THE ROYAL SOCIETY

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Submission to the British National Space Centre consultation on the UK civil space strategy 2007-2010

Summary of key points

- BNSC lacks the authority and resources to direct the wide range of activities within the UK space community, or to represent it adequately on the international stage. A new, more proactive UK Space Agency needs to be set up in place of BNSC; resolving problems with its current structure requires more than minor modifications.
- This UK Space Agency should be a 'one stop shop' for space. It should set out a clear national space strategy; have the authority to implement this strategy; provide a focal point for both the established and emerging areas of space science and their sub-disciplines; and raise the profile of UK space activities within the UK Government, wider society, as well as internationally.
- To achieve its aims a UK Space Agency would need funding commensurate with these objectives as well as support at the highest levels of Government.
- The ambition for UK involvement in human spaceflight should be retained and developed in a staged process. Bilateral, strategic partnerships should be considered and investigated as stepping-stones to more comprehensive programmes. The most immediate priority is to establish a UK Space Agency, which would help build the resources necessary for future and more extensive UK involvement in human spaceflight. Any UK involvement in human spaceflight programmes will require new funds and should not take resources away from the already limited UK expenditure on space research.

Introduction

We welcome the opportunity to submit evidence to the British National Space Centre consultation on the UK civil space strategy 2007-2010[1]. This submission has been prepared in consultation with national and international experts, including Royal Society Fellows and University Research Fellows. We have responded to the questions in the consultation document that relate to our expertise, and this response builds on our submission to the House of Commons Science and Technology Select Committee inquiry on space policy (Royal Society 2006a).

1 Science

Do the current areas of activity in space science and EO science allow the UK to enhance its current level of experience?

There are a range of earth observation (EO) activities that provide important scientific data to improve our understanding of natural systems and human impacts. Some of the many applications include the following:

- *Climate change:* monitoring trophospheric and oceanic temperature, ice sheet thickness, weather prediction, impacts monitoring (eg hurricanes and forest fires).

[1] Consultation document is available online at www.bnsc.gov.uk/assets/channels/about/UK%20Space%20Strategy%20Consultation.pdf

- *Sustainable forestry and marine production:* monitoring forest over-harvesting and fire damage, as well as well as the assessment of the release of greenhouse gases. Satellites are also becoming increasingly important in assessing fish stocks.
- *Disaster management:* tracking, monitoring and assessing natural hazards such as tsunamis, earthquakes, volcanoes and severe weather phenomena.

Are there new and emerging areas of scientific activity using space based systems in which the UK should take the initiative in order to develop a leading position?

The UK has been a world leader in the field of aviation medicine and also has the potential to play a leading role in the new and related area of space medicine. Space medicine is the medical science of the biological, physiological and psychological effects of space flight upon human; essentially, the effect of microgravity on the body. Several UK undergraduate education programmes currently exist and, through bilateral agreements, graduate elective placements with international space agency laboratories have been secured. Within this field there are opportunities for high quality, fundamental scientific investigation, stemming from the use of microgravity as a unique physiological perturbation. However, if the UK is to take advantage of these, the nascent space life sciences community in the UK must secure seed corn funding and the opportunity to develop further. It is also evident that space medicine as a discipline is reliant upon the UK's active participation in programmes of human space flight.

The UK is an acknowledged world-leader in the emerging field of small satellites. Work designing and constructing low-earth orbit satellites has made satellite technology relatively cheap, making it available for the wide range of earth observation activities discussed above.

What do you consider to be the technological and economic opportunities for exploitation through space exploration?

The UK has established world leading space science and technology programmes in specific areas since the 1960s (UKspace 2006). However, maintaining that programme and the future strategy for enhancing it and for moving into strategically important areas not well covered at this time is addressed by the points below.

