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Standard

Performance-Based System Reliability Modeling Requirements

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American National Standard

Performance-Based System Reliability Modeling Requirements

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Abstract

This Standard provides the basis for developing performance-based System Reliability Modeling to develop mathematical or simulation models to be used for making numerical apportionments and reliability predictions based on the reliability characteristics and functional interdependencies for all configured items required to perform the mission. 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 (R&M) standards is described, and a large number of keyword data element descriptions (DED) for use in automating the System Reliability Modeling process are provided.

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Foreword

Although the terms quality and reliability are often used interchangeably, they have different meanings. *Quality* as used in this Standard, is the ability of a product to meet the workmanship criteria established by an organization. A different, but often used, definition of quality: Quality is the set of all desired attributes that can be put in a product. In this sense, quality cannot be achieved without achieving the desired reliability. *Reliability* is the ability of a product or system to perform as intended function for a specified time or operating cycles. A high-quality product may not be a high-reliability product even though it conforms to stringent workmanship specifications. The ISO 9000 series standards that establish the ability of an organization to produce high-quality products consistently do not necessarily establish that same organization's ability to y deliver high-reliability products consistently. Consequently, the ISO 9000 series certification process, which serves as the main international reference for Quality Program requirements in business-to-business dealings, is not the appropriate reference for international or domestic Reliability Program requirements. A more suitable reference is the suite of AIAA S-102 performance-based Reliability and Maintainability (R&M) standards, which provide a framework for quantifying and improving the performance of R&M practices.

As Annex A shows, there are 35 standards in the AIAA S-102 performance-based R&M standards document tree. These standards provide criteria for rating the capability of R&M practices and 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 to achieve a level of R&M Program performance;

— appraise the performance 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 approve the S-102 standards. The S-102 Working Group is composed of R&M experts that represent the Government and industry sectors affected by the S-102 standards.

This Standard establishes uniform requirements and criteria for a performance-based System Reliability Modeling. The principles of System Reliability Modeling as promoted in a performance-based approach can be learned from this document 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 System Reliability Modeling standards are the following.

— It provides consistent rating of the "capability" of the reliability modeling process.

— It provides consistent rating of the "maturity" of the reliability modeling data products.

— It calls for the use of knowledge-based approaches to identify, analyze, and manage system-level to component-level reliability characteristics that pose unacceptable risk.

— For a Capability Level 3 or above System Reliability Modeling 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 System Reliability Modeling process, it calls for the use of predefined R&M data parameters to facilitate the exchange of reliability modeling data products among computer-aided analysis tools and other project databases.

At the time of approval, the members of the AIAA Reliability & Maintainability Standards Working Group were:

Tyrone Jackson (Chair)	SRS Technologies
Lily Lau	The Aerospace Corporation
David Oberhettinger	NASA Jet Propulsion Laboratory
Walt Willing	Northrop Grumman Electronic Systems
Steve Harbater	Northrop Grumman Integrated Systems
Alazel Jackson	Raytheon Space and Airborne Systems
Jan Swider	Pratt & Whitney Rocketdyne, Inc
Dev Raheja	Design for Competitiveness
Jeff Merrick	Merrick Consulting
Ken Gibson	Boeing Space and Intelligence Systems
James French	RMS Partnership
Dawson Coblin	Lockheed Martin Missile Systems Company
Ari Jain	Reliability Consultant
Terry Hardy	Federal Aviation Administration

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 performance-based System Reliability Modeling, including planning, performing, documenting, and evaluating. Although it is a common industry practice for reliability modeling to be performed using computerized tools, this Standard does not mandate that any particular computerized methodology be used.

1.1 Purpose

The primary purpose of System Reliability Modeling is to develop mathematical or simulation models to be used for probabilistic apportionments or predictions based on the collective reliability characteristics of all the functional items required for a system to successfully complete its mission. The baseline system reliability model consists of mathematical or simulation models for the following system attributes.

- system hierarchical functional flow
- system operating modes and the mission timeline
- functional to physical association of each item in the system, to include as a minimum:
  - all electrical, electronic, and electromechanical (EEE) items that perform essential functions in each specified mission time period or operating cycle, e.g., switches and sensors that control restorable functions,
  - all mechanical, pneumatic, pyrotechnical, and structural items that perform essential functions in each specified mission time period or operating cycle
  - system-level effects due to the loss of each functional item in the system
- inherent hazard rate or probability of failure for each functional item in the system

The primary output of the system reliability model is the system reliability prediction. The reliability model may be developed in either a textual or graphical form to represent the mathematical expressions or simulation instructions that are used to output probabilities.

System Reliability Modeling is particularly useful in determining where the project's reliability improvement resources should be applied. For example, reliability modeling of the system's inherent or operational reliability capability, using as inputs available engineering data modified to reflect mission environments and usage, will identify where changes in the existing design are required to meet system reliability requirements.

The graphical form of the reliability model is the Reliability Block Diagram (RBD). The RBD provides a concise and orderly method for visualizing the reliability characteristics, both individually and collectively, of all the functional items in the system. A system RBD may be developed starting from either the functional item level (bottom-up) or the system level (top-down). However, the mathematical expressions or simulation instructions are defined at the functional item level, and are combined in a bottom-up fashion. The effort required to perform system reliability predictions is dependent on the number and complexity of the reliability blocks in the RBD. A reliability block is the graphical representation of the mathematical or simulation model used to estimate the reliability of a system component.

1.2 Application

This Standard applies to acquisitions for the design, development, fabrication, test, and operation of commercial, civil, and military systems, equipment, and associated computer programs. Annex B of this Standard provides capability-rating criteria that are intended to categorize the capability of sets of activities commonly found in System Reliability Modeling processes. The capability level criteria provide the logical order of activities for improving the effectiveness of an existing System Reliability Modeling process in stages. Therefore, an existing System Reliability Modeling process may be improved by using the capability level criteria in Annex B to develop a list of minimally acceptable activities, and then compare that list to the