



SURFACE VEHICLE RECOMMENDED PRACTICE

J3119™

APR2020

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Reliability, Maintainability, and Sustainability
Terms and Definitions

RATIONALE

This SAE Recommended Practice is intended to provide comprehensive reference and background information pertaining to vocabulary of reliability, maintainability, and sustainability for use by the industry.

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Documents

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1. SCOPE

A glossary of basic terms and definitions useful for working in reliability, maintainability, and sustainability (RMS).

The terms used in most engineering technologies tend to be physical characteristics such as speed, rate of turn, and fuel consumption. While they may require very careful definition and control of the way in which they are measured, the terms themselves are not subject to different interpretations. Reliability, maintainability, and sustainability (RMS), however, use terms that are defined in a variety of ways with multiple interpretations.

The variety of definitions given to a single term creates problems when trying to compare the performance of one system to another. To eliminate the confusion, a literature search that listed current and past RMS terms and definitions was conducted. The literature search included input from the U.S. military, UK military, NATO, SAE, IEEE, NASA, ISO, university research, and other publications. The object was to determine the common definition of reliability terms from a variety of sources. It is accepted that some of the definitions may be unique because of the nature of the mission, but it is the strong conviction of the government and industry practitioners who make up the SAE Reliability Committee under the G-11 Division that there should be some fundamental definitions used for all hardware systems.

Accordingly, in October of 2003, there were discussions to revise the current AIR4896 that was published in 1995. It is understood by individuals who participated in this project that future editions will update terminology as developments are made within the RMS community. Due to the complexity and nature of software reliability, we have specifically excluded "software reliability" terms from this edition. Future updates of this document will continue to reflect the converging of defense and commercial technology and standards.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

J2940	Use of Model Verification and Validation in Product Reliability and Confidence Assessments
J2958	Report on Unmanned Ground Vehicle Reliability
JA1000-1	Reliability Program Standard Implementation Guide
JA1002	Software Reliability Program Standard

2.1.2 Department of Defense Publications

The military references are available from the Acquisition Streamlining and Standardization Information System (ASSIST) at <http://assist.daps.dla.mil/online/start> and the DoD Directives Systems at <http://www.dtic.mil/whs.directives>. It is recommended that standards are downloaded from DoD-sponsored websites to obtain the current version. However, websites are listed for other online resources that distribute the standards.

2.1.2.1 Military Standards

MIL-STD-1309D	"Definitions of Terms for Test Measurement and Diagnostic," Department of Defense, February 12, 1992.
MIL-HDBK-338	"Electronic Reliability Design Handbook," Department of Defense, October 1998. http://www.reliasoft.org/mil_std/mil_hdbk_338b.pdf

- MIL-STD-1472F "Human Engineering," Department of Defense, October 5, 2003.
http://www.reliasoft.org/mil_std/mil_std_1472f.pdf
- DoD 3110.5 "Materiel Condition Reporting for Mission-Essential Systems and Equipment," Department of Defense, September 14, 1990.
http://www.dtic.mil/whs/directives/corres/pdf/i31105_091490/i31105p.pdf
- OPNAVINST 4790.2D "The Naval Aviation Maintenance Program," Department of Defense, April 11, 2001.
<http://logistics.navair.navy.mil/4790>

2.1.2.2 Military Standards with Superseding Document

- MIL-STD-1388-1A "Logistic Support Analysis," Department of Defense, April 11, 1983. Superseded by MIL-HDBK-502, "Acquisition Logistics," May 30, 1997.
http://www.combatindex.com/mil_docs/pdf/Hopper/MIL-HDBK/CI-502-MH-7758-3304.pdf
- MIL-STD-471A "Maintainability Verification/Demonstration/Evaluation," June 12, 1995.
http://www.reliasoft.org/mil_std/mil_std_471a.pdf.
Superseded by MIL-HDBK-470A, "Designing and Developing Maintainable Products and Systems, Volume I and Volume II," August 4, 1997.
<http://assist.daps.dla.mil/docimages/0000/91/99/MAIN.PD5>

