House of Lords Science and Technology Committee inquiry into the Resilience of Electrical Infrastructure: response from the Royal Astronomical Society

Declaration of interests

1. Two of the authors of this submission are professionally employed in a university and in a research laboratory to carry out research into space weather and how it interacts with the Earth and its surroundings. The Royal Astronomical Society itself however has no financial interest in this area.

Written evidence

2. The Royal Astronomical Society (RAS) has around 3800 members (Fellows) and is the leading UK advocate for the fields of astronomy, space science and geophysics. Our membership includes professional scientists working in academia and industry as well as many people with occupations across diverse sectors of the economy who use the skills and knowledge obtained during their time in academic research.

3. In 2010 the House of Commons Science and Technology Select Committee considered the issue of space weather as part of its inquiry into scientific advice and evidence in emergencies, including its effects on electrical infrastructure[1]. The RAS submission to that investigation considered the risks posed by adverse space weather to not only electrical power supplies, but also satellite and space-based systems essential for areas such as navigation and communications.

4. Our recommendations at that time included a better coordination of space weather research activities; efforts to raise awareness of the issue with government bodies and potentially affected private industry, and an increased financial commitment to the European Space Agency Space Situational Awareness programme.

5. This new submission concentrates on the points of interest to the Lords inquiry i.e. the impact on electricity supply systems, acknowledges progress on the points raised in the previous paragraph and notes the need to improve our understanding of space weather through new ground- and space-based facilities.

6. In recent years the risks to electrical infrastructure posed by space weather (or solar storms) have become a topic of major interest around the world. It was formally recognised as a significant risk to the UK by the incorporation of severe space weather in our National Risk Register in 2012.

7. When large eruptions of material from the Sun (coronal mass ejections) pass over the Earth they can generate severe geomagnetic storms that inject quasi-DC electric currents

[1] See http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/498/498.pdf and http://www.ras.org.uk/images/stories/ras_pdfs/S_and_T_-_Scientific_evidence_and_advice_in_emergencies.pdf

(geomagnetically induced currents) into power grids and disrupt the operation of key grid components such as transformers. This disruption can cause parts of the grid to shutdown leading to widespread loss of power for many hours and, in worst cases, damage to a few transformers, which could lead to long power outages in affected areas.

8. The UK has been taking an international lead role in these efforts to understand and mitigate this risk. In particular National Grid has been working since the 1990s to improve its resilience against space weather, e.g. through use of more resilient transformers. National Grid also has specific, well-exercised, procedures for operational measures that can provide additional short-term resilience of electrical infrastructure in response to reliable warnings of adverse space weather. The work of National Grid has been reinforced in recent years by a wider UK effort to understand and mitigate space weather risks, encouraged by the UK Government through its National Risk Assessment process and supported by the willingness of UK experts from different fields to work together.

9. A notable example of this is the work of a team of UK engineers and scientists (including several members of the Society) to produce the report "Extreme space weather: impacts on engineered systems and infrastructure" published in February 2013 under the auspices of the UK Royal Academy of Engineering[2]. This report is now a cornerstone of UK work on space weather risks, providing much technical detail on the science and engineering of these risks, on how we can mitigate them and on what needs to be done. The recommendations of this report are now being followed up across a number of sectors including electrical infrastructure.

10. A recent example of this follow up is the formal opening of the Met Office Space Weather Operations Centre by Greg Clark, the Science Minister, on 8 October. The Met Office building is a UK-centric service, based on international collaboration, but delivering services customised to UK needs with National Grid as a key user. The Met Office has strongly engaged with the UK scientific community so that their service builds on the existing skills base in UK universities, Research Council institutes and industry and thus can exploit innovative new science coming out of UK research.

11. These UK skills span the whole range of space weather from the Sun to the Earth, our understanding of how space weather originates in the Sun, how it propagates to the Earth and how the terrestrial environment processes energy from the Sun to produce adverse impacts in different regions of the Earth, e.g. whether a particular space weather event impact the electrical infrastructure in China, Europe or North America. These are all ongoing research areas in which work is beginning to be funded by the UK Research Councils in particular the Natural Environment Research Council (NERC) and the Science and Technology Facilities Council (STFC). There is considerable scope for further research to improve the quality of space weather forecasts used by National Grid.

[2] See http://www.raeng.org.uk/publications/reports/space-weather-full-report

12. The delivery of these space weather forecasts relies on access to data on current space weather conditions: the monitoring of activity on the Sun, the tracking of solar ejecta heading towards Earth and the existing conditions at Earth (where prior conditions can play a major role in determining what happens when a coronal mass ejection arrives at Earth).

13. Many of our present observing capabilities are old and at risk of failure (as happened on 1 October when NASA lost contact with its STEREO-B spacecraft; this may be recovered but perhaps not for many months). Thus there is international interest in establishing new capabilities, especially through the launch of satellites and ground-based instruments, dedicated to operational space weather monitoring. The UK is playing an active role in international discussions, e.g. through our recent membership of ESA's Space Situational Awareness programme and through contacts with developments in the US and China.

14. Scientists from UK universities, Research Council institutes and the Met Office, as well as experts from the UK space industry, are actively working with the UK Space Agency to progress these ideas. For example, a recent industry-academic study has developed a concept (named Carrington after the 19th century British astronomer Richard Carrington[3]) for a UK-led operational mission to monitor solar ejecta travelling towards Earth. This is now being discussed and reviewed by the wider community.

15. The strong solar activity in the last days of October 2014 has provided a spectacular demonstration of the need for better application of our understanding of space weather science. A series of strong solar flares occurred over many days but did not produce any significant solar ejecta and, as of the time of writing, no serious adverse impacts have been reported. From a scientific viewpoint it has provided a textbook example of our understanding that it is the solar ejecta that produce the main adverse impacts. But this understanding is still poorly embedded in operational and policy activities related to space weather. Thus action is needed to embed this understanding in those more practical activities, and these recent events provide an excellent basis for such action.

16. Alongside the efforts of scientists and engineers, STFC recently commissioned a public dialogue project [4]on the mitigation of space weather, with a Steering Group whose members included representatives of NERC, the Met Office, the UK Space Agency, the RAS and the Cabinet Office as well as the authors of this submission.

17. The dialogue process included discussions with members of the public in a number of UK locations and was designed for example to test whether people would respond to a space weather emergency, including a major power outage, differently in rural and urban areas.

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[3] Carrington was a leading member of the Society, serving as RAS Secretary from 1857 to 1862. On 1 September 1859 he observed a large solar flare (the first ever such observation) which was followed some 17 hours later by the largest space weather event on record. This event is now often referred to as "the Carrington event" to recognise the importance of his observations. These were published in the RAS's scientific journal, Monthly Notices, and are still frequently cited today. See e.g. http://articles.adsabs.harvard.edu/full/1859MNRAS..20...13C

[4] See http://talkspaceweather.com

Participants were also asked to assess how government, local communities and private industry should respond to such an event and what steps should be taken to prevent and mitigate its impact.

18. Although the final report on this project is not yet available, Committee members should note that participants became particularly engaged with and spent time understanding this issue. The participants strongly support the need for more scientific research into space weather and for the development of space- and ground-based systems to better understand how it affects the terrestrial environment. Interestingly the public were also specifically clear that they themselves had a duty to be resilient in the difficult circumstances of a severe space weather event and made links to wider resilience to other extreme weather events.

19. Outside of medicine, there are few examples of scientific research where the case being made by scientists is so clearly endorsed by the wider public. The Society therefore asks the Government to note this support and to ensure that research into space weather receives the investment it needs.