



# IEEE Standard Dictionary of Measures of the Software Aspects of Dependability

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**IEEE Computer Society**

Sponsored by the  
Software Engineering Standards Committee

982.1<sup>TM</sup>

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(Revision of  
IEEE Std 982.1-1988)



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**Software Engineering Standards Committee**  
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**IEEE Computer Society**

Approved 8 November 2005  
**IEEE-SA Standards Board**

**Abstract:** A standard dictionary of measures of the software aspects of dependability for assessing and predicting the reliability, maintainability, and availability of any software system; in particular, it applies to mission critical software systems.

**Keywords:** availability, dependability, maintainability, reliability

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## Introduction

This introduction is not part of IEEE Std 982.1-2005, IEEE Standard Dictionary of Measures of the Software Aspects of Dependability.

Rationale for revision: In accordance with Software Engineering Standards Committee (SESC) policy, the first standard (this document) is a small document with just a few core measures dealing with reliability, maintainability, and availability. This will be followed by a second standard that will address safety, confidentiality, and integrity.

This standard has not been revised since 1988. It was reaffirmed in 1996, but there were significant negative comments. It has been revised because many of the original measures had the following undesirable characteristics:

- Unrealistic (i.e., there was naivety about the necessary data, personnel capabilities, and training to effectively use the measures)
- Did not measure what they purported to measure
- Complex equations that were hard to understand and implement
- Immature (i.e., they were not widely used)
- Little field data to back up claims for benefits

## History

This standard is 15 years old, and additional information on the topic has been developed since that time. This project updated the standard to include such information and to expand the scope of the standard. Specifically, the following topics were included in the standard:

- a) Determined specific criteria for inclusion of measures in the standard
- b) Performed a measure-by-measure review of the measures in the standard, with the following goals:
  - 1) Determined whether the measure should be modified, retained, or deleted, based on the criteria. The modified and retained measures are identified in this standard by their numbers from the original IEEE 982.1 standard (i.e., IEEE 982 #X).
  - 2) Added any additional information on the measures developed since 1988.
  - 3) Clarified definition and implementation conventions.
  - 4) Identified and incorporated, where appropriate, new measures that have appeared since 1988.
  - 5) Formulated generic measure classes and categorized the measures into these classes. These classes are reliability, maintainability, and availability.

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At the time this standard was completed, the P982 Working Group had the following membership:

#### **Allen Nikora, *Chair***

Thomas Antczak  
William Everett  
William Farr

Jairus Hihn  
J. Dennis Lawrence  
John Munson

Norman Schneidewind  
George Stark  
Linda Wilbanks

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Richard Biehl  
Mitchell Bonnett  
Juris Borzovs  
Antonio M Cicu  
Rita Creel  
Geoffrey Darnton  
Einar Dragstedt  
Sourav Dutta  
John Emrich  
William Eventoff  
John Fendrich  
Yaacov Fenster

Jon Hagar  
John Harauz  
Mark Henley  
John Horch  
William Junk  
Ron Kenett  
Thomas M. Kurihara  
J. Dennis Lawrence  
Denis Meredith  
Rajesh Moorkath  
Lou Pinto  
Garry Roedler

Terence Rout  
James Ruggieri  
Robert Schaaf  
Hans Schaefer  
Robert W Shillato  
Mitchell Smith  
Joyce Statz  
Udo Voges  
Paul Wolfgang  
Oren Yuen  
Janusz Zalewski  
Charles Zumba

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William B. Hopf  
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Herman Koch  
Joseph L. Koepfinger\*  
David J. Law  
Daleep C. Mohla  
Paul Nikolich

T. W. Olsen  
Glenn Parsons  
Ronald C. Petersen  
Gary S. Robinson  
Frank Stone  
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Richard L. Townsend  
Joe D. Watson  
Howard L. Wolfman

\*Member Emeritus

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Satish K. Aggarwal, *NRC Representative*  
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Don Messina  
*IEEE Standards Project Editor*

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# IEEE Standard Dictionary of Measures of the Software Aspects of Dependability

## 1. Overview

### 1.1 General

This standard has the following clauses: Clause 1 provides the scope of this standard. Clause 2 provides a set of definitions. Clause 3 through Clause 5 specify new, modified, and existing measures for reliability, respectively. Clause 6 and Clause 7 specify new measures for maintainability and availability, respectively. In addition, there are three informative annexes. Annex A documents the process that was used to determine whether a measure in the existing standard should be modified, retained, or deleted; this annex states the criteria that were used to determine whether a measure should be included in the standard, including new measures. Annex B describes the *Software Reliability Engineering Case Study*, which provides a case study example of how to apply selected measures in Clause 3. Annex C is a glossary of terms taken from *The Authoritative Dictionary of IEEE Standards Terms* [B8].<sup>1</sup> Annex D is a bibliography that provides additional information about measures in Clause 3 through Clause 7. Table 1 summarizes the categories of measures. Numerical applications of the measures can be found in the reference(s) that are keyed to each measure.

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<sup>1</sup> The numbers in brackets correspond to those of the bibliography in Annex D.

