AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING

AUSTRALIAN ACADEMY OF SCIENCE

SPACE WEATHER

Executive Summary

The Australian Academy of Technological Sciences and Engineering and the Australian Academy of Science are convinced that the implications of Space Weather Events for Australia must not be ignored. Such events have the potential to significantly and detrimentally affect our access to space based (i.e. satellite) services, and in some instances may also severely degrade ground based and airborne electronic services. Australia is strongly reliant on access to space based services for telecommunications, positioning and timing information and remote sensing imagery among others. These services contribute to Australia's national security, environmental integrity and to our standard of living. There are strong government, community and business interests that must be served by these services. In recognising this, the Academies share the view of other developed countries such as the US (1), the EU (2) and Japan that a practical response to space weather effects should be developed and coordinated. Accordingly, the Academies call for a priority to be placed on the development of space weather monitoring infrastructure and services to support the mitigation of space weather effects; the encouragement of priority research in space science to respond to space weather effects and the development of outreach initiatives to inform government and industry of space weather issues. Australia has the potential to harness some of its world leading research in these areas if a cohesive and comprehensive approach to a national Space Weather Policy, implemented by a dedicated Space Weather Agency, is adopted (3).

Space Weather and its Effects

Space weather refers to conditions in the solar atmosphere and near-Earth space environment that can influence the performance and reliability of space-borne and ground-based technological systems. Examples of activities and systems affected by space weather include:

- satellite communications and operations,
- aviation communications and operations,
- navigation and timing systems,
- general electrical control systems,
- high-frequency communications,
- short-wave broadcasting,
- surveillance radars,
- geophysical exploration,
- electricity power grid distribution.

Intense space weather events are triggered by the explosive release of energy stored in the Sun's magnetic fields. A strong burst of electromagnetic and "cosmic" radiation reaches Earth within 9-30 minutes, with the potential to disrupt the services outlined above. The explosion also results in a shock wave that reaches the Earth about 24 hours later, and this can give rise to disruptions of infrastructure that may also have impacts upon economic activity. There is little warning of these events, and appropriate alerts and a predetermined response plan are necessary to allow the impact to be managed in an effective manner.

Space Weather Events of sufficient size to impact economic activity occur relatively infrequently - a few times every 5 to 10 years in recent experience. However, outages or degradation of space segment services can carry a high cost. Satellite outage revenues are estimated to be $230 000 per satellite per year and insurance claims per satellite per year are quoted (4) as $5.7 million with an estimate of 10-15% of these due to space weather (5). The March 1989 blackouts in Quebec had a net cost of about $13.2 million, damaged equipment accounting for about $6.5 million. Re-routing aircraft around the polar circle during extreme space storms carries extra fuel and landing costs estimated to be about $10 000 per aircraft per event.

Technological Impacts

Being situated at mid-latitudes, Australian ground systems are protected to some extent from high latitude phenomena such as geomagnetic storms. However, satellites are vulnerable to large space weather events. Their internal controls and power supplies may be seriously and permanently damaged, with occasional complete loss of operations, and is regarded as a serious ongoing risk by the NASA, ESA, JAXA and other overseas agencies. Details of commercial outages are difficult to obtain but during the major events of October-November 2003 80% of space science missions were affected, 40% either turned off their instruments or took other protective action in response to the severe solar activity (6). One satellite was totally lost and several instruments on others were damaged. Increasingly, Australia's national infrastructure is dependent upon overseas space data delivered as both services and products. Satellite transmissions control many processes including credit card transactions, stock exchange activities, telephone networks, as well as many aspects of aircraft and terrestrial navigation. Much of the Bureau of Meteorology's weather data is sourced from satellites operated by other nations. A sudden reduction or loss of any of these services as a result of a space weather event would have a significant effect on Australia.

Telecommunications and information technology are likewise vulnerable to space weather. Australia, like all modern societies, relies heavily on space systems (7) for communications and resource information (meteorological, geophysical prospecting, navigation, and remote sensing). There are high costs and high risks associated with the consequences of space weather events, as insurance companies recognise (8). Our reliance on satellites for communications, paging systems, and remote sensing devices requires a coordinated strategy to understand and prepare for space weather events.

In Australia, GPS navigation data, satellite usage, short wave communication, surveillance radar and mining surveys have failed or been severely degraded during intense space disturbances. Reports documenting other major impacts include the collapse of the electrical grid system in Quebec, disruptions to power distribution systems in Scandinavia and New Zealand, cosmic rays causing altitude dependent affects on computers in the US and failures of railway speed controls in Germany. In many cases there have been major costs associated with such events and yet, in general, the connection with space weather is not appreciated until after the event.

