The Royal Academy of Engineering

UK Space Agency Strategy 2011-2015

A response to the UK Space Agency

July 2011

Introduction

The Royal Academy of Engineering is pleased to respond to the UK Space Agency Strategy 2011-2015 Consultation. This response has been prepared following consultation with Fellows who have expertise in this area, both in industry and academia.

The Academy is very supportive of the UK Space Agency (UKSA) and is encouraged by the public consultation on its strategy. Many of our Fellows in the space industry are based at or associated with the University of Surrey and demonstrate support through the International Space Innovation Centre (ISIC).

Through the ISIC, the University of Surrey sees a strong role for business to knowledge base interaction to support the strategy's concepts of 'Growth from New Opportunities' and 'Innovation Supporting Growth'. They particularly see the possibility for growth in these areas through further uniting the upstream and downstream sectors of the Space Industry and increasing the emphasis on cross-sectoral knowledge transfer. The Academy supports the ISIC hub and spoke model and feels this can provide a route to delivering growth and innovation.

The Academy also supports the Agency's remit under the Department for Business, Innovation and Skills along with the opportunity it creates to drive and support the growth of an already world-class manufacturing and technology sector. The £6bn UK industry represents an excellent example of the kind of high tech sector the UK needs to rebalance its economy for the future.

1. Does the draft strategy adequately address the space policy issues facing the UK?

The Academy supports the policy document which articulates a long-term, ambitious view of a growing high-value space sector for the UK. The Academy values the strategy's focus on continuing to support economic growth and welcomes its aim of the UK space sector accounting for 10 percent of the global market by 2030.

However, the document does not specifically address key structural weaknesses in the UK space engineering research and development (detailed in response to question three). We would like to propose that the UKSA pays close attention to space weather and have attached our response to the House of Commons Science and Technology Select Committee on this specific issue (Annex A).

Further consideration needs to be given to providing more detail within the UK Space Agency Strategy. It might be beneficial to frame it more closely in terms of the Space Innovation and Growth Strategy (IGS) recommendations.

The Academy would also like to suggest that a Steering Board is put in place to guide delivery of the Strategy and that this should include a wide range of space sector stakeholders. To promote the development of new disruptive technologies, we would propose that non-space industry technology representatives are also invited to join the Board. The Academy would be able to assist in identifying individuals for this.

2. In the current context, is the overarching theme of growth of the space sector the correct one?

The Academy strongly supports the overarching theme of growth of the space sector and agrees that continuing economic growth will depend on a strong UK presence in future markets, such as satellite broadband. This ambitious growth-driven strategy is supported in order to ensure the UK can make up lost ground in exploiting its science and engineering base and capture new opportunities for the future.

3. Are there any space policy issues which are missing or not clearly addressed?

The policy document makes a clear case for innovation as the key driver for future growth in the UK space industry, stating that the UKSA will:

"facilitate exploitation of technology by encouraging academia-industry collaboration at all stages of the technology development cycle"

We believe that this goal should be clarified such that "ensure that all stages of the technology development cycle" is understood as including low technology readiness levels (TRL) developments. The near-term growth of the UK space industry will be driven by exploitation of current, mature technologies. However, future growth must be primed by low TRL research and development.

The strategy does not contain specific proposals for educational activity such as industrial internships, graduate summer schools, MSc/PhD scholarships or national undergraduate educational programmes, although we note that the continuation of the UK Universal Bus Experiment (UKube) programme offers significant potential

We recommend the provision of a national Space Engineering Doctoral Training Programme, both to support the development of low TRL technologies with industry and to ensure a flow of high-quality staff into industry. Such a programme could be resourced through future EPSRC calls.

The policy identifies space science as an important aspect of the strategy, which we support. However, we note that the entire UK space industry is underpinned by engineering, both basic research and the provision of high-quality engineering graduates. Strong support for space engineering is essential.

4. Are there critical organisations or interfaces which are not mentioned?

The policy document notes existing links between UKSA, STFC and NERC stating that:

"Existing relationships with the Science and Technology Facilities Council (STFC) and the Natural Environment Research Council (NERC) – who are responsible for funding exploitation of our scientific missions – will be strengthened. New relationships with the wider family of Research Councils will be forged."