2.1.2.3 Military Standards (Inactive)

- MIL-STD-721C "Definitions of Terms for Reliability and Maintainability," Department of Defense, June 12, 1981.
http://www.reliasoft.org/mil_std/mil_std_721c.pdf
- MIL-STD-785B "Military Standard Reliability Program for Systems and Equipment Development and Production," Department of Defense, September 15, 1980.
http://www.reliasoft.org/mil_std/mil_std_785b.pdf
- MIL-STD-1843 USAF "Reliability-Centered Maintenance for Aircraft, Engines & Equipment," Department of Defense, August 9, 1995.
<http://www.mil-standards.com/Maintainability%20Standards.pdf>
- MIL-E-5007D "General Specification for Engines, Aircraft, Turbojet and Turbofan," October 15, 1973.
- NAVAIR 01-1A-32 "US Navy, Reliability Engineering Handbook," Department of Defense.

2.1.2.4 Other Military Standards

- ERDC99 Mission Rating Speed (MRS) and Terrain Definition Overview. ERDC, October 8, 1999.
<http://www.erd.usace.army.mil/>

2.1.3 Ministry of Defense Publications

The MoD publications are available via DSTAN the UK Defense Standardization at <http://www.dstan.mod.uk/>.

- Defense Standard 00-40 "Reliability and Maintainability Part 4 - Guidance for Writing NATO R&M Requirements Documents," Ministry of Defense, June 13, 2003.
<http://www.dstan.mod.uk/data/00/040/01000500.pdf>

2.1.4 NATO Publications

Available from Directorate of Standardization, Stan 2, Kentigern House, 65 Brown Street, GLASGOW G2 8EX, United Kingdom, or <http://www.nato.int/>.

- ARMP-7 NATO R&M Terminology Applicable to ARMPs, July 2001.
<http://www.nato.int/docu/stanag/arm7/arm7-e.pdf>

2.1.5 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO12207-ISO/IEC 12207 "Software Life Cycle Processes," August 1, 1995.

2.1.6 Government Organizations

SAND98-1189 A Survey of Probabilistic Methods Used in Reliability, Risk and Uncertainty Analysis: Analytical Techniques I.
<http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1998/981189.pdf>

NHB 5300.4(1G) NASA Assurance Terms and Definitions.
<http://ndeaa.jpl.nasa.gov/nasa-mp/backgrnd.htm>

2.1.7 Reliability and Maintainability Symposium (RAMS) Publications

RAMS hosts annual symposiums in the area of reliability and maintainability; proceedings can be ordered via:
<http://www.rams.org/proceedings/>.

HEALY97 Healy, J.D., "Basic Reliability," 1997 Annual Reliability and Maintainability Symposium.

2.1.8 AIAA Publications

Available from American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, Tel: 703-264-7500, www.aiaa.org.

ANSI/AIAA R-013 "Recommended Practice for Software Reliability," 1992.
<http://www.aiaa.org/content.cfm?pageid=313>

2.1.9 Other Publications

TAGU00 Taguchi, G., Subir, C. and Taguchi S., "Robust Engineering," New York: McGraw-Hill 2000.
<http://books.mcgraw-hill.com/>

STRU03 Strutt, J. and Hall, P., "Global Vehicle Reliability: Prediction and Optimization Techniques," Professional Engineering Publishers. ISBN: 1860583687. March 4, 2003.
<http://www.pepublishing.com/>

DSTO-TR-1306 Kappas, J., "Review of Risk and Reliability Methods for Aircraft Gas Turbine Engine," 2002.
<http://www.dsto.defence.gov.au/corporate/reports/DSTO-TR-1306.pdf>

BILL98 Billinton, R., "Diagnosing the Health of Engineering Systems," Quality and Reliability Engineering International, Volume 13, Issue 5, Pages 317-323. 4 Dec 1998.
<http://www3.interscience.wiley.com/cgi-bin/abstract/10704/ABSTRACT>

NARE70 Naresky, J., "Reliability Definitions," IEEE Transactions on Reliability. November 1970.