Satellite navigation systems such as GPS are becoming an indispensable feature of Australian industry and society. Trucks, trains, taxis, and tractors and other agricultural and mining systems, for example, are using them to increase productivity. There is an unquantified risk that a significant space weather event will result in losses of capital equipment and productivity.

Often, High-Frequency (HF) systems are the mainstay of public safety or emergency communications and can be degraded or disrupted by space weather. HF communications support Defence, maritime services, airlines and general aviation (particularly in remote areas), Police, Customs, Australian Antarctic Division, State Government Agencies such as Water Authorities, Fire Brigades and Emergency Services, and rural medical services.

It is now widely recognized that airline passengers and crew are subject to measurable radiation exposure due to the cosmic radiation that continually bombards the upper atmosphere from space. As a result, France has regulated against excess radiation exposure to staff on airline flights, and this is under close scrutiny elsewhere in Europe (9) and the USA. In October/November 2003 the US Federal Aviation Authority issued alerts of increased radiation dosage over polar routes and flights over the polar cap were modified to reduce this risk. While the relatively low latitudes of continental Australia mean that this is a low risk for domestic air travel, it is of concern for all international air travel over the Antarctic or Arctic and has the potential to seriously impact the economics of international air travel.

From past experience of satellite failure, power grid burnout, loss of radio communication and GPS navigation we know that these can be caused by extremes of the space environment (see for example ref 10). Lessons learned have led to improvements that have, for example, reduced the number and severity of disruptions to power grids. Nevertheless not all known risks have been reduced to manageable levels and new problems will arise, particularly with satellite-dependent technologies. Consequently Australia needs to understand the risks associated with extreme space weather in order to successfully manage those risks through being forewarned and having suitable mitigation plans ready. This Space Weather Statement supports a program of monitoring and research that will coherently build the technical knowledge and effective services required to accurately specify immediate and future space environment conditions.

What Australia Can Do

Given that current and future systems underpinning Australian society are vulnerable to space weather, what can be done to mitigate the effects of space disturbances? Firstly, it is vital to know when a disturbance is likely to occur and what its effects will be. This can be met by monitoring the space environment and recognising abnormal conditions before they reach extreme levels. Monitoring space weather variations is a long-term task best conducted by an organisation dedicated to monitoring, forecasting and providing alerts of adverse conditions. Such a centre would be a national focus for space weather activities, for collecting and distributing relevant global data in Australia and overseas, for application of research results from other groups, and for promoting the inclusion of space weather in future planning.

Monitoring of the Sun, interplanetary space, the Earth's magnetosphere and ionosphere provides the data that leads to improved methods of forecasting space weather. In Australia IPS Radio and Space Services (IPS) monitors sun-earth conditions for the purpose of supporting ionospheric communications, and other technologies affected by space weather. IPS is in practice the Australian Space Weather Agency and the focus for the application of new research to improve space weather predictions. There is significant Australian space weather research that matches overseas research in quality if not in quantity because research groups are small and dispersed. Their research will be more effective, in terms of space weather application, if groups collectively decide the priorities for space weather research and promote the subject as an overall Australian priority. It is essential that there be strong research linkages between the Space Weather Agency and relevant Australian research groups.

In promoting the research aspect to the funding agencies, it is equally important to promote the subject to those areas of government, industry and the public most affected by space weather. To this end, a coordinated program of public outreach should be adopted so that knowledge of the space environment can be appreciated and applied in planning future systems.

The Academies believe the importance of space weather in today's society and in the management of future technology is a demonstrated fact. For this reason the Academies are committed to supporting the development of a scientifically well-informed and balanced Australian response to the issue of space weather effects on infrastructure. In particular, the Academies support:

- space weather monitoring and services,
- priority research into space weather,
- improved outreach to government, industry and the public.

Specifically, the Academies support the following.

- IPS as the Australian Space Weather Agency to provide monitoring and prediction services and to be a focal point for the application of the results of space weather research.

- The development of a research strategy by the National Committee for Space Science to improve space weather forecasting in Australia. This should identify research priorities, especially those relevant to Australia, and develop a ten-year costed plan of priority research for space weather after consultation with the space weather community. The research should aim at providing practical improvements for forecasting and protection from space disturbances.

- The existing World Data Centre for Solar-Terrestrial Science as the Australian warehouse for space weather data.

- Free exchange of space weather data on an international basis.

- Further public discussion of space weather and its effects on technological systems.

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