ROYAL ACADEMY OF ENGINEERING

House of Commons Science and Technology Select Committee inquiry on Space and Satellites

Response to the inquiry, 29 January 2016

This evidence is submitted by the Royal Academy of Engineering. As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering.

The views described in this response were assembled through consultation with our Fellows. These include experts in space engineering from industry and academia.

Introduction

1. Since the publication of the UK Space Innovation and Growth Strategy 2014-2030, the government has picked up many of the recommendations, which has galvanised the industry. The success of the strategy is illustrated by the high annual growth figure of 7.3%[1] reported in 2014. Furthermore, this is a high-productivity industry whose expansion aligns well with the objectives of the government's Productivity Plan and which is well placed to capitalise on the UK's strengths in IT, the digital economy and finance for investment.
2. Overseas companies perceive the UK as a good place to locate their business and inward investment is happening. This positive perception is a direct result of the UK's clear long-term strategy, the creation of the UK Space Agency, European Space Agency (ESA) investment to establish a presence in the UK, the broader business environment, a strong technology base and the availability of entrepreneurial and highly-skilled people to employ.
3. The Academy welcomes government's continuing support represented by the recent National Space Policy and recognition of the cross-cutting nature of space across a huge range of government departments and agencies. This recognition is vital in realising the considerable potential for growth that can be achieved both by scaling up levels of activity in existing markets, and breaking into new markets. Key to this is the coherence of the space community, and close ties between industry, academia and government.

4. This inquiry is timely and is an important vehicle for highlighting what actions are needed to maintain momentum. A key component is the identification of barriers that government and the space community must find ways to tackle if the UK is to maintain its status as a leader in space and satellite capabilities, and meet its growth targets.

5. Another crucial element is a strong and clear framework that connects the vision in UK's space strategy to the realisation of market opportunities. This requires clarity over the UK's capabilities and technologies, and the support needed for programmes, people and facilities. Through the innovations that arise as a result of the framework, the UK can remain in a leading position.

[1] Annual average in real terms in the two years since 2010/11 (*UK space industry: size and health report 2014*, UK Space Agency).

What satellite-based capabilities should the Government particularly support — telecommunications, navigation, earth observation, space science, or others — and how?

6. The UK has considerable strengths in satellite manufacturing and satellite-based capabilities,[2] in the technologies[3] that often cut across these capabilities and in space science research:

    6.1 Satellite telecommunications represent the largest part of the industry in terms of earnings, exports and employment. Strengths in satellite telecommunications exist across the value chain, encompassing satellite operations, satellite systems, sub-systems, specialist parts and equipment, and applications such as maritime communications. There is future potential to increase satellite capacity, reduce costs and enable new services.

    6.2 Earth observation has growing applications, such as climate change and environment monitoring. The underpinning sensing technologies are applicable to space science, in which the UK should attempt to retain front-runner status, as well as in defence and surveillance. There is also potential to export high-performance space instrumentation abroad.

    6.3 Further strengths exist in positioning, navigation and timing technologies; the potential to develop future commercial applications is enhanced by the UK's involvement in EU programmes such as Galileo and EGNOS[4].

    6.4 Extracting value from the data collected from space will build on the UK's strengths in data science, requiring an ability to handle wide-ranging and large quantities of data produced (for example, for climate monitoring and other purposes). The ability to integrate satellite and other data from a variety of other 'big data' sources, in order to produce value-added information and services for both government and the private sector, is also essential.

7. The capabilities described above have broad applicability, in both civil applications and in security and defence. Government should continue to support all these areas, but with a strategic approach that aligns with other initiatives such as European programmes, and helps to close gaps in the UK's supply chain. Policies are needed that are able to withstand changes in political views. A systems view of the relevant policies and their interdependencies is crucial in ensuring that any interventions generate the greatest value.

8. Government support is needed for programmes that fund academic research, the development of technologies at various technology readiness levels (TRLs) and collaborative research and development, between academia and industry. Support is also needed for facilities and people.

9. Investment in technologies is key to sustaining the UK's competitiveness in satellite-based capabilities and also for opening up downstream 'space-enabled' services, from which considerable growth and value-adding opportunities are forecast. Funding programmes

[2] National Space Technology Steering Group (2012), *The UK National Space Technology Strategy: March 2012 – One year on.*

[3] The UK space technology strategy identifies cross-cutting technologies that are relevant to multiple applications: UK National Space Technology Steering Group (2014), *National Space Technology Strategy*.