Much of the current UKSA resourcing is part of existing STFC programmes which are science-driven. Space technologies developed through STFC support have been primarily instrument technologies, rather than spacecraft platform technologies which can underpin innovation across the sector.

This goal should clearly state that EPSRC support is essential to deliver the long-term National Space Technology Plan. It is a structural weakness in UK space research and development that the main research council for engineering does not play a central role in UKSA forward plans. We encourage UKSA to pursue support from EPSRC and to ensure that space engineering is seen as key, whether as a stand-alone activity of as part of wider EPSRC aerospace interests.

We encourage UKSA to support a national academic university space engineering network. Such a network could be resourced through future EPSRC calls. A critical mass of academic research would then form the basis of future co-funded (EPSRC/UKSA/industry) managed programmes on space engineering.

While the UKSA is clearly a national agency of the UK government, we encourage UKSA to form strong links to devolved government across the UK to ensure regional support for the space sector and the national space strategy. For example, Scotland offers unique expertise in disruptive space technologies, facilities for the development of space tourism and a test bed for integrated space applications. The exploitation of these resources for the advantage of the UK sector can be expedited through a dialogue between UKSA and the Scottish government.

5. How should industry and other stakeholders best be involved in taking forward the strategy?

In order to access expertise from across the UK, we recommend UKSA exploits the evolving ISIC hub and spoke network to build core expertise across disciplines which can take the new strategy forward.

The strategy rightly makes the case for growth through the application of space technology. However, we note that spin-in from other sectors to space is also of key importance, from both component level to systems. We recommend a Technology

User Panel be established to support both spin-out from space and spin-in from other sectors. Such an end-user panel functions successfully with EPSRC.

Mechanisms should be put in place to educate the general public about (a) the benefits of the global space programme to the public, and (b) the significant role that the UK plays in space. The vast majority of the UK public are unaware that we have any significant space programme.

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8 July 2011

ANNEX A

Scientific Advice and Evidence in Emergencies
A response to the House of Commons Science and Technology Committee
September 2010

Introduction

The Academy welcomes the inquiry into *Scientific advice and evidence in emergencies* and has previously responded to the Government Chief Scientific Officer's consultation on *Guidelines on scientific advice in policy making* in February 2010[1].

In the *Guidelines on scientific advice in policy making* response, the Academy made the point that while it is important that the scientific and engineering advice used by government should be independent, at the height of a crisis, the level of independence could be less of a priority as expert knowledge becomes more important. To take the example of BSE, at the inception of the crisis, it would have been unhelpful not to use the expertise of stakeholders such as farmers and vets directly involved, despite their having a direct interest in the issues.. Later, as the issues become clearer, a broader group of experts with fewer direct interests would be appropriate to advise on mitigation and recovery.

In this response, we have tackled two of the four case studies the Committee has chosen to cover: solar events and cyber security. These differ in important aspects: space weather is a natural phenomenon, whereas an attack on cyber infrastructure is likely to be a deliberate act. The emphasis in terms of space weather events is therefore resilience and recovery where as the emphasis for cyber attacks is prevention ahead of resilience and recovery.

Solar Storms

1. **What are the potential hazards and risks and how would they be identified? How prepared is the Government for the emergency?**

Extreme solar storms can knock out space craft and affect passengers' health on transpolar air flights through the effects of high energy particles and radiation. They can also cause long lasting problems if physical damage or data corruption occurs in space to ground radio communication, radio navigation or radio surveillance systems. Furthermore, such storms can damage electrical transformers and thus cause outages on the electricity network. These extreme events, sometimes known as Carrington Events (after British astronomer Richard Carrington), probably occur once every century or two.

Many critical infrastructure systems rely on timing signals derived from the GPS system to manage date transfers over networks and synchronisation. In the event of the loss of that timing signal, for what ever reason, most systems can "free wheel" with marginally reduced efficiency for a number of hours or days on less accurate internal clocks. Alternatively, highly accurate timing signals could be derived from ground based navigation systems such as eLORAN which would be significantly more robust to space weather events than the GPS satellite constellation. In the event of the loss of external timing signals, new innovations such as chip scale atomic clocks (CSACs) will reduce this vulnerability further. It is expected that such

[1] http://www.raeng.org.uk/societygov/policy/responses/pdf/Scientific_Analysis_in_Policy_Making.pdf

systems would be able to "free wheel" for the duration of any space weather event, re-synchronising their clocks when timing signals from the GPS system become available again.