**Table 1—Summary of measures**

| Identification                                 | Name                                                    |
|------------------------------------------------|---------------------------------------------------------|
| <b>Clause 3. New reliability measures</b>      |                                                         |
| 3.2                                            | Time to next failure (s)                                |
| 3.3                                            | Risk factor regression model                            |
| 3.4                                            | Remaining failures                                      |
| 3.5                                            | Total test time to achieve specified remaining failures |
| 3.6                                            | Network reliability                                     |
| <b>Clause 4. Modified reliability measures</b> |                                                         |
| 4.1                                            | Defect density (982 #2)                                 |
| 4.2                                            | Test coverage index (982 #5)                            |
| 4.3                                            | Requirements compliance (982 #23)                       |
| 4.4                                            | Failure rate (982 #31)                                  |
| <b>Clause 5. Retained reliability measures</b> |                                                         |
| 5.1                                            | Fault density (982 #1)                                  |
| 5.2                                            | Requirements traceability (982 #7)                      |
| 5.3                                            | Mean time to failure (MTTF) (982 #30)                   |
| <b>Clause 6. New maintainability measures</b>  |                                                         |
| 6.1                                            | Mean time to repair                                     |
| 6.2                                            | Network maintainability                                 |
| <b>Clause 7. New availability measures</b>     |                                                         |
| 7.1                                            | Availability                                            |
| 7.2                                            | Network availability                                    |

## 1.2 Scope

This standard specifies and classifies measures of the software aspects of dependability. It is an expansion of the scope of the existing standard; the revision includes the following aspects of dependability: reliability, availability, and maintainability of software. The applicability of this standard is any software system; in particular, it applies to mission critical systems, where high reliability, availability, and maintainability are of utmost importance. These systems include, but are not limited to, systems for military combat, space missions, air traffic control, network operations, stock exchanges, automatic teller machines, and airline reservation systems.

## 1.3 Purpose

This standard provides measures that are applicable for continual self-assessment and improvement of the software aspects of dependability.

## 1.4 Compliance

An application of the measures specified herein complies with this standard if Clause 2 through Clause 7 are implemented, with the exception of subclauses identified as either “Experience” and “Tools”. These subclauses are intended to (1) provide information about application domains for a given measure and (2) identify the types of tools appropriate for computing that measure.

## 1.5 Interaction with other standards

The measures defined in this dictionary may provide information that can help support certain evaluations discussed in other IEEE Software Engineering Standards. The following list is meant to be suggestive:

IEEE/EIA Std 12207.0

Subclause 6.4.2 of IEEE/EIA Std 12207.0 lists verification tasks, and 6.5 lists validation tasks. Dependability measures may provide useful quantitative information that will help satisfy these tasks. For example, in 6.4.2.5, one criterion states (among other requirements) that “the code implements ... correct data and control flow.”<sup>1</sup>

IEEE Std 1074<sup>TM</sup>

Subclause A.5.1 discusses evaluation activities, including reviews, traceability, testing, and reporting evaluation results. Dependability measures can provide useful quantitative information that can be used to assist these activities.<sup>2, 3</sup>

IEEE Std 1012<sup>TM</sup>

This standard lists verification and validation tasks, inputs, and outputs in Table 1. The dependability measures provided in this standard can provide useful quantitative information that can assist many of the tasks listed in this table.

## 2. Definitions

For the purposes of this document, the following terms and definitions apply. The glossary in Annex C and *The Authoritative Dictionary of IEEE Standards Terms* [B8] should be referenced for terms not defined in this clause.

**2.1 defect:** A generic term that can refer to either a fault (cause) or a failure (effect). (adapted from Lyu [B12])

**2.2 dependability:** Trustworthiness of a computer system such that reliance can be justifiably placed on the service it delivers. Reliability, availability, and maintainability are aspects of dependability. (adapted from Lyu [B12])

**2.3 maintainability:** Speed and ease with which a program can be corrected or changed. (adapted from Musa [B14])

**2.4 measure (noun):** (A) The number or symbol assigned to an entity by a mapping from the empirical world to the formal, relational world in order to characterize an attribute. (adapted from Fenton and Pfleeger [B5]) (B) The act or process of measuring. (adapted from *Webster's New Collegiate Dictionary* [B23])

**2.5 measure (verb):** To make a measurement. (adapted from *Webster's New Collegiate Dictionary* [B23])

**2.6 time:** In decreasing order of resolution, CPU execution time, elapsed time (i.e., wall clock time), or calendar time. (adapted from Musa [B14])

<sup>1</sup> EIA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

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### 3. New reliability measures

#### 3.1 General

The software reliability model specified in this clause (Schneidewind [B20]) is one of the four models recommended in ANSI R-013-1992 [B1]. See this reference for the other three recommended models that could be used in place of the specified model.

#### 3.2 Time to next failure (s) (Lyu [B12])

##### 3.2.1 Definition

$T_F(t)$  is the predicted time for the next  $F_t$  failures to occur, when the current time is  $t$ .

$$T_F(t) = [(\log[\alpha / (\alpha - \beta(X_{s,t} + F_t))]) / \beta] - (t - s + 1)$$

##### 3.2.2 Variables

$T_F(t)$  is the predicted time for the next  $F_t$  failures to occur, when the current time is  $t$ .

$X_{s,t}$  is the observed failure count in the range  $[s, t]$ .

$T$  is the test or operational time interval when *time to next failure* prediction is made.

##### 3.2.3 Parameters

$\alpha$  is the failure rate at the beginning of interval  $s$ .

$\beta$  is the negative of derivative of failure rate divided by failure rate.

$F_t$  is the given number of failures to occur after interval  $t$ .

$s$  is the starting interval for using observed failure data in parameter estimation.

$t_m$  is the mission duration.

##### 3.2.4 Application

Given a mission duration requirement  $t_m$  and number of failures  $F_t$ , a prediction is made at time  $t$  to see whether  $T_F(t) > t_m$ .

##### 3.2.5 Data requirements

Failure counts by time interval, in the range  $[1, t]$ , where time can be execution time, clock time, or calendar time, for estimating  $\alpha$ ,  $\beta$ , and  $s$ , and for obtaining  $X_{s,t}$ .

##### 3.2.6 Units of measurement

$T_F(t)$ ,  $t$ ,  $t_m$  is the seconds, minutes, hours, and so on, as appropriate.

$F_t$  is the number of failures.