European Union Aviation Safety Agency

Safety Information Bulletin

Airworthiness

SIB No.: 2012-10R1

Issued: 28 April 2021

Subject: **Single Event Effects on Aircraft Systems caused by Atmospheric Radiation**

Revision:

This SIB revises EASA SIB 2012-10 dated 23 May 2012.

Ref. Publications:

- International Electrotechnical Commission (IEC) Technical Specification 62396, Parts 1 to 5 inclusive.
- IEC Technical Report 62396, Parts 6 and 7.
- Eurocae ED 79A (Society of Automotive Engineers, Aerospace Recommended Practice 4754A) Guidelines for Development of Civil Aircraft and Systems.
- EASA SIB 2012-09R1 dated 28 April 2021, which should be read in conjunction with this SIB.
- EASA Certification Memorandum CM-AS-004 Issue 01 dated 08 January 2018.

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 (SEE).

In electronic devices, SEE 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. SEE 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 SEE types are:

- Single Event Upsets (SEU)
- Multiple Bit Upset (MBU)
- Multiple Cell Upset (MCU)
- Single Event Latchup (SEL),
- Single Event Gate Rupture (SEGR)
- Single Event Burnout (SEB)
- Single Event Transient (SET)
- Single Event Functional Interrupt (SEFT)

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

Potential Effects on Aircraft Systems:
The effects of SEE on aircraft systems can be varied. They could result in a hardware failure, be transitory in nature, or even go un-noticed. When an 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:

- fly-by-wire technology,
- autopilot,
- flight warning,
- communication (voice and data),
- navigation,
- displays,
- FADEC (Full Authority Digital Engine Control)
- any other aircraft system containing electronic components.

Each communication and navigation system could be affected to varying degrees. It is unlikely that current levels of SEE would affect all communication and navigations systems simultaneously.

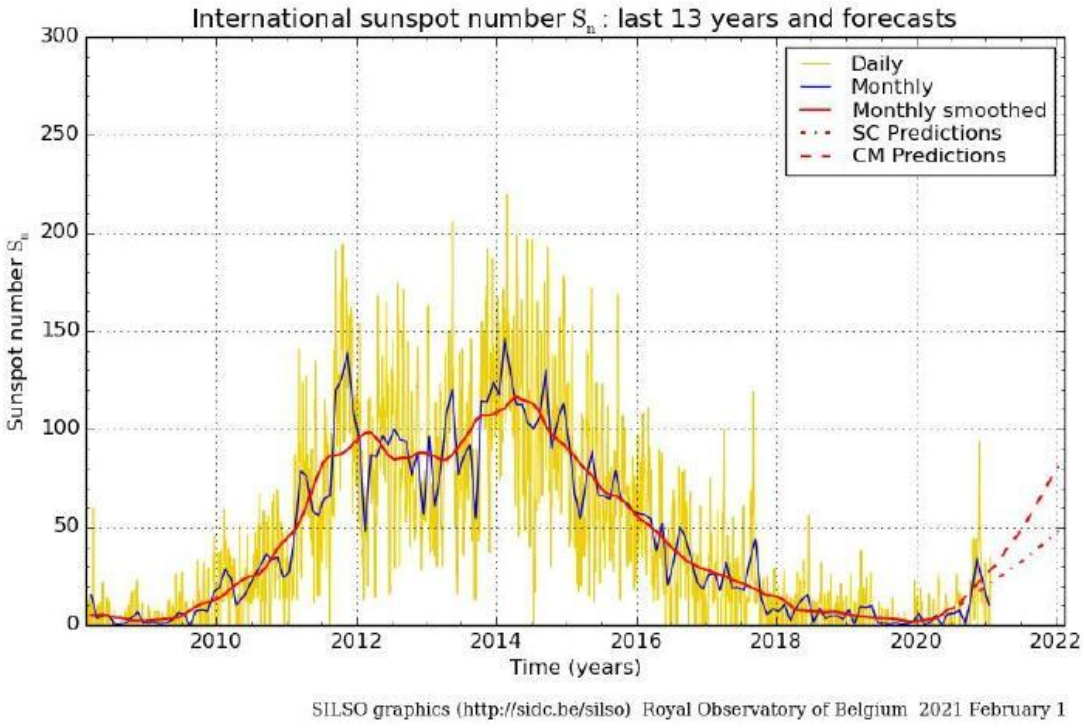
Cosmic Rays:
Cosmic rays consist of charged particles, with high energy, which reach the Earth's atmosphere from all directions. Cosmic rays originate from outside our solar system as well as from the Sun. Cosmic rays originating from outside our solar system are partly shielded from the Earth by the 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 from outside of 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.

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. 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. 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 the United States' National Oceanic and Atmospheric Administration (NOAA).



The diagram above gives an indication of when the Earth will be subjected to increased solar activity in the coming years. The solar activity follows an eleven year cycle. The last peak was in April 2014 and the next one is forecasted for 2025 (forecast published on 15 September 2020 on https://www.weather.gov/news/201509-solar-cycle).

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

At this time, the safety concern described in this SIB is not considered to be an unsafe condition that would warrant Airworthiness Directive (AD) action under Regulation (EU) 748/2012, Part 21.A.3B.

Recommendation(s):

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 SEE should be reported to EASA safety reporting system, as follows:

- When reporting the occurrence, select the state you want to report to by choosing the "EASA" flag.
- In the WHAT section include "SIB 2012-10R1" in Headline field.

Aircraft manufacturers, avionics systems designers, electronic equipment and component manufacturers (stakeholders) should ensure that SEE are adequately addressed in a system (or equipment) and that the effects (if any) at aircraft/engine level are acceptable. EASA Certification Memorandum CM-AS-004 provides guidance to address SEE in the overall design process. In addition, stakeholders should continue to work together, via the existing industry groups, to assess the potential effects of SEE at component, systems and aircraft level and provide fault tolerant systems.

Contact(s):

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