EASA Safety Information Bulletin

SIB No.: **2012-10**
Issued: **23 May 2012**

Subject: **Single Event Effects (SEE) on Aircraft Systems caused by Cosmic Rays**

Ref. Publication:
1. IEC TS 62396 Parts 1 to 5;
2. Eurocae ED 79A (SAE ARP 4754A) Guidelines for Development of Civil Aircraft and Systems;
3. SIB No. 2012-09 Effects of Space Weather on Aviation;
4. NOAA Space Weather (http://www.swpc.noaa.gov/today.html).

Applicability: All aircraft equipped with systems, required for the continued safe flight and landing, that contain electronic components.

Description: This SIB informs aircraft operators, aircraft manufacturers, avionics systems designers, electronic equipment and component manufacturers of the fault conditions that could be caused by Single Event Effects.

In electronic devices, Single Event Effects are induced by charged particles, with high energy, which reach the Earth's atmosphere from all directions. These charged particles, with high energy, are called cosmic rays.

Note: this SIB should also be read in conjunction with SIB 2012-09 Effects of Space Weather on Aviation.

Single Event Effects occur when a single particle (neutron, proton or other heavy ion) interacts with the atoms that makeup a semiconductor contained within the electronic component of an aircraft system. Some examples of Single Event Effect types are:

- Single Event Upsets (SEU),
- Single Event Latchup (SEL),
- Single Event Gate Rupture (SEGR),
- Single Event Burnout (SEB).

This is information only. Recommendations are not mandatory.

The susceptibility of the electronics, used in aircraft, has increased due to the decreasing size of integrated circuit components.
A larger number of Single Event Effects are more likely to occur on aircraft flying at higher altitudes and/or high polar latitudes.

Potential Effects on Aircraft Systems: The effects of Single Event Effects on aircraft systems can be varied. The effect could:

- result in a hardware failure,
- be transitory in nature, and
- even go un-noticed.

When the effect causes the malfunctioning of a system and the crew reports the system malfunction, the subsequent re-test on the ground or in the air may not reproduce the system malfunction. This can result in a 'no fault found' entry in the aircraft technical log and the system/equipment may continue, thereafter, to operate correctly with no further system malfunctions.

Systems and functions which may be affected include:

i. fly-by-wire technology,

ii. autopilot,

iii. flight warning,

iv. communication (voice and data),

v. navigation

vi. displays

vii. FADEC (Full Authority Digital Engine Control)

viii. Any other aircraft system containing electronic components.

Note that each communication and navigation system could be affected to varying degrees. It is not expected that the current levels of Single Event Effects would affect all communication and navigations systems simultaneously.

Cosmic Rays: Cosmic rays consist of charged particles, with high energy, which reach the Earth's atmosphere from all directions. Cosmic rays originate from outside our solar system as well as from our Sun. Cosmic rays originating from outside our solar system are partly shielded from the Earth by the solar wind. Most of this shielding is attributed to the zone where solar wind transitions from supersonic to subsonic, which is far beyond the Earth.

During phases of high solar activity the shielding of cosmic rays, originating outside our solar system, is normally more effective than at periods of low solar activity. More cosmic rays are, however, received from the Sun during the periods of high

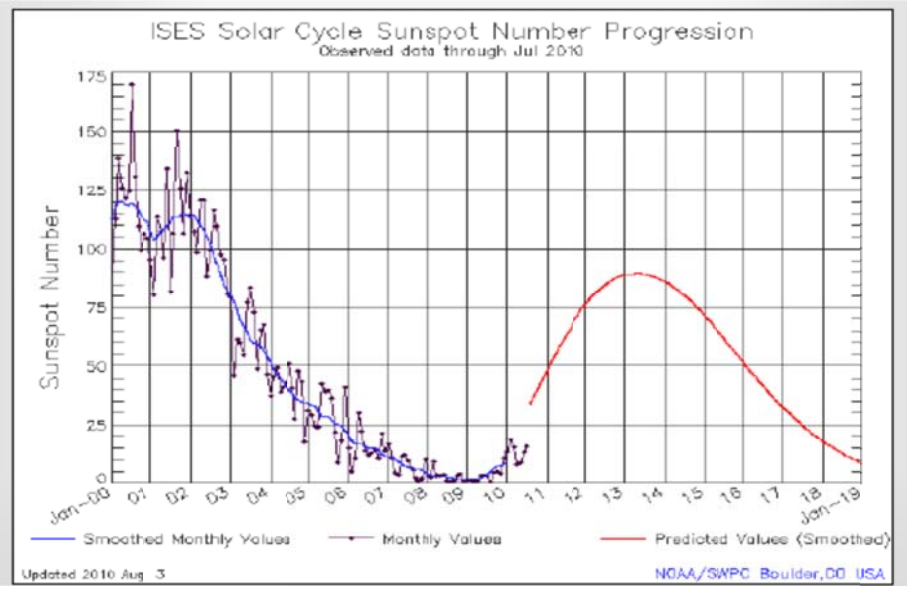
solar activity. The solar activity has a period of roughly 11 years and is commonly characterized by the sunspot number. A history of the sunspot number can be found at http://sidc.be/sunspot-index-graphics/sidc_graphics.php. Currently we are in the ascending part of the solar activity.

Cosmic rays are partially deflected by the magnetic field surrounding the Earth. When traveling parallel to the magnetic field, they are not deflected, while the deflections are at a maximum when they travel perpendicular to the magnetic field. The deflection also depends on the magnitude of the magnetic field, which tends to be higher close the magnetic poles and lower close to the magnetic equator.

A cosmic ray interacting with a molecule in the atmosphere can generate a multitude of charged and uncharged particles[1]. This process is most pronounced at altitudes below 30 km. The various interactions, of the resulting particles, with the denser atmosphere lead to an eventual reduction of the resulting particle flow at lower altitudes.

Solar Activity:

It is a long established fact, that the solar activity cycle lasts approximately 11 years. This is depicted for the last and current solar cycle in the diagram provided below by NOAA (National Oceanic and Atmospheric Administration).



The diagram gives an indication of when the earth will be subjected to increased solar activity in the coming years.

[1] Studies also indicate that thermal neutrons, which are generated after many interactions of cosmic rays, have the potential to cause (for example via a nuclear reaction with the B10 isotope present in many semiconductor devices) bit flips in computer systems.

Whilst the increase in solar activity will potentially decrease exposure to galactic particle induced Single Event Effects, the probability of solar particle induced Single Event Effects could increase.

At this time, the airworthiness concern described in this SIB is not considered to be an unsafe condition that would warrant Airworthiness Directive (AD) action under EC 1702/2003, Part 21A.3B.

Recommendations: Aircraft operators should be aware of this phenomenon and that there is a possibility that the frequency of apparent random system failures might change during the solar cycle.

Suspected occurrences of Single Event Effects should be reported to EASA:

- http://easa.europa.eu/iors/reporting.html

Aircraft manufacturers, avionics systems designers, electronic equipment and component manufacturers should continue to work together, via the existing industry groups, to assess the potential effects of Single Event Effects at component, systems and aircraft level and provide fault tolerant systems.

Contacts: For further information contact the Safety Information Section, Executive Directorate, EASA. E-mail: ADs@easa.europa.eu.