WATOG92 Ref. TL 552.A157, World Airlines Technical Operations Glossary, 1992.
<http://www.slu.edu/libraries/pius/resguides/aviation.html#Directhand>

3. APPROACH

3.1 Discussion of Data Base Generation

Existing military and commercial documents (see Section 2), both domestic and foreign, which contain RMS terms and definitions were reviewed. These terms and their definitions were extracted from the documents to form the total data base.

Several actions were then taken to refine the data base:

- a. Terms/definitions that were not applicable to RMS were removed.
- b. Terms that had similar definitions with a minor difference were combined.
- c. Terms that had multiple definitions were compared and reviewed with recommendations from project and committee members.
- d. In cases where a recommended term had multiple definitions, a preferred definition was selected.

The step-by-step approach to the selection and recommendation process is given in the next section.

3.2 Selection/Recommendation Process

3.2.1 Selection of Terms Applicable to RMS

Terms identified in the selected documents were reviewed for their applicability to the RMS fields and retained in the data base.

The criteria applied for retention in the data base of applicable terms are:

- a. Those with definitions specific to, or closely associated with, the RMS disciplines.
- b. Those whose definitions are needed to support or qualify the definitions of specific RMS terms.
- c. The following types of terms were excluded from the data base of applicable terms:
 1. Common engineering terms; i.e., fatigue, angle of incidence.
 2. Most statistical terms.
 3. Software reliability terms.

3.2.2 Selection of Recommended Terms

The list of applicable terms was then reviewed and those to be recommended by SAE members were noted. Criteria for selection included how necessary the term is in the quantification of RMS performance. Terms included in this document are generic. For any particular application, they may need to be tailored—for example, “mean time between failures” may be applied only to certain types of failure, as appropriate; these tailorings are not included.

3.2.3 Selection of Preferred Definitions

For many terms, more than one definition was found in the selected documents. In these instances, one definition was selected as the preferred definition if it met the following criteria:

- a. Clarity
- b. Completeness
- c. General application (generic)

Where equivalent definitions were found in more than one document, one of which being a military standard, the preferred definition was that contained in the military standard.

When only one definition was found for a term and that definition met the above criteria, then it was not reviewed further and was included in the database as preferred.

3.2.4 Consensus Process

The Terms and Definitions Project Clarification team consisted of five individuals that reviewed over 40 technical reports and standards which represent the military and commercial industry in the area of reliability and modeling.

The intent was to achieve a broad perspective for the recommendation of RMS terminology by condensing the current terms to a reasonable number (216). The reduction was accomplished by eliminating multiple definitions of the same term, removing terminology that is no longer used in the RMS community, and inserting immersing terminology.

Table 1

Term	Acronym	Definition	Formula	Reference
Accelerated Life Test	ALT	A test in which certain factors are increased or decreased beyond normal operating values to obtain observable deterioration in a reasonable period of time, and thereby afford some measure of the probable life under normal operating conditions or some measure of the durability of the equipment when exposed to the factors being aggravated.		MIL-STD-1309D
Accept Criteria		The limits for R&M parameters which will lead to an acceptance of tested items if the values measured during an R&M demonstration are within prescribed limits.		ARMP-7
Acceptance Tests	AT	The required formal tests conducted in accordance with approved test plans and procedures, and when required, witnessed by an authorized contacting agency representative, to demonstrate acceptability of an item for delivery and use by the intended party. They are intended to demonstrate conformance to operational and/or specification requirements and to act as a quality control screen to detect deficiencies of workmanship, material, processes, and quality.		NHB 5300.4(1G)
Accessibility		A measure of the relative ease of admission to the various areas of an item for the purpose of operation or maintenance.		ARMP-7 MIL-STD-721C
Active Time		That time during which an item is in an operational inventory.		MIL-STD-721C
Adaptive Importance Sampling		An adaptive method of calculating the sampling domain using the failure side of the system limit state surface constructed from the approximate parabolic surfaces, the most probable points, and the final sampling domain contains the system failure domain. NOTE: This is a complex concept. For more detailed information, further references should be sought.		AIR5083
Administrative Delay Time		Administrative delay: The accumulated time during which an action of corrective maintenance on a faulty item is not performed due to administrative reasons.		ARMP-7 MIL-STD-721C
Alert Time		That element of up-time during which an item is assumed to be in specified operating conditions, and is awaiting a command to perform its intended mission.		ARMP-7 MIL-STD-721C
Augmented Lagragian Method		A dual method which incorporates the concept of the penalty method to eliminate the limitations on the dual method. NOTE: This is a complex concept. For more detailed information, further references should be sought.		Defense Standard 00-40
Availability		The ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided. This is usually expressed as a percentage.	$MTBF/(MTBF + MTTR)$	ARMP-7 Defense Standard 00-40 MIL-STD-721C NHB 5300.4(1G)
Availability, Intrinsic		The probability that the system/equipment is operating satisfactorily at any point in time when used under stated conditions, where the time considered is operating time and repair time (active). Thus, intrinsic availability excludes from consideration all free time, storage time, administrative delay time and logistic delay time.	$A_i = MTBF/(MTBF + MART)$; MART is Mean Active Repair Time	ARMP-7 Defense Standard 00-40

