Science and Technology Committee: Inquiry into Satellites and Space
Response from the Royal Astronomical Society

Declaration of interests

1. This is the official response from the Royal Astronomical Society (RAS) to the Committee inquiry into satellites and space. With a total global membership of nearly 4,000, the RAS represents many UK astronomers, space scientists and geophysicists who use satellites for their work, so have an interest in the subject of the inquiry.

2. The Society also works closely with the Science and Technology Facilities Council, the Natural Environment Research Council and the UK Space Agency, and receives payments from the first of these for the National Astronomy Meeting conference and occasionally for other work.

Introduction

3. In framing this submission, we have consulted with our governing Council, heads of university departments, our members who are active in research, and our Astronomy and two Geophysics Forums. We have also received input from our sister learned society, the Geological Society of London (GSL), and from the British Geophysical Association, a joint association of the RAS and the GSL.

4. The Society acknowledges the response of successive science ministers to proposals from the space community, including the RAS. The need for a UK Space Agency[1] and the scientific value of human space exploration[2] were the subjects of policy work and submissions to Select Committees as long ago as 2005, and so we welcome both of these developments, including Tim Peake's current mission on the International Space Station.

5. The UK has a strong research base in both astronomy and geophysics, supported in the main by funding from the Science and Technology Facilities Council, the Natural Environment Research Council and the European Research Council. The UK performs exceptionally well internationally, for example in citation indices, where it consistently ranks second or third in the world[3]. Given the relatively small level of public expenditure in science, compared with other OECD countries, research here is also very cost-efficient.

6. In space, the UK is a leading partner in many international projects, as recognised in the newly published National Space Policy. Research groups across the country, including the Mullard Space Science Laboratory and the Harwell Campus, the Astronomy Technology Centre in Edinburgh, the National Centre for Earth Observation, the British Geological Survey, the Open University, the universities of Leicester, Glasgow, Birmingham, Cranfield, Warwick, Aberystwyth, Surrey, UCL, and Imperial College, are all involved in constructing instruments for space missions in collaboration with organisations including NASA, ESA, and the Japanese, Indian and Chinese space agencies.

7. Having a strong curiosity-driven base has undoubtedly helped the commercial space industry to grow to its current value of nearly £12 billion, through direct commercial contracts for companies like Airbus Defence and Space, and through the transfer of skills from academia to the private sector. The RAS included some examples of these benefits in our recent publications on the wider

---

[1] http://www.ras.org.uk/images/stories/ras_pdfs/UK%20Policy%20on%20Space.pdf
[2] http://www.ras.org.uk/images/stories/ras_pdfs/Final%20Report%20October%202005.pdf
[3] E.g. for space and planetary sciences http://www.scimagojr.com/countryrank.php?area=1900&category=1912&region=all&year=all&order=ci&min=0&min_type=it

impact of astronomy[4] and geophysics[5].

8. In our response we have drawn on examples from across these disciplines, in order to illustrate the benefits an active space and satellite programme has for research, and how this in turn feeds into economic and other benefits for society as a whole. The Society though stresses that this is an interdependent system, where developments in the different fields, and in engineering, support each other, and this should be noted when the Committee assesses the UK approach to space and satellite policy.

Response to committee questions

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

9. The scientific interests of the RAS are in astronomy, space science and geophysics, so this response is restricted to the merits of those areas. These sciences are about understanding the Earth and its interaction with its surroundings (Earth Observation, geohazards and solar-terrestrial physics), the Solar system (planetary science) and the wider universe (astronomy), and their importance is recognised in the National Space Policy. Satellites and their space-based instruments are vital to all of these fields and can only realistically be supported by government, though many of them have downstream commercial applications, and their data are often of great interest to the private sector. The following paragraphs are examples of work where the UK has a world-leading role, and which depend on public investment, even where they have a significant commercial benefit.

10. In earth sciences, the field of Earth Observation (EO) is exceptionally strong and includes the use of navigation satellites as EO sensors. The gradually developing commercial market in EO is nurtured by continued government funding towards satellite mission costs and to ensure the supply of trained researchers and research in this area through the UK research councils. Public investment has also supported recent advances in applications, tools and services offered to users around the world, such as sensors in the form of new optical and radar systems. UK companies have taken advantage of this development, for example constructing state of the art sensors and satellites, and it has played a significant role in the growth of the UK space sector in recent years.

11. Data from space are also essential in studying and mitigating earthquakes and volcanic eruptions. In the UK a world-leading group in this area is the Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET)[6], which brings together 8 universities and collaborates with BGS and ESA. Examples of the work of COMET include the use of Sentinel-1A to study the Calbuco volcano in Chile, and studies of the effects of the 2015 Nepal earthquake. COMET scientists depend on EO, and hence satellites, and receive long-term funding from NERC. Effective EO monitoring of these geohazards also needs long-term datasets and continuous satellite observations.

