British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Press Release

New risk index for satellite operators

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For immediate release

CAMBRIDGE, UK. Scientists, satellite operators, insurance industry and Government policy officials gather this week (7 February 2014) to discuss the latest advances in forecasting and 'nowcasting' that, for the first time, enable 'real-time' risk assessment of space radiation damage to Earth-orbiting satellites.

The new system is a result of the EU-funded SPACECAST project which, for the last three years, has investigated and modelled the physics of high and low-energy electrons and protons in near Earth space. The system also provides risk indices for satellite operators of the space radiation in different satellite orbits.

SPACECAST is led by Professor Richard Horne of British Antarctic Survey (BAS). He says,

"Despite all the advances in design, satellites are still damaged by space weather. In March 2012 three satellites suffered loss of services for hours during a space weather event. Ten per cent of the entire fleet were malfunctioning during the 2003 'Halloween' magnetic storm. With more than 1000 satellites on orbit it is important that the satellite industry, space insurance and Government have real-time information to help them take the necessary measures to protect satellites and the services they provide.

Now, for the first time we can forecast radiation levels for a whole range of different orbits, from geostationary orbit to the slot region, including medium Earth orbit where there is a tremendous growth in the number of satellites. The new system, which is updated every hour, will help protect satellites used for navigation, telecommunications, remote sensing and other services. Nobody has done that before."

SPACECAST involves researchers from 5 European countries, working in partnership with colleagues in the USA and two European companies. Satellite data, ground-based measurements of the Earth's magnetic field, and state-of-the-art computer models are used to forecast space weather for the region where most satellites orbit the Earth. This is the so-called Van Allen radiation belt – a doughnut–shaped ring of charged particles, trapped within the Earth's magnetic field – which encircles the planet high above the equator.

Space weather is of intense interest to the UK and US Governments*. Millions of dollars have been lost as a result of large magnetic storms in space causing satellite damage. In 2003 a large magnetic storm caused more than 47 satellites to malfunction, including the total loss of a scientific satellite valued at $640m. The largest magnetic storm ever recorded - the Carrington storm of 1859 - occurred long before society became reliant on satellites for TV, internet, navigation and telecommunications. If such a super-storm occurred again it could have a major impact [Royal Academy of Engineering, 2013].

Changes on the Sun trigger magnetic storms around the Earth, and during the 11-year sunspot cycle the number of moderate to large magnetic storms varies from about 15 to 60 per year or more. .The Sun is currently close to sunspot maximum and over the next few years will be entering the declining phase, a period associated with high speed solar wind streams and enhanced levels of space radiation.

The forecast and nowcast of the radiation belt environment are available on the internet at: http://www.fp7-spacecast.eu together with the associated risk indices for satellite operators. Information on energetic protons at geosynchronous orbit is also provided, including the dose rate and an associated risk index. Satellites continue to operate during space weather events, but given advance warning operators can reduce the risk of disruption by switching off non-essential systems, re-routeing signals, and by re-scheduling orbit manoeuvres and software upgrades.

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Notes for editors:

The SPACECAST stakeholder meeting will be held at British Antarctic Survey, Cambridge on Friday 7 February 2015

SPACECAST is a major EU initiative under Framework 7, which has funding up to a total of €2.0 million. It includes researchers from the BAS (UK), University of Helsinki (Finland), the Finnish Meteorological Institute (Finland), the French Aerospace Laboratory (ONERA) (France), University of Barcelona (Spain), the Catholic University of Leuven (Belgium), and, DH Consultancy (Belgium). It also included close collaboration with 4 groups in the USA, Los Alamos National Laboratory, the University of California, Los Angeles, NASA Goddard Space Flight Centre, and the Applied Physics Laboratory of Johns Hopkins University.

*Space Weather is a topic of special collaboration between the UK and USA following President Obama's visit to the UK in May 2011, and a priority for Europe's space situation awareness programme. SPACECAST also has strong involvement from satellite companies such as SES Global in Luxembourg, and Atrium Space Insurance in the UK who provide guidance on user needs.

Van Allen radiation belts

The Van Allen radiation belts were the foremost discovery of the space age after being detected by the first US satellite Explorer I, which was launched during the International Geophysical Year of 1957-58. They are composed of energetic charged particles trapped inside the Earth's magnetic field, which surrounds the Earth like a ring doughnut. Energetic electrons in the Earth's Van Allen radiation belts occupy two distinct regions. The inner zone, which typically extends from altitudes of 200 km to 7000 km in the equatorial plane, is relatively stable. In contrast, the outer zone, which typically lies between 13,000 km and 40,000 km in the equatorial plane, is highly dynamic. The gap between the two zones, known as the slot region, is usually devoid of energetic electrons.

High energy particle radiation

High energy particle radiation causes internal charging which can damage electronic components on satellites which may lead to temporary loss of service, component failure and in extreme cases total satellite loss. The amount of radiation can change by up to 10,000 fold or more during magnetic storms on timescales of an hour to a few days, but the changes are very difficult to predict. Using satellite data, ground-based measurements of the Earth's magnetic field, and state-of-the-art computer models the SPACECAST project is now able to forecast electron radiation levels throughout the so-called Van Allen radiation belts where most satellites orbit the Earth and provide risk indices for internal charging.

Low energy particle radiation

Low energy electrons are injected into the Earth's inner magnetosphere during magnetic storms and substorms. Enhanced fluxes of low energy electrons observed at these times may lead to surface charging, the subsequent discharge of which can lead to damage to surface materials and underlying components. Knowledge of the low energy electrons is also important for radiation belt modelling since these particles form the seed population of electrons which may ultimately be accelerated to high energies. Using solar wind data from the ACE spacecraft the SPACECAST project can now provide a nowcast of the low energy electrons throughout the Van Allen radiation belts and issue risk indices for surface charging.

Energetic Protons

Energetic protons can penetrate electronic components causing single event effects such as corruption to memory circuits and damage to components. They also cause displacement damage which leads to the degradation of solar array power. For example, energetic protons associated with a large solar energetic particle event can cause 2% power loss in modern solar arrays, which is equivalent to the degradation normally expected over an entire year in orbit.

Magnetic storms

Magnetic storms are a global disruption of the Earth's magnetic field where the field changes shape and "wobbles" for days. They are triggered by changes on the Sun. During the 11-year sunspot cycle the number of moderate to large magnetic storms varies from about 15 per year at sunspot minimum to 60 or more per year just after sunspot maximum. The Sun is currently close to sunspot maximum and the number of magnetic storms is expected to peak over the next few years.

Reference

Extreme space weather: impacts on engineered systems and infrastructure, Royal Academy of Engineering, London, 2013.

British Antarctic Survey (BAS), a component of the Natural Environment Research Council, delivers world-leading interdisciplinary research in the Polar Regions. Its skilled science and support staff based in Cambridge, Antarctica and the Arctic, work together to deliver research that underpins a productive economy and contributes to a sustainable world. Its numerous national and international collaborations, leadership role in Antarctic affairs and excellent infrastructure help ensure that the UK maintains a world leading position. BAS has over 450 staff and operates five research stations, two Royal Research Ships and five aircraft in and around Antarctica. www.antarctica.ac.uk