[4] Galileo is Europe's global navigation satellite sytem; EGNOS is the European Geostationary Navigation Overlay Service (EGNOS), the first pan-European satellite navigation system.

such as the National Space Technology Programme (NSTP), which supports the development of technologies at low levels of market readiness, are crucial since these technologies would otherwise not be taken forwards. It is important to join up TRLs, to ensure that technologies continue unimpeded along a path towards market readiness.

10. A critical mass, a continuum of investment and a solid activity programme are crucial. Technologies coming into the pipeline now have the potential to come to market in 10 to 20 years' time; some projects may need a sustained funding stream over a 20-year period. It is vital that sufficient financial support is sustained at a level to build critical mass.

11. Funding for collaborative research and development, for partnerships between business and academia, is a key part of delivering innovation. To achieve this, new business-research partnerships must be grown[5]. This would benefit established SMEs looking for new business opportunities, as well as newer companies. For example, funding to allow engineers employed in SMEs to do long-term, part-time work in universities would allow sustained transfer of experience and intellectual property, in both directions. The period must be long enough to cope with the business cycle.

12. Government should also consider barriers to SMEs seeking funding in Europe. The ESA bidding process for sub-system suppliers is highly complex and time-consuming, with the same process in place for small and large contracts. This complexity extends to the delivery of bids, with adverse impact on cost and cash flow. If the involvement of SMEs in ESA's R&D programmes is to be encouraged, the UK should use its influence in ESA to attempt to reduce the administrative burden on SMEs, which are under-resourced in both time and money.

13. Much of current UK Space Agency resourcing is part of existing Science and Technology Facilities Council (STFC) programmes which are science-driven. Space technologies developed through STFC support have been primarily instrument technologies, rather than spacecraft platform technologies. We encourage direct support from the Engineering and Physical Sciences Research Council (EPSRC) for space engineering, whether as a stand-alone activity or as part of wider EPSRC aerospace interests.

14. Support is needed for conditioning of data sets, for exploration of new applications (potentially via the Catapult(s)) and for bringing together communities of potential service users and suppliers to facilitate the formation of new supply chains through which satellite data can flow.

15. It is currently estimated that the shortfall in the UK of advanced technicians and professional engineers by 2022 will be at least 550,000[6]. Support is also needed for developing skills. There is a looming challenge around the supply of skilled people with backgrounds in both IT/software and the science and engineering underpinning application services which involve the handling, presentation and use of satellite (and other) data. There is also a challenge around the supply of engineers to work in the space industry.

16. We note and applaud the significant support by government for the development of new Spacecraft and Payload Test Facilities at Harwell, and encourage further investment by government in strategic capabilities such as this. This support is already rapidly increasing the space sector job creation by industry.

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[5] The Dowling Review of Business-University Research Collaborations, July 2015

[6] Engineering UK 2015, *The State of Engineering*
http://www.engineeringuk.com/EngineeringUK2015/EngUK_Report_2015_Interactive.pdf

17. Funding a UK-based spaceport has the potential to catalyse the market for low-cost access to space, hand-in-hand with the development of smaller satellites that could be launched from the spaceport. In turn, this will catalyse new markets in space-enabled services. It will also reduce UK dependence on key facilities outside its control, increase competition and thereby act to drive down an important element of launch costs. We welcome the government's initiative to develop options for taking this forward.

What steps should the Government be taking to build markets for both new satellites and the 'space services' that they provide (such as space-based internet services or high resolution imaging)?

18. Clarity is needed over the framework for encouraging innovation through investment in people, programmes and facilities, so that entrepreneurs and investors have the confidence to enter the industry. It is also important that easy access to funding is provided.

19. The UK should aspire to being an exemplar in exploiting space services. A key aspect is the government's role as a customer of space services, and for this it will need to understand how space services can be used to deliver policies and services, and reduce costs. This will require a clear vision from government, and a willingness and ability for government departments to collaborate to realise that vision. In particular, there is much that satellite-based services can provide to government to help in strategic decision-making, such as modelling and response to floods and next-likely flood areas. We therefore welcome the Space for Smarter Government Campaign and the moves by the Department for the Environment, Food and Rural Affairs and others in government departments to explore the use of satellite capabilities and data to improve efficiency of delivering public services and policy advice. It is important to ensure that such initiatives are carried through to operational implementation.

20. We also welcome therefore the government's continued funding of the Catapults, as the Satellite Applications Catapult plays a major role in supporting development of the technologies and services that will grow new markets, as well as providing expertise on potential markets and overcoming the barriers to market growth[7].

