Cosmic Radiation as a Mechanism of Motion of an Aircraft through MIRCE Functionability Field

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Abstract

The main objective of this paper is to demonstrate the necessity of addressing all physical causes that lead to the transition of maintainable systems from positive to negative functionability state during their lives. Addressing the reliability characteristics of components and systems in isolation from the analysis of the impact of the natural environment on it, is not sufficient. Hence, results of the research performed in accordance to the MIRCE Mechanics principles, have shown the significant impact of cosmic radiation on the in-service behaviour of aviation systems Due to the rapid advances in electronics technology and the unrelenting demand for increased avionics functionality the complexity of avionics systems has risen exponentially. Hence, ever more advanced microprocessor and memory semiconductor devices are being used that exhibit an increased susceptibility to cosmic radiation phenomena. Single Event Effects have been the primary radiation concern for avionics since the late 1980's when the phenomenon, which had previously only been observed in orbiting satellites, also began to appear in aircraft electronic systems. The trend with each new generation of avionics system is to use increasing quantities of semiconductor memories and other complex devices that are susceptible to decreases in reliability due to ionising radiation from the cosmic rays from space. and alpha particles from radioactive impurities in the device itself. The interaction of this radiation can result in either a transient 'soft error' effect such as a bit flip in memory or a voltage transient in logic, alternatively a 'hard error' can be induced resulting in permanent damage such as the burn out of a transistor. Thus, this paper concludes that MIRCE Mechanics approach to reliability is the only way forward for all members of the reliability community who wish to develop a method for accurate predictions of reliability, cost and effectiveness of aviation systems at early design stages, rather than to measure their in-service values and produce end of life statistics.

1 Introduction

2. A Few Words on MIRCE Mechanics

3. Naturally-occurring Radiation

3.1 Galactic Cosmic Rays
3.2 Solar Energetic Particles

4. The Earth's Magnetic Field

5. Single Event Effects in Avionics

6. Physical Analysis of SEE on Avionics

7. Evaluation of the Cosmic Radiation Exposure of Aircraft Crews

8. Conclusion

The main objective of this paper was to advocate the necessity of addressing all physical causes that lead to the transition of maintainable systems from positive to negative functionability state during its in-service life. Addressing the reliability characteristics of maintainable systems in general and avionics in particular, in isolation from the investigation of the impact of the natural environment is not sufficient. Hence, MIRCE Mechanics approach to the reliability analysis of avionics, presented here; have shown the significant impact of cosmic radiation on the occurrence of negative functionability events, and consequently, the necessity for addressing them when the reliability characteristics of avionics are considered and predicted, at the design stages of their life cycle management process. [4]

Single Event Effects (SEEs) have been the primary radiation concern for avionics since the late 1980’s when the phenomenon, which had previously only been observed in orbiting satellites, also began to appear in aircraft electronic systems. Cosmic radiation causes daily concerns regarding the reliability of avionics equipment, particularly for those systems that are considered safety critical. The trend with each new generation of avionics system is to use increasing quantities of semiconductor memories and other complex devices that are susceptible to failures induced by ionising radiation from the following two main sources: cosmic rays from space and alpha particles from radioactive impurities in the device itself. The interaction of this radiation can result in either a transient ‘soft error’ effect such as a bit flip in memory or a voltage transient in logic, alternatively a ‘hard error’ can be induced resulting in permanent damage such as the burn out of a transistor. These functionability effects caused by a single radiation event are collectively termed as Single Event Effects.

The research results obtained by applying the principles of MIRCE Mechanics principles to the scientific understanding of the physical mechanisms that lead to the occurrence of the Single Event Upset, which is the principal SEE affecting avionic devices, are presented in this paper. It is caused when a sole incident particle creates a charge disturbance of sufficient magnitude in a memory cell, flip-flop, latch or register to reverse or flip its currently stored data state. Alternatively, in logic or support circuitry a transient voltage pulse can be generated that dependent on the right conditions can propagate through the logic of the device and become latched into a memory cell.

Consequently, this paper concluded that the scientific approach to reliability is the only way forward for all members of the reliability community who wish to make accurate predictions that will be confirmed during the operational processes of the future systems. For that to happen scientific understanding of functionability phenomena is required. Further more, this paper advocates that physical scale from

10^{-10} metre to 10^{+10} metre must be considered in order for functionability mechanisms like, single event upset, and many others, to be understood. Only then, accurate and meaningful reliability predictions become possible, which is imperative for the development of the risk-based technology and their successful applications.

9. Acknowledgement

10. Referemces

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