12. In a different area of geophysics, the UK has great expertise in the physics of the Earth's magnetic field and makes use of the ESA Swarm mission, launched in 2013, which is a leading facility for research into the Earth's magnetosphere. It uses 3 satellites to model the magnetic field, and understand the structure and composition of the Earth's interior and crust. This is important for navigation where it uses magnetic referencing, including drilling in hydrocarbon exploration, as well as the construction of charts and maps.

13. The interaction of the terrestrial magnetic field with the solar wind and solar storms (so-called

---

[4] https://www.ras.org.uk/publications/other-publications/2294-beyond-the-stars
[5] https://www.ras.org.uk/publications/other-publications/2410-going-underground-geophysics
[6] http://comet.nerc.ac.uk/

solar-terrestrial physics or STP) has attracted public attention in the last few years, as the risks of adverse 'space weather' such as communications and power blackouts, and serious disruption to satellites, have become better understood, and the government added this to its risk register in 2010. The Select Committee investigated 'space weather' as part of its inquiry into emergencies that same year and the UK is now involved in the ESA Space Situational Awareness programme[7]. Continued support for ESA projects (see also our comments on the balance between national and international endeavour) is therefore vital.

14. In the UK research into STP is divided between STFC (for the magnetosphere and space instrumentation research) and NERC (for the upper atmosphere). Limited extra funding was given to NERC when it took on some STP work. This increased the competition with other researchers who bid for NERC grants. One researcher in this area reports that as a result there is a high risk that upper atmosphere projects like the UK component of the SuperDARN radar network are at risk of closure, which would result in a significant loss of geographic coverage and data.

15. Similarly, the creation of the Space Weather Operations Centre (MOSWOC) has been focussed on monitoring outbursts from the Sun, rather than the manifestation of space weather in the Earth's upper atmosphere. Effective space weather predictions depend on both of these facets, as well as research into the basic physics. Given the potential impact on satellites and other high value assets, there should be a more coherent policy in this area, that also includes adequate resources for exploiting equipment. Like EO, space weather also offers the potential for commercial applications.

16. In space science and exploration, the UK is a leading partner in many ESA programmes. The recent increase in our ESA contribution, and decision to participate in the International Space Station, signified a serious commitment to that partnership.

17. For example, the UK has a significant role in all three of the current medium cost M-class missions under construction, namely Euclid, PLATO and Solar Orbiter. In the last of these the UK has two principal investigator positions, as well as one co-investigator, and the spacecraft is under construction at Airbus in Stevenage. UK scientists are also leading the most recently selected low cost S-class mission (SMILE), and have substantial roles in the Jupiter mission JUICE, in ExoMars and in LISA Pathfinder.

18. In astronomy, X-ray missions such as XMM-Newton, the infrared Herschel observatory, and the Gaia and Planck missions, all had UK scientists leading their development and exploitation. Astronomers and space scientists here are now working on projects such as PLATO, which aims to find habitable planets around other stars, and is supported by £25 million of public funding announced in 2014.

19. Over the last two decades there have been few ESA space science missions where the UK has not had a leading role, involvement that has helped us to achieve such a strong global position in science. Perhaps the best known example in the last year is the Rosetta mission and its Philae lander, which achieved the first soft landing on a comet, and has key instruments led by teams based here.

20. These and similar areas, all of which are dependent on satellites and space missions, will only thrive if there is sustainable, long-term investment by government. The benefits of that investment are in some cases seen while projects are underway, but in some cases not until long after the projects have come to an end.

21. The National Space Policy should state this explicitly, and recognise the need for complementary

---

[7] The RAS evidence to this inquiry is available at http://www.ras.org.uk/images/stories/ras_pdfs/S_and_T_-_Scientific_evidence_and_advice_in_emergencies.pdf

facilities on the ground, such as facilities for receiving and processing data. Maintaining and building this scientific base, and increasing the supply of skilled workers, as described in the Policy, will depend on collaboration and support from and between the Department for Education, the research councils, the UK Space Agency and the European Space Agency.

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)?

22. Several of the 'space services' examples given above have the potential for commercialisation. RAS Fellows working in for example EO describe and welcome growing commercial interest in their work, with businesses keen to see how it might support their land- and marine-based needs. The academic researchers see the opportunity to develop more space based commercial applications, but require seed funding to test and develop their ideas, before they are ready for market.

23. As well as ensuring this investment is in place, the Government needs to work more effectively alongside the researchers and end users to help them highlight this UK expertise, data and applications.

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

24. Access to European, and other international space and science programmes, such as space missions, enables the UK to take a leading global role. Membership of the European Union and its Horizon 2020 programme is a key part of this, as is our membership of the European Space Agency.

