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INTERNATIONAL STANDARD

colour inside

Process management for avionics – Atmospheric radiation effects – Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment

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Process management for avionics – Atmospheric radiation effects – Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment

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FOREWORD

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International Standard IEC 62396-1 has been prepared by IEC technical committee 107: Process management for avionics.

This second edition cancels and replaces the first edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) removed, in Clause 7 related to system design, reference to level A Type I and Type II (system and references). As Clause 7 is now for guidance, "shall" statements have been changed to "should" and in 9.5.2 the requirement for electronic component management is clarified;

b) all current definitions included in Clause 3 are those used within the IEC 62396 family of documents;

c) incorporated in Annex G related to new technology or latest news reference to some new papers and issues which have appeared since 2011;

d) solar flares and extreme space weather reference added in 5.6 to a proposed future Part 6;

e) reference added in 7.1 to a proposed new Part 7 on incorporating atmospheric radiation effects analysis into the system design process;

f) reference added in 6.2.10 d) to a proposed future Part 8 on other particles including protons, pions and muons;

g) clarification on calculating event rates where cross-sections have been obtained with non-atmospheric radiation like neutron sources, addition of a new Annex H, and changes to 5.3 and 8.2.

The text of this standard is based on the following documents:

FDIS	Report on voting
107/271/FDIS	107/275/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 62396 series, published under the general title *Process management for avionics – Atmospheric radiation effects*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This industry-wide International Standard informs avionics systems designers, electronic equipment manufacturers, component manufacturers and their customers of the kind of ionising radiation environment that their devices will be subjected to in aircraft, the potential effects this radiation environment can have on those devices, and some general approaches for dealing with these effects.

The same atmospheric radiation (neutrons and protons) that is responsible for the radiation exposure that crew and passengers acquire while flying is also responsible for causing the single event effects (SEE) in the avionics electronic equipment. There has been much work carried out over the last few years related to the radiation exposure of aircraft passengers and crew. A standardised industry approach on the effect of the atmospheric neutrons on electronics should be viewed as consistent with, and an extension of, the on-going activities related to the radiation exposure of aircraft passengers and crew.

Atmospheric radiation effects are one factor that could contribute to equipment hard and soft fault rates. From a system safety perspective, using derived fault rate values, the existing methodology described in ARP4754A (accommodation of hard and soft fault rates in general) will also accommodate atmospheric radiation effect rates.

In addition, this International Standard refers to the JEDEC Standard JESD 89A, which relates to soft errors in electronics by atmospheric radiation at ground level (at altitudes less than 10 000 ft (3 040 m)).

PROCESS MANAGEMENT FOR AVIONICS – ATMOSPHERIC RADIATION EFFECTS –

Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment

1 Scope

This part of IEC 62396 is intended to provide guidance on atmospheric radiation effects on avionics electronics used in aircraft operating at altitudes up to 60 000 ft (18,3 km). It defines the radiation environment, the effects of that environment on electronics and provides design considerations for the accommodation of those effects within avionics systems.

This International Standard is intended to help avionics equipment manufacturers and designers to standardise their approach to single event effects in avionics by providing guidance, leading to a standard methodology.

Details of the radiation environment are provided together with identification of potential problems caused as a result of the atmospheric radiation received. Appropriate methods are given for quantifying single event effect (SEE) rates in electronic components. The overall system safety methodology should be expanded to accommodate the single event effects rates and to demonstrate the suitability of the electronics for the application at the component and system level.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62239-1:2015*, Process management for avionics – Management plan – Part 1: Preparation and maintenance of an electronic components management plan*

IEC 62396-2:2012, *Process management for avionics – Atmospheric radiation effects – Part 2: Guidelines for single event effects testing for avionics systems*

IEC 62396-3, *Process management for avionics – Atmospheric radiation effects – Part 3: System design optimization to accommodate the single event effects (SEE) of atmospheric radiation*

IEC 62396-4:2013, *Process management for avionics – Atmospheric radiation effects – Part 4: Design of high voltage aircraft electronics managing potential single event effects*

IEC 62396-5, *Process management for avionics – Atmospheric radiation effects – Part 5: Assessment of thermal neutron fluxes and single event effects in avionics systems*

EIA-4899, *Standard for Preparing an Electronic Components Management Plan*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Users of this international standard can use alternative definitions consistent with convention within their companies.

3.1
aerospace recommended practice
documents relating to avionics which are published by the Society of Automotive Engineers (SAE)

3.2
analogue single event transient
ASET
spurious signal or voltage produced at the output of an analogue component by the deposition of charge by a single particle

3.3
availability
probability that a system is working at instant t, regardless of the number of times it may have previously failed and been repaired

Note 1 to entry: For equipment, availability is the fraction of time the equipment is functional divided by the total time the equipment is expected to be operational, i.e. the time the equipment is functional plus any repair time.

3.4
avionics equipment environment
<aeronautical equipment> applicable environmental conditions (as described per the equipment specification) that the equipment is able to withstand without loss or degradation in equipment performance during all of its manufacturing cycle and maintenance life

Note 1 to entry: The length of the maintenance life is defined by the equipment manufacturer in conjunction with customers.

3.5
capable
ability of a component to be used successfully in the intended application

3.6
certified
assessed and compliant to an applicable standard, with maintenance of a certificate and registration

3.7
characterisation
process of testing a sample of components to determine the key electrical parameter values that can be expected of all produced components of the type tested

3.8
component application
process that assures that the component meets the design requirements of the equipment in which it is used

3.9
component manufacturer
organisation responsible for the component specification and its production

3.10
could not duplicate
CND
reported outcome of diagnostic testing on a piece of equipment

Note 1 to entry: Following receipt of an error or fault message during operation, the error or fault condition could not be replicated during subsequent equipment testing (see IEC 62396-3).