An opportunity is opening for European Space Agency (ESA) to take the lead and be more competitive with NASA in robotic missions due to NASA focusing its resources on human spaceflight programmes. If the UK increases its contribution to ESA, then it could obtain greater value for money through increased returns in this area that would also have spin off benefits for society and other industrial sectors, which are discussed in more detail in sections 2 and 3 respectively.

The UK's contribution to ESA in 2006 amounts to approximately only 7% of ESA's total budget, which is comparable to Belgium's contribution of 5%; whereas France, Germany and Italy contributed approximately 25%, 20% and 10% respectively (ESA 2006). This modest contribution could be preventing the UK from exploiting valuable opportunities and could mean the UK can no longer take a leading role in the development of technologies for European missions. This could also compromise the scope for commercial exploitation of technologies being developed in the UK and the standing of the UK space science community.

Most of the UK contribution is to ESA's mandatory programmes and there is potential for greater UK involvement in the optional programmes. Europe currently dominates particle physics through the Large

Hadron Collider at CERN and could dominate areas of space science if ESA and its funding governments chose to do so.

In pursuing UK interests in exploration and exploitation are there limits to robotic missions that the UK should consider?

The arguments regarding whether or not humans or robots are best suited to space exploration are now largely redundant. There are scientific questions of profound importance to space science that can only be addressed by using automated platforms and those that can only be addressed through human presence. More energy should be focussed upon deciding what the right blend of robotic and human mission should be to meet exploration goals. Any UK involvement in human spaceflight programmes will require new funds and should not take resources away from the already limited UK expenditure on space research.

The ambition for UK involvement in human spaceflight should be retained. While the UK lacks the resources to subscribe to the European Space Agency's human space flight programmes at this time, alternative and less costly strategies should be considered to facilitate engagement in human space flight programmes in the short term. Options for potential cost effective collaborations would be assessed on a case-by-case basis to determine how the UK could contribute expertise and what the returns from the financial investments would be. Such collaborations would not necessarily require the UK to take the financial lead. Bilateral, strategic partnerships should be considered and investigated as stepping-stones to more comprehensive programmes. The interdisciplinary nature of human spaceflight means that there are many ways that the UK can be involved. For instance, the UK could invest in certain areas to sustain or build the expertise in emerging areas of human spaceflight, such as space technology and space medicine.

This ambition should be developed in a staged process with the most immediate priority being to establish a UK Space Agency. In addition to the roles described in section 6 below for the proposed Space Agency, it would build the resources necessary for future and more extensive UK involvement in human spaceflight without affecting other UK space science programmes and robotic missions.

We recognise that scientific benefits are only one factor in the decision for involvement in human spaceflight. This decision will also be driven by economic, social and especially political factors. A major driver for US plans to return to the moon, for example, is due to other nations, notably China and India, planning their own lunar explorations.

2 Societal benefits

For what new applications can space based systems and services deliver greater benefits to society?

Global Positioning Systems are particularly good examples of a type of technology with a large potential that could be exploited. It has many different applications including land, sea and air transport, land surveying, environmental protection, agriculture and law enforcement (POST 2000). Nottingham University's Institute of Engineering Surveying and Space Geodesy and its new Satellite Navigation Centre are world leaders in the field.

Investment by the space industry in research and development often leads to benefits to other industrial sectors. This effect has been estimated to be large, so that for every £100 million of the R&D investment in

the aerospace industry there is an additional increase in GDP of £70 million in other sectors as well as the direct benefits to the aerospace industry (UKspace 2006).

How important is it to sustain basic sets of key observations over long periods of time?

The need for maintaining basic sets of key observations over long periods of time is a generic issue that affects many scientific disciplines. For instance, climate change and weather predictions and space weather applications all require reliable records of data sets that have been monitored over long periods of time. The Society has previously outlined the importance of good data sets for providing the basis for biodiversity measurement and assessment necessary to inform policy responses to the loss of biodiversity (Royal Society 2003). The Society has also recommended that biodiversity monitoring programmes at the global and local levels be enhanced and funding increased to enable new assessment programmes to be established (Royal Society 2002).

