

Standard

Performance-Based Product Failure Mode, Effects and Criticality Analysis (FMECA) Requirements

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American National Standard

Performance-Based Product Failure Mode, Effects and Criticality Analysis (FMECA) Requirements

Sponsored by

American Institute of Aeronautics and Astronautics

Approved 17 November 2008

American National Standards Institute

Abstract

This standard provides the basis for developing the analysis of failure modes, their effects, and criticality in the context of individual products along with the known performance of their elements. The requirements for contractors, the planning and reporting needs, along with the analytical tools are established. The linkage of this standard to the other standards in the new family of performance-based reliability and maintainability standards is described, and all of the keywords for use in automating the Product FMECA process are provided.

Library of Congress cataloging-in-publication data on file

Published by

American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Reston, VA 20191

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Printed in the United States of America

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Foreword

A performance-based Product Failure Mode, Effects, and Criticality Analysis (FMECA) standard has been developed to aid organizations in assuring that their product FMECA tasking presents a “value-added” contribution to the product development effort. The need for such a standard arises from the absence of an accepted methodology for assessing the capability of reliability and maintainability (R&M) programs. The ISO 9000 series standards presently guide organizations in establishing practices for consistently producing superior products, but only within the discipline of quality assurance. The ISO 9000 series of standards do not define processes and practices for achieving high-reliability products. Because the criteria for quality and reliability differ, an organization that conforms to stringent workmanship specifications and produces high-quality products through participation in the ISO 9000 certification process may still lack the capability to consistently deliver high-reliability products. Hence, this product FMECA standard was developed as part of a suite of AIAA S-102 performance-based R&M standards for quantifying the results of, and improving the performance of, R&M programs.

The AIAA S-102 performance-based R&M standards document tree (Annex A) includes 35 standards that provide criteria for rating the capability of R&M practices. They represent proven approaches for planning and implementing the product life cycle R&M program. The S-102 R&M capability-rating criteria allow organizations to:

- specify a level of R&M program performance,
- plan the activities necessary to achieve a level of R&M program performance,
- appraise the performance of an R&M program or individual practice, and
- identify the activities necessary to improve the performance of an R&M program or individual practice.

The S-102 R&M capability-rating criteria (Annex B in all S-102 standards) are intended to aid organizations in assuring their R&M programs are a “value-added” contribution to the product development effort. *There is no intent to prescribe a universal methodology for quantifying the evaluation or improvement of R&M programs or individual practices.* The S-102 R&M capability-rating criteria reflect the collective body of knowledge of the S-102 Working Group, which was chartered by the AIAA Standards Executive Council to develop and improve the S-102 standards. The S-102 Working Group is comprised of R&M experts that represent the government and industry sectors affected by the S-102 standards.

This standard establishes uniform requirements for a performance-based product FMECA. The principles of the product FMECA as promulgated in a performance-based approach can be learned from this standard alone, but its proper use requires careful planning, for which the prerequisite is, understanding associated S-102 documents and identifying the desired R&M data products in the systems engineering process. What distinguishes this standard from all past and present product FMECA standards is the following:

- It provides consistent criteria for rating the “capability” of the product FMECA process.
- It provides consistent criteria for rating the “maturity” of the product FMECA data.
- It calls for the use of knowledge-based approaches to identify, analyze, and manage failure modes that pose unacceptable risk.
- For a Capability Level 3 or above FMECA process, it calls for the collection and review of existing lessons learned, and the generation and formal approval of new lessons learned.
- For a Capability Level 4 or above product FMECA process, it calls for the use of predefined R&M data parameters to facilitate the exchange of product FMECA data among computer-aided analysis tools and other project databases.

At the time of approval the members of the AIAA Performance-Based Reliability and Maintainability Standards Working Group were:

Tyrone Jackson (Chair)	SRS Technologies
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David Oberhettinger	NASA Jet Propulsion Laboratory
Walt Willing	Northrop Grumman Electronic Systems
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The above consensus body approved this document in June 2006.

The AIAA Standards Executive Council (Mr. Amr ElSawy, Chairman) accepted the document for publication in July 2008.

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1 Scope

This standard establishes uniform requirements and criteria for a performance-based, product Failure Mode, Effects and Criticality Analysis (FMECA). The performance-based aspect of this standard requires that the organization's FMECA capability be rated according to predetermined criteria for process capability and data maturity.

1.1 Purpose

The primary purpose of the product FMECA is to collect and evaluate the necessary system design information to identify and eliminate or control all failure modes that pose unacceptable risk. Depending on how it is performed, the FMECA can be used for many purposes, but its most important use in systems engineering is to aid the improvement of design reliability before the product is manufactured. For this standard, a failure mode is defined as the consequence of the mechanism through which the failure occurs, i.e., the manner by which the failure is observed. Accordingly, a failure mode that poses unacceptable risk is a failure mode whose effect, either singularly or in combination with other failure mode effects, violates a system design requirement or goal. The FMECA is a systematic methodology that is widely used to evaluate the effects on systems and interfaces caused by the failure modes of functional or physical components, to estimate the criticality of each failure mode in terms of its end-effects, and to evaluate the appropriate failure compensation methods for mission critical failure modes. The S-102 Product FMECA is comprised of three components:

- failure mode and effects analysis (FMEA),
- criticality analysis (CA) and risk priority analysis (RPA), and
- critical item analysis (CIA) and failure compensation analysis (FCA).

The FMEA answers system failure questions regarding *what's, how's, where's, when's, and why's*. The CA and the RPA answer system failure questions regarding *relative significance*. The CIA and the FCA answer system failure questions regarding *failure mitigation*. The minimum activities that constitute the baseline practice for the product FMECA are the following:

- timely establishment of the requirements and analytical ground-rules for the product FMECA;
- timely establishment of product FMECA technical performance metrics (TPM);
- timely collection and evaluation of the necessary system design information to identify and eliminate or control all inherent, singular hardware (H/W) failure modes that pose unacceptable risk across the system life cycle;
- timely creation of a product FMECA dataset for each postulated system failure mode;
- timely application of reliability critical item (RCI) selection criteria and the evaluation of RCI failure modes;
- timely calculation of the criticality number (CN) and detection risk priority number (RPN);
- timely identification of scheduled project activities that are intended to help reduce the failure likelihood or manage the consequences of the failure;
- timely identification and documentation of all non-credible Severity Classification 3 (i.e., Marginal) or higher inherent, singular H/W failure modes;
- timely validation of each product FMECA dataset; and
- timely development and documentation of the product FMECA report.