Term	Acronym	Definition	Formula	Reference
Availability, Operational		The probability that an equipment/system at any instant in the required operating time will operate satisfactorily under stated conditions where the time considered includes operating, corrective and preventive maintenance, administrative delay time and logistic delay time.	$\text{Uptime}/(\text{Uptime}+\text{Downtime})$	ARMP-7 Defense Standard 00-40 NHB 5300.4(1G)
Axis-Orthogonal Simulation		A method for updating first-order reliability method/second-order reliability method results. NOTE: This is a complex concept. For more detailed information, further references should be sought.		AIR5083
Bayesian Approach		A method of statistical inference with a focus on subjective probability used primarily when limited data is available to determine the distribution of a system. NOTE: This is a complex concept. For more detailed information, further references should be sought.		AIR5083
Built-in Test Equipment	BITE	Any device permanently mounted in the equipment and used for the express purpose of testing the equipment, either independently or in association with external test equipment.		ARMP-7
Built-in Test	BIT	An integral capability of the equipment which provides an on-board test capability to detect, diagnose, or isolate system failures down to the LRU level, if possible. The fault detection and, possibly, isolation capability is used for periodic or continuous monitoring of a system's operational health, and for observation and, possibly, diagnosis as a prelude to maintenance action.		ARMP-7
Burn-in		The operation of an item to stabilize its characteristics. Primarily used with items where infant mortality is a significant failure mode. Basically, a reliability conditioning procedure which is a method of aging an item by operating it under specified environmental and test conditions in accordance with an established procedure in order to eliminate early failures and age or stabilize the item prior to final test and shipment.		ARMP-7
Calibrate		To determine and make required corrections in calibration standards or precision measuring equipment (PME). It consists of the comparison of two instruments, one of which is a certified calibration standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the other instrument or PME being compared with the certified calibration standard.		OPNAVINST 4790.2D
Common (Critical) Failure Mode		Failures of distinct components caused by a common initiating event.		ARMP-7
Concurrent Engineering		A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.		ARMP-7
Confidence Level		The probability that the value of a parameter falls within a specified range of values.		ARMP-7
Confidence Test		1. A test performed to provide a high degree of certainty that the unit under test (UUT) is operating acceptably. 2. A check of the performance of all test system stimulus and measurement functions, to detect degradation with respect to system specifications, and to inform the system operator.		MIL-STD-1309D
Configuration Control		The establishment of an agreed build standard for an item and the procedure for controlling change to that standard, in order that it may be defined at any time.		ARMP-7 NAVAIR 01-1A-32
Consumer's Risk		The probability of accepting equipment with a true mean time between failure (MTBF) equal to the lower test MTBF. The probability of accepting equipment with a true MTBF less than the lower test MTBF will be less than the consumer's.		ARMP-7