3.11
critical charge
smallest charge that will cause an SEE if injected or deposited in the sensitive volume

Note 1 to entry: For many electronic components, the unit applied is the pico coulomb (pC); however, for small geometry components, this parameter is measured in femto coulomb (fC).

3.12
cross-section
σ
<in proton and neutron interactions> combination of sensitive area and probability of an interaction depositing the critical charge for a SEE

Note 1 to entry: The cross-section may be calculated using the following formula:

σ = number of errors/particle fluence

Note 2 to entry: The units for cross-section are cm^2 per electronic component or per bit.

3.13
double error correction triple error detection
DECTED
system or equipment methodology to test a digital word of information to determine if it has been corrupted, and if corrupted, to conditionally apply a correction

Note 1 to entry: This methodology can correct two-bit corruptions and can detect and report three-bit corruptions. (Used within IEC 62396-3.)

3.14
digital single event transient
DSET
spurious digital signal or voltage, induced by the deposition of charge by a single particle that can propagate through the circuit path during one clock cycle

Note 1 to entry: See 6.2.4.

3.15
electron
elementary particle having a mass of approximately 1/1 840 atomic mass units, and a negative charge of $1,602 \times 10^{-19}$ C

3.16
electronic components management plan
ECMP
equipment manufacturer's document that defines the processes and practices for applying electronic components to an equipment or range of equipment

Note 1 to entry: Generally, it addresses all relevant aspects of the controlling components during system design, development, production, and post-production support.

3.17
electronic component
electrical or electronic device that is not subject to disassembly without destruction or impairment of design use

EXAMPLE Resistors, capacitors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays.

Note 1 to entry: An electronic component is sometimes called electronic device, electronic part, or piece part.

3.18
electronic equipment
item produced by the equipment manufacturer, which incorporates electronic components

EXAMPLE End items, sub-assemblies, line-replaceable units and shop-replaceable units.

3.19
electronic flight instrumentation system
EFIS
avionics electronic system requiring system development assurance level A and for which the pilot will be within the loop (within the control loop) through the pilot/system information exchange

3.20
expert
person who has demonstrated competence to apply knowledge and skill to the specific subject

3.21
firm error
<semiconductor community> circuit cell failure within an electronic component that cannot be reset other than by rebooting the system or by cycling the power

Note 1 to entry: Such a failure can manifest itself as a soft fault in that it could provide no fault found during subsequent test and impact the value for the MTBUR of the LRU.

Note 2 to entry: See also soft error.

3.22
firm fault
<aircraft function level> failure that cannot be reset other than by rebooting the system or by cycling the power to the relevant functional element

Note 1 to entry: Such a fault can impact the value for the MTBF of the LRU and provide no fault found during the subsequent test.

3.23
fly-by-wire
FBW
avionics electronic system requiring system development assurance level A and for which the pilot will not be within the aircraft stability control loop

3.24
functional hazard assessment
FHA
assessment of all hazards against a set of defined hazard classes

3.25
giga electron volt
GeV
energy gained when an electron is accelerated by an electric potential of 10^9 volts, that is, radiation particle energy of giga electron volts (thousand million electron volts)

Note 1 to entry: The SI equivalent energy is 160,2 pico joules.

3.26
gray
Gy
SI unit of ionising radiation dose, defined as the absorption of one joule (J) of radiation energy per one kilogram (kg) of matter

Note 1 to entry: Related units are centigray (cGy) and rad. 1 cGy is equal to 1 rad.

3.27
hard error
permanent or semi-permanent damage of a cell by atmospheric radiation that is not recoverable even by cycling the power off and on

Note 1 to entry: Hard errors can include SEB, SEGR and SEL. Such a fault would be manifest as a hard fault and can impact the value for the MTBF of the LRU.

3.28
hard fault
<aircraft function level> permanent failure of a component within an LRU

Note 1 to entry: A hard fault results in the removal of the LRU affected and the replacement of the permanently damaged component before a system/system architecture can be restored to full functionality. Such a fault can impact the value for the MTBF of the LRU repaired.

3.29
heavy ion
positively charged nucleus of the elements heavier than hydrogen and helium

3.30
in-the-loop
test methodology where an LRU is placed within a radiation beam that provides a simulation of the atmospheric neutron environment and where the inputs to the LRU can be from an electronic fixture external to the beam to enable a closed loop system

Note 1 to entry: The electronic fixture can contain a host computer for the aircraft simulation model. The electronic fixture can also contain appropriate signal conditioning for compatibility with the LRU. In the case of an automatic control function, the outputs from the LRU can be, in turn, sent to an actuation means or directly to the host computer. The host computer would automatically close a stability loop (as in the case of a fly-by-wire control system). In the case of a navigation function, the outputs from the LRU could be sent to a display system where the pilot could then close the navigation loop.

3.31
integrated modular avionics
IMA
implementation of aircraft functions in a multitask computing environment where the computations for each specific system implementing a particular function are confined to a partition that is executed by a common computing resource (a single digital electronic circuit)

3.32
latch-up
triggering of a parasitic p-n-p-n circuit in bulk CMOS, resulting in a state where the parasitic latched current exceeds the holding current

Note 1 to entry: This state is maintained while power is applied.

Note 2 to entry: Latch-up can be a particular case of a soft fault (firm/soft error) or in the case where it causes electronic component damage, a hard fault.

3.33
linear energy transfer
LET
energy deposited per unit path length in a semiconductor along the path of the radiation

Note 1 to entry: The units applicable are MeV·cm^2/mg.

3.34
linear energy transfer threshold
LET_{th}
for a given component, the minimum LET to cause an effect at a particle fluence of 1×10^7 ions·cm^{-2}