Very much less extreme solar storms occur much more frequently and mitigation is largely provided through good engineering practice; for example by designing well protected spacecraft and using suitably rated transformers on the electricity network. Through strong engineering in place already, the UK infrastructure is generally well protected with long lasting problems being most unusual. Somewhat more problematical is dealing with the variability of signals caused by day-to-day space weather. For such radio systems, the national need is generally focused on defence systems which require higher signal integrity rather than civilian applications.

2. How does the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

There are three types of space weather effects that need to be considered, each with differing warning periods from observation and duration. Because of the topology of the earth's magnetic field, the effects of radiation and geomagnetic storms are felt more acutely near the poles.

- Electromagnetic radiation
  - Arrival: 8 minutes
  - Duration: 1-2 hours
  - Effects: Dayside high frequency (HF) radio blackout, radio noise bursts causing interference on some satcom, navigation and radar systems
- High-energy charged particles – direct effects
  - Arrival: 15 minutes to days
  - Duration: hours to days
  - Effects: Satellite anomalies, passenger radiation exposure, avionic glitches
- High-energy charged particles – indirect effects
  - Arrival: 1-4 days
  - Duration: hours to days
  - Effects: Severe HF radio blackout in polar regions (including polar HF communications to aircraft), suppression of HF capability at all latitudes, GPS/Galileo accuracy degradation, potential for power grid problems.

The quantification of the risk associated with major storm events is not a simple matter and can only be achieved through the combined study of both engineers and space scientists. Many studies of this type have been conducted by various agencies, but the majority fail to consider both the engineering and scientific solutions. In principle, it is best, where possible, to engineer out the risk at the design stage if this can be achieved at acceptable cost.

There have been no extreme solar storm events in the UK since the start of the space era, but lesser storms have caused problems on European Space Agency (ESA) satellites and on HF communication systems amongst others. Lesser storms have also caused minor perturbations to the electricity network in the UK.

Scientific and engineering advice on space weather effects has been used and applied by operators to safeguard the services they provide and ensure a certain level of system resilience. Space weather events are transient and most effects are transient as well. Where there are longer term effects and where risks have not been successfully engineered out of systems, the recovery and resilience of affected systems are, to a large extent, independent of the cause of the failure. Where it is applicable, Government should use scientific and engineering advice to ensure the resilience or quick recovery of critical systems in the event of a serious space weather event.

3. What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies?

The UK has no central coordinating agency for these events. One clear candidate is the Centre for the Protection of National Infrastructure (CPNI). Another is Defence Intelligence (DI) Intelligence Collection Strategy and Plans (ICSP) in the MOD. This Department has responsibility for the Defence Meteorological Programme and the MOD embryonic Space Weather programme. Wherever in Government this capability is located, it should have the ability to deal with classified material.

4. How effective is the strategic coordination between Government departments, public bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies.

There have been no major storm events since the start of the space era but in the context of lesser storm events there is little indication of any coordination across government. However, the MOD recognised some years ago that the response to impact of space weather on radio systems must be unified. Consequently, it contracted QinetiQ to develop a space-weather mitigation model with real-time capability which can be used operationally to support radio systems, where engineering mitigation is not possible.

How important is international coordination and how could it be strengthened?

International coordination is critical. Space weather sensors and predictions are an international endeavour; moreover the impact of extreme solar storms will be global. Realistically, the US will be a focus for space weather monitoring and notification as US society and defence are highly reliant on space assets. The US electricity network is also located at a higher geomagnetic latitude than the UK system making it more susceptible to such events. The European Space Agency (ESA) has the remit to provide the civilian focus for solar storm monitoring and space weather in Europe and will develop high level links into the US programme. In the UK and in the defence domain, linkages have been developed between MOD and DoD, resulting in a series of US-UK MOU Project Arrangements in this topic area.

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14 September 2010