programme) and strategic ESA programmes. For example, 'TechDemoSat' and 'UKube-1' have been used to test space technology and so reduce development time (Box 2).

As well as technological development, two key issues need to be addressed to enable growth. These are the cost and limited availability of satellite launch opportunities, and risks to space infrastructure, discussed below.

Launch capability: A UK space port by 2018?

The UK does not have satellite launch facilities. Operators rely on other nations' facilities, which adds to the cost of launching a satellite. Small satellites have to share launches, which can cause costly delays. Most satellites are launched vertically on large rockets that are not reusable. However, horizontal launch vehicles (space planes), that use a runway for take-off and landing, are in development. Part or all of such space planes are reusable, reducing costs. Several commercial programmes (such as Virgin Galactic, XCOR and Swiss S3) are underway. All may launch small satellites and most will offer sub-orbital space-flights.[44] To launch larger satellites at reduced cost, UK company Reaction Engines is developing the Synergetic Air-Breathing Rocket Engine, 'SABRE' and a space place 'SKYLON' that will use SABRE. SABRE will allow aircraft to be launched in a single stage, avoiding the need to discard spent rocket stages and build a new rocket for each launch. Both SABRE and SKYLON should be operational by 2024.

Government aims to put a regulatory framework in place to enable a working UK space port by 2018, from which space planes could operate.[1] The 2010 government published a list of possible locations for horizontal space plane operations in March 2015, following a technical study by the Civil Aviation Authority (CAA) and a public consultation.[44 45] The National Space Policy reiterates the government's commitment to a UK spaceport, and states that it is likely to be in a coastal location, offering the potential to stimulate high-tech growth in local communities. The next step will be for the Government to set out detailed technical requirements for spaceport and space plane operations.[46] Even if no space planes are ready or available to operate in the UK by 2018, establishing a space port would still have have many benefits, such as advertising the UK's 'readiness for business'.[47,48]

Protecting space infrastructure

The National Space Policy highlights the need to mitigate against threats from space debris, space weather, or human attack (Box 4). The National Space Security Policy policy (NSSP), published in 2014, is now being implemented by the UK Space Agency, in cooperation with the Ministry of Defence, the Foreign and Commonwealth Office and the Cabinet Office. The NSSP states the Government's intention to work with international partners to improve the monitoring, forecasting and mitigation of space debris and space weather. It highlights the need for fall-back systems, and the need to increase resilience to cyber attacks.[49]

Box 4. Potential risks to space infrastructure

- Space debris: According to NASA, there are over 21,000 large pieces of space debris (>10cm) in orbit around the Earth, arising mainly from defunct satellites and the explosion of spent launch stages. There are millions of smaller fragments too small to be identified.[50] Some experts have raised concerns over the space debris risk posed by CubeSats, because of the rapid growth in their numbers, and uncertainty over how long they will spend as debris before falling out of orbit.[51] However, proponents argue that 50% of CubeSat launches in 2014 have already re-entered the Earth atmosphere.[52] Sails are being tested to drag small satellites out of orbit and so reduce the time they spend as space debris.
- Space weather: Mainly the result of solar eruptions, space weather can damage both satellites and ground-based infrastructure (POSTnote 361). It can also reduce the accuracy of GPS. In 2014 the Met Office opened its Space Weather Operations Centre, to help build the UK's resilience to space weather events. Space weather is included in the 2015 National Risk Register.[53]
- Human attack: Satellites, their ground-based infrastructure and the communications links between them are all vulnerable to cyber-attack.[54] Physical attacks on satellites could disrupt space operations by creating debris. However, they would be technically challenging and only a few states have the capability.[49]

Policy challenges

The IGS highlights the importance of public funding, and a robust regulatory and licensing environment, for the UK to be competitive. Many stakeholders stress the importance of building a workforce with appropriate skills and expertise.

Public funding

Public funding is considered essential for early-stage technology that the private sector deem too risky or long-term to invest in; it also benefits the UK economy.[11,43] UKSA had a budget of £319m in 14/15,[55] of which around 84% was delivered via ESA.[56] The UK's ESA contribution was deemed 'good value-for-money' in a 2013 parliamentary inquiry.[11] However, the IGS notes that the ad-hoc nature of Government funding for home grown space programmes has hindered strategic planning and that the UK struggles to compete with higher spending nations. In 2013, UK government expenditure on civil space R&D ranked 7th amongst OECD countries, at $454m compared to $1.7bn (France), $3.3bn (Russia) and $10.6bn (USA).[57] However in December 2014 the 2010 government pledged £200m of extra ESA support, which industry say could "enable [the UK space industry] to pursue new markets worth over £1.5 billion".[20]

Regulatory issues

Licensing of space objects

All UK operators of satellites or other space vehicles must obtain a licence from the UKSA along with 3rd party insurance.[58] In response to concerns that insurance requirements in the UK were hindering the growth of the space industry (particularly small satellites) the Government has capped this liability at EUR 60m.[59,60] It is also looking at ways to streamline the regulatory process for CubeSats. Rather than assessing each mission on a case-by-case basis, it has proposed that risk analyses be conducted in advance, based on a range of potential mission characteristics.

Box 5. Space Law

The United Nations Outer Space Treaty, which is the foundation of international space law, is ratified by 102 states. The treaty says that "the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind" along with a number of other principles. For example it establishes liability for damage caused by space objects. Under international law a state is "absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft, and liable for damage because of its faults in space". [61] The Outer Space Act grants powers to the UKSA to enable the UK to meet its international obligations under the Outer Space Treaty.

The risks posed by a specific mission will be classified according to a 'traffic light' system (green = low-risk, amber =medium risk, red = high-risk) and the regulatory requirements set accordingly.[59]

Exports and export control

UK exports will have to increase significantly to reach the targets set by the IGS. To support this, IGS stakeholders have set up a Strategic Export Group to address the challenges that companies are facing.[1] The UK's Strategic Export Controls restrict the transfer of sensitive space technology in line with the UK's international obligations and national security and foreign policies. The US International Traffic in Arms Regulations can further restrict export of space technology. The UK Export Control Organisation works closely with the space industry and runs events for smaller companies to improve awareness of export controls.

Frequency and orbital allocations

The orbits that satellites occupy and the electromagnetic spectrum they use to exchange data are limited resources for which there is international competition. To help address issues with spectrum allocation, an advisory committee jointly chaired by Ofcom and the UKSA was set up in 2015.[1]

Skills and education

The UK space industry employs almost 35,000 people.[2] It will need around 100,000 more to achieve the IGS targets, but already struggles to find UK candidates with appropriate skills and so relies on international recruitment.[62] The UKSA is evaluating the skills deficit and identifying training opportunities. It supports several academy, apprenticeship and graduate internship schemes and runs an outreach programme to encourage students to take science, technology, engineering and mathematics subjects.

Endnotes

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