These long-term projects often have unknown purposes and tend to be given a low priority by funding bodies. Cost effective ways of extending the allocated lifetime of missions once particular projects have been completed need to be identified.

Have you any views on ways in which we could improve coordination of activities in climate change and environment between different government bodies?

It is important that BNSC does not duplicate activities already being undertaken by other parts of Government and identifies how the UK space sector can best contribute to these activities. The BNSC must co-ordinate with the recently established Office of Climate Change and, if it is established, the proposed independent climate change commission outlined in the draft climate change bill (Defra 2007). It is also important for BNSC to undertake regular two-way communication with the most appropriate BNSC partners on how climate change and environment activities are being co-ordinated and where relevant space science can feed in.

3 Wealth creation

What areas offer the best commercial opportunities to maximise wealth creation, considering both upstream and downstream?

There are some well developed connections between industry and the space science research community, supported by schemes such as the PPARC Industrial Programme Support Scheme. We stress that schemes such as this must continue after PPARC and CCLRC merge to form the Science and Technology Facilities Council.

Effective innovation and knowledge transfer require the development of further connections, or where there is no appropriate existing firm, the establishment of spin-off companies. Examples of successful spin-off companies in this field include the University of Surrey's company Surrey Satellite Technology Ltd, which commercialises the results of the University's small satellite engineering research activities, and the University of Nottingham's commercialisation of its global navigation satellite systems.

Both research and industry-related activities affect the UK's international competitiveness. Examples include research in astronomy, planetary and environmental sciences as well as industrial activities related to satellite and instrument development for space missions.

We also recognise that there have been a number of examples of the UK losing its industrial capabilities and expertise, such as British Aerospace selling its space interests to the French/Spanish/German firm of EADS-Astrium.

After a decrease from £183.18million to £160.20million between 1997/98 and 2002/03, civil space expenditure co-ordinated through BNSC has since then increased by nearly 30% to £207.61million in 2005/06 (BNSC 2006a). Although the UK is competitive and the business return is large, we are concerned that this is largely as a result of past investment and sustaining this growth will require increased investment in emerging technologies. The space sector is one of the most productive industries with GDP per worker being around £135,000 in 2004/05, which is nearly four times higher than the economic average. The UK space industry helps support almost 70,000 jobs and generates £5.2 billion in GDP through both its direct and economic multiplier impacts (UKspace 2006).

Private companies, such as Virgin Galactic, may provide commercial opportunities for space tourism. However, the proposed Virgin Galactic spaceships are not currently designed for space science activities and suborbital flight profiles can offer only a few minutes of exposure to microgravity. It is possible that Virgin Galactic could be developed into a cheap, alternative method for launching satellites but this depends upon the development of commercial vehicles capable of orbital rather than sub-orbital flight which is accompanied by an order of magnitude change in complexity of engineering. However, space tourism should not be viewed as an alternative to the Government involvement in national programmes of human space exploration.

How can BNSC best deploy its resources to ensure that industry is well placed to exploit these opportunities?

Determining a clear national space strategy is vital to ensuring that industry is well placed to exploit opportunities in the space sector. BNSC (or our proposed UK space agency) should have a strategy for industrial engagement to help flag-up long-term procurement and technology development opportunities for industry. The agency should look to learn lessons from other industrial sectors, such as developing a technology roadmap and exploiting existing structures such as the Technology Development Board.

Opportunities for the UK are being lost because other nations' space agencies negotiate more aggressively on behalf of their companies than the BNSC. A higher profile UK Space Agency would help to address this problem. A higher profile UK Space Agency would also help to attract and retain the highest quality staff to represent UK interests at ESA and other international fora.

4 Technology programme

What priorities for technology would best enable the UK to achieve its programmatic goals across science, wealth creation and the public good?