What is the impact of the current UK regulatory environment on growth in the satellites and space sector? Is it conducive to new players, such as SMEs and start-ups, entering the market? Has the regulatory environment kept pace with innovations in satellite/space technologies?

21. Regulation can be a help or hindrance, depending on how it is designed and delivered. The UK should take an active lead on the development of policy that enables the UK satellite and space sector. Government needs to ensure that regulation does as much as possible to support exports, and keep companies in the UK. Government needs to further strengthen its own resolve for "we can help you make it happen" by further reducing regulation red-tape and timescales.

[7] For example, Satellite Applications Catapult (2014), *Small is the new Big*, White Paper - Nano/Micro-Satellite Missions for Earth Observation and Remote Sensing, and Satellite Applications Catapult (2014), *Spaceport UK: forging ahead with commercial confidence*.

22. Research leads to thought leadership which enables the UK to take a leading position on defining regulation rather than another country leading and then the UK responding. In particular:

    - the UK needs regulation to maintain access to space and to radio spectrum
    - the business side of exports is hard enough, so government needs to ensure that export policy does not disadvantage the industry. SMEs need support on how to assess whether potentially sensitive products are likely to obtain an export licence, and thus whether they should expend effort in taking forward bids with international organisations, given the time and cost in obtaining them. Specifically, there should be a mechanism to brief SMEs on areas of concern relating to their specific technology
    - government may need to take some risks with respect to regulation, if the industry is going to access new markets. As an example, the Civil Aviation Authority is a world leader in the regulation of unmanned aircraft
    - cross-government working is needed, and we welcome the collaboration of the Department for Business, Innovation and Skills, the Ministry of Defence and the Department of Transport on the issue of access to airspace.

23. Notwithstanding, and as testament to the expertise and entrepreneurship resident in the UK, there are some excellent examples of SMEs and start-ups that are successfully developing a wide range of satellite capabilities, such as Clyde Space (small and micro spacecraft systems), Oxford Space Systems (deployable space structures), Thomas Keating Ltd (instrumentation with space applications) and Astrostat (satellite-driven data services). We also welcome the arrival and expansion of major overseas space companies having a base in the UK, such as Lockheed Martin Space UK and Thales-Alenia Space UK.

24. Regulation will also be necessary in due course to deal with the space debris issue.

What mechanisms are needed to encourage investment in UK space and satellite technology, and improve access to finance?

25. The continuation of government support for actions arising from the Space Innovation and Growth Strategy (2014-2030) is crucial for creating confidence in investing in space-based capabilities.

26. We see the following mechanisms as being key to encouraging investment:

    - greater coordination of government initiatives that support access to finance for SMEs
    - tax incentives to encourage investment in research and development by the industry
    - continuation and expansion of grants for public/private collaborative research and development projects.

27. The Satellite Finance Networks (SFN) exists to broker contacts between (all kinds of) providers of finance and those seeking finance. Its experience shows that the UK's strong finance sector is a further factor attracting new businesses to consider locating in the UK

and this is an important aspect therefore of the drive to increase inward investment. With the demise of the Business Growth Service, the burden of providing support to help underpin the process will fall increasingly on the SFN and the Catapult. This support is vital in creating a better understanding of finance amongst those seeking it and of the business opportunities amongst financiers. It will be necessary to ensure that sufficient capacity is available for such specialist training and education activities.

Is the Government striking the right balance between national and European/international endeavour?

28. There is widespread agreement across the engineering community that international collaboration brings major benefits to engineering research and innovation in the UK[8]. Collaboration gives UK researchers and businesses access to a broader range of knowledge, people and facilities than could be obtained in the UK alone. Collaboration facilitates innovation as new ideas are generated, shared, refined and challenged.

29. It is important to achieve value for money from international collaboration, such as with the European Space Agency, and with NASA, JAXA (Japan), ROSCOSMOS (Russia) and increasingly with CNSA (China), and to make sure the UK is investing in well-run organisations nationally and internationally.

30. Government support of international endeavours can and does provide local benefit. Investment in the European Space Agency has helped to catalyse the UK industry. For example, the European Centre for Space Applications and Telecommunications (ECSAT) which opened in 2009 at Harwell, is the first major ESA facility in the United Kingdom. It has helped to strengthen the international standing of the UK Space Gateway, the cluster of space organisations located in Harwell. Harwell provides a place to access the UK satellites and space industry for all stakeholders, including government and overseas companies interested in investing.

31. While the existence of a strong cluster at one geographical location has huge national benefit, we also note also that many space companies are located in other parts of the UK and not always in clusters. We also note that there is a perception from some quarters that government support centred on particular institutions makes it harder for other players to compete on a level playing field for commercial work. It is important that the role of government institutions is made clear, and that they are tasked with collaborating with the supply chain and developing capability in the industry.