25. An example supported by Horizon 2020 is the NEOShield-2 project[8], which is characterising near-Earth Objects that might someday hit the Earth, and developing the technologies needed for mitigation strategies. UK partners include Queen's University Belfast and Airbus Defence and Space.

26. The Society welcomed the 30% uplift in the UK contribution to ESA announced at the 2012 ministerial meeting, which has allowed scientists here to take part in programmes such as the European programme for Life and Physical Sciences (ELIPS) on the International Space Station. The UK would also have no prospect of taking part in human space exploration using its national resources alone. Areas of excellence described earlier in this response, like EO, depend heavily on ESA collaboration too, not least in enabling coverage of the whole globe and in allowing data to be shared. This investment is valued, provided it is accompanied by the resource funding needed to exploit projects to the full.

27. The Society also endorses the commitment to increase UK representation within ESA and to promote secondments there for UK-based employees in the public and private sectors.

28. This though is not to argue that ESA membership negates the need for a strong national space programme. ESA member states such as France, Germany and Italy carry out their own development of missions and instruments, which enables them to seek partnerships with countries elsewhere in the world as well as contributing to the space and defence sectors of their own national economies through the transfer of technology and personnel.

29. The UK and ESA therefore also need to look to other partners, including NASA, India, China and Japan, and actively encourage the bilateral programmes referred to in the space policy. These not only present opportunities for mission development, and some contracts for UK companies, but also allow science programmes to have a global reach, which is again important for areas like EO. The Government could facilitate this by establishing a funding line for bilateral cooperation beyond

[8] http://www.neoshield.net/

the global challenge fund i.e. one not restricted to developing nations.

What are the key challenges facing the Government and industry in developing and implementing new space capabilities and services?

30. There is a challenge in the UK in joint funding of scientific space missions by STFC and the UK Space Agency. STFC supports the development of missions at a low Technology Readiness Level (TRL 1-3), as well as science exploitation from ground- and space-based facilities, and the Agency invests in the development of instruments selected for flight (at TRL 5 and higher). The missions themselves are funded by the Agency as part of the ESA science subscription and related programmes.

31. There is thus a gap between the low level development supported by STFC and the higher level development supported by the UK Space Agency, which makes it harder for UK scientists to propose instruments for future missions.

32. Missions are also now subject to a business case that emphasises short to medium term benefits to UK industry, something that is hard to deliver with scientific projects that can take a decade or more to go from inception to launch. As business case development is only possible following final mission selection, UK academics are at a disadvantage in negotiations on proposals and leadership.

33. The 2014 Space Growth Action Plan recognised the importance of downstream growth, something more likely to be delivered through fostering a symbiotic relationship between industry and academia, but which still recognises the distinct needs of each sector. A prerequisite for this is a healthy supply of highly trained individuals (see also paragraph 23), and the maintenance of leading-edge capability and research excellence.

34. Government might take a role in promoting the transfer of not just knowledge, but also people from academia to industry. For example, the majority of astronomy and geophysics PhD graduates are in the long term unlikely to be hired in academic roles, but have transferable skills that would benefit the space sector.

35. The Plan also rightly noted the shortage of graduates in Science, Technology, Engineering and Mathematics (the so-called STEM subjects). There is significant evidence that astronomy and space exploration foster interest in science and engineering as a whole, an effect noted in the National Space Policy. Tim Peake's mission is of course a major part of this work, but we would also point to the flight of Helen Sharman, some 25 years ago, when she became the first British national to travel into space and stay on the Russian Mir space station. Given that physics and engineering struggle to recruit women (and also people from black and minority ethnic backgrounds – see for example the 2010 RAS Demographic Survey[9]), it is important to have a diverse set of role models, and for Helen's mission to be included in the public engagement work of the UK Space Agency.

What are the technical barriers to further growth in the sector, including the lack of a UK launch capacity?

36. The Skylon spaceplane and an associated spaceport could provide the UK with a domestic launch system, although there is debate on whether the lack of this is a major technical barrier to growth in the space sector, given the UK's access to and partnership in the ESA Ariane rocket programme.

37. If successful, the pioneering work being carried out by Reaction Engines on Skylon would however offer the prospect of revolutionising access to space, which would be a major benefit for UK space science. The proposed spaceport should also though include a conventional vertical launch facility, which is likely to remain important for access to space for some time to come.

[9] http://www.ras.org.uk/images/stories/ras_pdfs/Demographics%20and%20Research%20Interests%20of%20the%20UK%20Astronomy%20and%20Geophysics%20Communities%202010%20-%20Revised%202013.pdf

38. One additional point for the Committee to consider is the impact of the space environment on satellites and space hardware, beyond space debris. Protecting space-based assets from atmospheric drag and from the other effects of space weather depends on a good understanding of the whole Earth-Sun system, with instruments on the ground and in orbit. This mitigation work should be supported as part of the monitoring programmes referred to in the space policy.