Technological innovation needs a strong and well developed research base and so depends on a healthy and sustainable pool of research scientists. BNSC warned that the workforce is ageing and a steady flow of

replacements depends on skilled staff (BNSC 2006b). This not only applies to space science but also equally across all science areas. Unfortunately, although the skills base of UK space science is world class, there is a genuine risk that this level of quality may not be sustainable.

Research Council funding is awarded on the basis of research excellence, not on the subsequent development of the research group or on employment opportunities for scientists. A primary aim of science base policy must be to ensure that UK university research is as good and fit for purpose as it can be by international standards. It is therefore important to provide adequate support for the necessary skills base required to deliver new technologies and innovation in UK space science.

The UK Government's Next Steps consultation on improving Research Councils' effectiveness proposed a single management structure for large facilities to solve current deficiencies. In response, we stressed that the main deficiency that needs to be addressed is the lack of a clear mechanism for setting priorities for investment and exploitation across the full spectrum of large facilities (Royal Society 2006b). This is relevant to space science and this aspect must be borne in mind given the restructuring of the CCLRC and PPARC into the Science and Technology Facilities Council.

5 Education

What further mechanisms for education and outreach do you think are important to inspire young people and encourage them to take up science and technology?

There is considerable anecdotal evidence that space science inspires and encourages individuals at all educational levels and career stages. It can encourage students of all abilities to take an interest in science and technology at school and also to study physical sciences at university. However, in most cases it is reasonable to assume an enthusiastic and talented teacher is crucial to successfully engaging young people in these topics. A report by the National Foundation for Education Research showed that for the academic year 2004-5 only 19% of science teachers in maintained schools were physics specialists and over a quarter of 11-16 schools did not have any physics specialists at all (National Foundation for Educational Research 2006). Since this time the Government has set targets for increasing the numbers of young people taking A Levels in physics so that by 2014, entries to A Level physics are 35,000 (from 24,094 in 2005), and stepping up recruitment, retraining and retention of physics specialist teachers so that by 2014, 25% of science teachers have a physics specialism (UK Government 2006). The Society is working with others to support the realisation of this ambition and notes that many professional development courses run by the Science Learning Centres include opportunities for science teachers to update their knowledge and skills in space education (DfES 2006).

Astronomy provides numerous opportunities for young people's formal science education to be enriched and enhanced but, as the DfES and DTi noted last year in their STEM programme report (DfES & DTI 2006), to make such schemes and initiatives efficient, successful and widely accessible to schools throughout the UK requires improved delivery networks, greater co-ordination and an exploration of economies of scale. Many stakeholders are currently involved in work flowing from this report, and it is important that those with a particular concern regarding space education are fully engaged. The Society suggests that a UK Space Agency does not seek to reinvent wheels and works wherever possible in concert with the Government's STEM programme and other stakeholders to ensure the best outcome for space science education and young people.

In order to stimulate demand for higher level study in space science among young people there also needs to be an adequate supply of appropriate jobs and careers paths for graduates and post-graduates to encourage interested students to continue with space-related education and academic research. This applies to other areas of science, as discussed in our report on first degrees in science, technology and mathematics (Royal Society 2006c). In addition, many scientists working on space instrumentation are reaching retirement age and it is proving difficult to recruit younger scientists. One possible solution would be to have smaller and faster missions to continue inspiring younger scientists and create more new employment opportunities for them. This problem is not unique to the UK as illustrated by an ESA study that showed a Europe-wide decrease in the under 25 year old population of space scientists (ESA 2003).

6 Delivery structures

How do you think that BNSC could improve its ability to direct programmes to meet its objectives?

Whilst recognising the important co-ordinating role of BNSC, the Society is concerned that its remit and resources prevent it from operating as effectively as it could. BNSC is a loose partnership of bodies that lacks an overarching, long term policy and vision to direct their disparate activities. BNSC has no direct control over the implementation of the space policies it puts forward in contrast to NASA, which implements and co-ordinates US space policy set at the highest level of the US Government by the Office of the President.

