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Process management for avionics – Highly severe stress tests for operating margins identification and robustness improvement of avionics equipment – Application guidelines

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PROCESS MANAGEMENT FOR AVIONICS – HIGHLY SEVERE STRESS TESTS FOR OPERATING MARGINS IDENTIFICATION AND ROBUSTNESS IMPROVEMENT OF AVIONICS EQUIPMENT – APPLICATION GUIDELINES

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IEC TR 62500 has been prepared by IEC technical committee 107: Process management for avionics. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
107/411/DTR	107/415/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

In an increasingly harsh economic context (higher performance requirements, shorter development cycles, reduced cost of ownership, etc.), consideration is given to rapid equipment maturity, preferably from its entry into service (EIS).

It is with a view to remedying shortcomings that "highly severe stress" tests for margins research and robustness improvement are considered in equipment design and development methods. The main underlying principle behind this type of test strategy is as follows: rather than reasoning in terms of conformity with a specification and applying tests in line with the specification requirements, it is on the contrary attempted to push the equipment to its operating limits by applying environmental stresses or stimuli, whose levels are higher than the specification requirements.

PROCESS MANAGEMENT FOR AVIONICS – HIGHLY SEVERE STRESS TESTS FOR OPERATING MARGINS IDENTIFICATION AND ROBUSTNESS IMPROVEMENT OF AVIONICS EQUIPMENT – APPLICATION GUIDELINES

1 Scope

This technical report considers the targets assigned to highly severe stress tests for operating margins research and robustness improvement of avionics equipment, their basic principles, their scope of application and their implementation process. It is primarily intended for avionics programme managers, electronic equipment project managers, designers, test managers, and dependability team.

This document provides guidance which can apply to all avionics programmes and is of primary interest to the original equipment manufacturers (OEMs) in charge of designing, developing and producing equipment built for these programmes, for obtaining early equipment maturity.

NOTE 1 Highly severe stress tests approach is often an industrial will in a global lifecycle cost effective approach (see the Introduction) and it is not required at certification level. Moreover, customers can potentially define, in contract clauses, in-service availability requirements, for example, from the entry into service (EIS) or in operation.

This highly severe stress tests approach is part of the avionics equipment design and development stage, and it can address stresses in mechanical, climatic, electrical, etc., domains.

NOTE 2 The principles and objectives described in this document can apply to all types of equipment used in systems developed in avionics programmes, whatever their nature (electronic, electromechanical, mechanical, electrohydraulic, electro-pneumatic, etc.) and whatever their size, from "low-level" subassemblies (circuit card assemblies (CCAs), mechanical assemblies, connectors, etc.) up to system level groups of equipment.

This document can be used in conjunction with IEC 62429, IEC 62506, or both, with regard to dependability aspects related to equipment consisting of hardware with embedded software.

NOTE 3 This document can provide an aid in an equipment definition justification process (see CEN-CENELEC prEN 9215) which can address:

- the development of a definition justification dossier (DJD) by bringing data related to equipment margins and to decisions; or
- the justification of potential future changes made at equipment definition, for example when processing cases of electronic component obsolescence.

For the purpose of this document, if the term "deficiency" is used alone afterwards, it is stated as "built-in deficiency" or "weak point" and encompasses the concept of "deficiency and associated potential malfunction or failure" (see 3.1.1).

Although developed for the avionics industry, this document can be used by other industrial sectors at their discretion.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1.1 built-in deficiency

fault, flaw, imperfection, shortcoming or abnormality, often called weak point, in the design or in the manufacturing processes of an item, which can potentially lead to a malfunction or a failure and cause the item not to operate or function correctly

Note 1 to entry: Deviation from state-of-the-art design rules or inaccurate manufacturing process control can constitute risks and be, for example, at the origin of equipment built-in deficiencies. These built-in deficiencies are usually considered as weak points.

Note 2 to entry: The correction of a built-in deficiency goes in the direction of improving operating margin and robustness of an item, and so in the direction of improving its early maturity.

Note 3 to entry: A built-in deficiency is usually latent (present or potential but not obvious or not explicit or dormant) and manifests itself in operating time or certain conditions.

3.1.2
destruct limit

point from which an item breaks and suffers permanent and irreversible damage

Note 1 to entry: The destruct limit is above (beyond) the operating limit. The stress level leading to the destruct and the permanent and irreversible damage is in excess of the one characterizing the operating limit of an item. The item no longer functions, even the stress level is reduced and returned to below the one characterizing the operating limit.

3.1.3
highly severe stress test

test during which the equipment or some of its parts are submitted to environmental or operating condition or stress that is increased progressively to values far in excess of the specified values, up to the operating limit of the equipment

3.1.4
intermitent

occasional or irregular

Note 1 to entry: An intermittent malfunction or failure occurs occasionally or at irregular intervals.