32. The government must continue to act strategically to ensure there is alignment between national and international endeavours, and that benefits accrue to the UK from international endeavours. Export is key to the success of the UK space industry, and it should be recognised that the EU is both a partner and a competitor. The European Commission is however a significant customer of growing importance in the procurement of systems such as Galileo and more recently Copernicus. The UK must engage with European space services infrastructure and government has a key role to play in the recently produced IGS European Engagement Plan.

[8] Royal Academy of Engineering (2015), *Relationship between EU membership and UK science*, Response to the House of Lords Science and Technology Committee

33. For the above reasons, it is therefore important to maintain a significant national programme in order to fully benefit from the international programme. Industry needs to be able to test new disruptive technologies on national programmes in some cases before they are applied on international programmes.

What are the key challenges facing the Government and industry in developing and implementing new space capabilities and services? What are the technical barriers to further growth in the sector, including the lack of a UK launch capacity?

***Incentives for entrepreneurs to start businesses*:**

34. Limited access to finance and factors constraining financial reward for entrepreneurs, such as ownership of intellectual property rights, are two disincentives that could reduce the number of individuals willing to enter the space and satellite application services industry. For example, in the US, entrepreneurs are given more of the intellectual property rights, providing a greater incentive for individuals to become entrepreneurs.

35. There is a perception that the risk appetite of investors in technology is much lower in UK than US. Funds investing on behalf of institutional or retail investors tend to be more risk averse, and the UK has fewer high-net-worth individuals willing on their own account to take on significant risk. Space is perceived as a risky investment, although the word 'satellite' may have better connotations. The benefits of satellite capabilities and services need to be articulated to potential funders.

***Creating new markets*:**

36. A major challenge is how the industry can improve understanding of diverse new markets, such as agriculture, transport, security, marine and climate change, and how to connect with new customers and end-users and understand their requirements. Industry needs work together with the Satellite Applications Catapult to achieve this. In particular:

    - The value of space-enabled services should be communicated to potential customers, with the focus on services, not technologies
    - Building new supply chains will take time
    - Market analysis will help to understand the nature of the competition from other technologies and countries, although this is challenging when markets do not yet exist
    - The space industry needs help from UKTI to support companies engaging with the UK.

Developing new business models:

37. Business models for satellite communications and satellite navigation are fairly mature, although the UK needs to increase its presence in these markets. In addition, new business models need to be unlocked for areas such as satellite surveillance and earth observation, and this will require creativity. Disruptive business models, which have the greatest leverage, are hard to find. In the US, there are many examples of technological push leading to sudden take-up of technology; however, the UK does not have an

equivalent to Silicon Valley which creates technological push. Government could help to unlock the sector, for example by making data available or being a customer for satellite data services.

38. See also previous comments in earlier sections of this response on the importance of bringing together communities of suppliers, users and financiers to foster better mutual understanding and to facilitate opportunity spotting and business development. Note that this is a key element of the roadmap for climate services development produced by the European Commission.

Maintaining a pipeline of technologies:

39. The level of funding needs to be expanded to ensure that areas which traditionally have not previously received funding (technologies at low levels of market readiness) are also supported, and a critical mass of technologies coming to market is created. Creating a culture that supports an ability, willingness and acceptability to take managed risks is vital. Such support creates the potential for significant competitive advantage in the future but is usually beyond the capabilities of all but the very largest companies to support on their own account.

The lack of skills:

40. To achieve the numbers of engineers needed to work in the industry in the future, the industry needs to inspire young people. The National Space Centre, Leicester, hosts 150,000 children per year. There is a role for the industry to inspire children, working alongside the UK Space Agency. Activities such as STEM ambassadors should be coordinated to have maximum impact. There is considerable interest in space science and space engineering at undergraduate level, although more postgraduate training in the form of masters and doctoral degrees is needed.

41. However, the main emerging pressure on skills in the near term is, as noted in an earlier paragraph, to do with combining IT/software capabilities with an understanding of big data applications and the science that underpins those applications. Initiatives to develop such skill sets, with appropriate university involvement, and deployment of such capabilities to develop application skills, could be a significant product for the UK to export in its drive to upskill some developing nations in the use of satellite data for their own uses.

42. Tim Peake's current ISS mission has received a great deal of attention and is being very well received by the media and public alike. This is a demonstration of the value that can be obtained, in terms of excitement and inspiration, from modest UK involvement in human space flight.