We are concerned about BNSC's ability to equally represent all of the interested parties in the UK space community. BNSC needs to improve its links with all UK research activities since it is poorly connected to the grassroots research community. It is important that the grass roots research community inputs into the direction of UK space strategy, and so there is a need for improved mechanisms of communication across the space science sector. For example, the Research Councils' links with the grass roots community could be used to improve representation in BNSC.

BNSC also fails to co-ordinate the funding of space research across all of its sectors. Some in the space research community believe that the BNSC's Space Advisory Board and Council favour existing interests and established disciplines over emerging areas of space research. Emerging areas, such as space medicine and space technology, have the additional problem that they fall between the remits of the Research Councils. UK space policy requires a body that will provide vision for both emerging and established areas.

The current arrangements spread scientific expertise thinly across the various Government Departments with space interests and there is often confusion over which Department should take the lead. This situation has resulted in the UK losing key European Space Agency (ESA) projects, such as the Global Monitoring for Environment and Security.

BNSC's profile as the UK's national space body also needs to be improved at the international level. Participation in international programmes is essential to the UK's space ambitions since the costs of space projects are so great that no single European country can afford to go it alone. It also allows the UK to access the results from joint missions, as well as the expertise of non-UK scientists. However, BNSC has less authority and prestige than other national space agencies and bodies, which weakens the UK's position when negotiating bi- or multilateral agreements. UK bids for ESA funding are at a further disadvantage to nations with a national space programme: a UK national programme would give UK individuals and companies

experience and thereby increase their chances of successfully bidding for ESA contracts. In addition, BNSC currently lacks the resources to exploit new bilateral opportunities with emerging space powers, such as Brazil, China, India and Russia, where relatively low investments that could yield excellent financial and longer term, strategic benefits.

How can these delivery structures in the UK and internationally best be used to meet the UK's objectives?

A new, more proactive UK Space Agency needs to be set up in place of the BNSC; resolving problems with its current structure requires more than minor modifications. As a 'one stop shop' for space, this Agency should:

- set out a clear long term vision through a national space strategy;
- have the authority to implement this strategy;
- provide a focal point for both the established and emerging areas of space science and their sub-disciplines;
- raise the profile of UK space activities within the UK Government, wider society and internationally;
- cover both science and applications, with a balanced representation of academia, industry and government;
- have a significant budget to fund research and its applications;
- capitalise on and develop the UK experience and expertise gained during the Beagle 2 programme.

There is no point creating a Space Agency without additional funding also being made available for space activities. BNSC has a small staff with no formal budget of its own; and the money it does have is very limited, and so it is difficult for it to be spent in a strategic manner. This new Agency would therefore need to be responsible for its own budget, which would be significantly increased (perhaps tenfold) if it is to operate optimally.

A higher profile UK Space Agency would require greater representation within Government. Given the likely restructuring this would involve, it is unclear which Department and Minister it would report to. Other issues that would need to be addressed include whether the Agency would have peer review powers or whether this would remain at the level of the Research Councils; and how it would it be linked to the Science and Technology Facilities Council. In any event, the Agency's space strategy would have to feed directly into these funding activities.

7 Trade promotion

What opportunities do you think exist for BNSC to assist industry in increasing its share of international markets?

International bodies and initiatives, such as the Committee on Space Research (COSPAR) and the 2007 International Polar Year and International Heliophysical Year programmes, provide valuable platforms for promoting the interests of the UK space research community. To sustain these international programmes, it is important that BNSC is involved.

We also recognise that BNSC has successfully collaborated with non-ESA space agencies, a notable example of which was collaboration on NASA's Swift programme. However, there is a potential role for BNSC to help the community take a more effective lead to maintain and widen collaborations with emerging non-

European space powers. For example, BNSC could assist industry through establishing intergovernmental memoranda of understanding.

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