Note 2 to entry: Intermittent malfunction or failure can occur at stress level in excess of the specified operating limit of an item where the item functions with nominal load. The purpose of highly severe stress tests approach is to precipitate the potential built-in deficiencies (at design or manufacturing processes level for example) into intermittent or permanent malfunctions or failures to investigate them and seek corrective actions.

Note 3 to entry: Intermittent malfunction or failure origin can sometimes be detected by applying an additional specific low stress level (vibrations for example) during a function test.

3.1.5
intrinsic limit
point below which an item, a material or a technology keeps its intrinsic properties or characteristics, with respect to given condition(s) (for example, temperature, vibration, electrical voltage, etc.)

Note 1 to entry: For example, melting temperature of a plastic, maximum junction temperature of a semiconductor, yield strength of an alloy, etc., are intrinsic properties or characteristics of these materials or technologies.

Note 2 to entry: This limit, whether or not destructive, is an absolute barrier.

3.1.6
maturity
state of an item whose functional and operational performance can be considered stabilized with respect to the specification

Note 1 to entry: Maturity is usually the result of a gradual process of eliminating built-in deficiencies still present at the item level and its associated processes (manufacturing processes for example).

3.1.7
operating limit
point at the boundary of the operation area of an item where it still operates or functions correctly and beyond which it no longer operates or functions correctly

Note 1 to entry: The operating limit defines the maximum range of correct operation area of an item, and it is usually characterized by stress level above which the item no longer operates or functions correctly. Usually, for determining this stress level, the stress level at which the item no longer operates or functions correctly is reduced to verify if the function of the item resumes; if the functionality resumes at the reduced stress level, then this stress level characterizes the operating limit.

Note 2 to entry: The operating limit can correspond to the intrinsic limit of a technology. In this case, this is the maximum range of operation which can be reached by the equipment.

3.1.8
operating margin
difference between the operating limit and the nominal operating level under specified stress levels

3.1.9
robustness
property of an item having reduced sensitivity of its performance under, for example, the environmental conditions, to components variations, or to drifts in its manufacturing processes

Note 1 to entry: Robustness is usually the result of actions taken to obtain sufficient operating margins while at the same time reducing all forms of variability.

3.2 Abbreviated terms

CCA	circuit card assembly
CDR	critical design review
EIS	entry into service
EMC	electromagnetic compatibility
ESD	electrostatic discharge
ESS	environmental stress screening
LCD	liquid crystal display
MTBF	mean operating time between failures
OEM	original equipment manufacturer
PCB	printed circuit board
PDR	preliminary design review

RTV rapid temperature variation

TTM time to market

4 Highly severe stress tests for margins research and robustness improvement – Approach

4.1 General

With regard to the initiative for obtaining early equipment maturity, the approach based on highly severe stress tests for operating margins research and robustness improvement consists in submitting an equipment or some of its component parts to environmental or operating stresses, or both, which are gradually raised to values in excess of the specified values until the equipment operating or destruct limits are reached.

Instead of reasoning in terms of conformity with the specification (which is representative of the equipment real lifecycle or mission profile), the highly severe stress tests approach aims, indeed, on the contrary with a view to obtaining robust and mature equipment, to push the equipment to its operating limits or potentially to its destruct limits in order to:

- detect potential intermittent or permanent malfunctions or failures that were not foreseen before the tests;
- reveal, identify and then, depending on margins targets if defined, correct built-in deficiencies which can lead to intermittent or permanent malfunctions or failures; and
- explore available margins and improve, if needed, these margins through appropriate actions, for example, on the equipment design itself or the manufacturing processes.

Equipment operating margin targets are often defined to orientate the highly severe stress approach.

NOTE For example, if not specified by the customer, an operating margin target of 5 °C can be defined with regard to the specified low operating temperature, $T_{\text{op-low}}$, of an equipment; so, in this case, the highest level of stress is limited to $T_{\text{op-low}}$-5 °C. The equipment operating margin target can also be defined according to the industrial usage or application domain or by experience feedback.

Usually, the highly severe stress tests activity is part of a global lifecycle cost effective approach and is formalized with its general objectives and principles in quality system procedures or other specific summary documents, allowing effective coordination and OEM executive officers' support.

Annex A, Figure A.1, provides a typical flowchart related to the highly severe stress tests approach.

4.2 Objectives

The main objectives of the approach include:

a) achieving, in a relatively short time, an early equipment maturity by improving its robustness toward the specification;

b) taking, from the first prototypes, full advantage of technologies and manufacturing processes, by:

   – eliminating, for example, design and manufacturing processes built-in deficiencies;

   – researching operational limits or destruct limits in operating and environmental conditions more severe than the specified ones;

   – considering operational margins allowing to:

     • satisfy, for example, potential technologies or manufacturing processes variations (which can lead later to potential malfunctions, failures or specification non-conformities);