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IEEE Recommended Practice on Software Reliability

IEEE Reliability Society

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USA

IEEE Std 1633™-2016
(Revision of IEEE Std 1633-2008)

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Abstract: The methods for assessing and predicting the reliability of software, based on a life-cycle approach to software reliability engineering (SRE), are prescribed in this recommended practice. It provides information necessary for the application of software reliability (SR) measurement to a project, lays a foundation for building consistent methods, and establishes the basic principle for collecting the data needed to assess and predict the reliability of software. The recommended practice prescribes how any user can participate in SR assessments and predictions.

Keywords: IEEE 1633™, software failure modes, software reliability

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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Introduction

This introduction is not part of IEEE Std 1633-2016, IEEE Recommended Practice on Software Reliability.

Software is, from a materials viewpoint, both malleable and ductile. This means there are multiple ways to introduce failures, intentional and un-intentional. Fixing a software defect can introduce a potential defect. In many cases the failures that result from software defects are both predictable and avoidable but they still occur because of the following:

a) Lack of available calendar time/resources to find all of the defects that can result in failures

b) Exceedingly complex event driven systems that are difficult to conceptualize and therefore implement and test

c) Organizational culture that neglects to support sufficient rigor, skills, or methods required to find the defects

d) Technical decisions that result in incorrect architecture or design decision that cannot support the stakeholders specifications

e) Insufficient project or risk management that leads to schedule delays that lead to less time for reliability testing

f) Operations—Contract issues, interoperability due to bad specifications and stakeholder communications

Even a small number of software failures can lead to monetary catastrophes such as a cancelled project. Hardware (HW) failures can be random, due to wear-out or the result of a systematic design flaw. Reliability maintainability availability (RMA) is used to prevent and deal with hardware failures. Software failures may result from systematic flaws in the requirements, design, code or interfaces. Hence, software failure does not require an RMA but instead a corrective action to an existing installation. Software failures can be common cause failures in that the same failure mode can cause multiple failures in more than one part of the software.

Software reliability engineering (SRE) is an established discipline that can help organizations improve the reliability of their products and processes. It is important for an organization to have a process discipline if it is to produce high reliability software. These are specific practices and recommendations, each of which has a context within the software engineering life cycle. A specific practice may be implemented or used in a particular stage of the life cycle or used across several stages. Figure 1 shows how the focus of SRE shifts as a project progresses from inception to release. The size of each bubble on this figure corresponds to how much the particular SRE practices are being executed during each particular phase of development or operation. For example in software engineering projects, the failure modes and effects analysis (FMEA) is typically performed earlier in the life cycle.

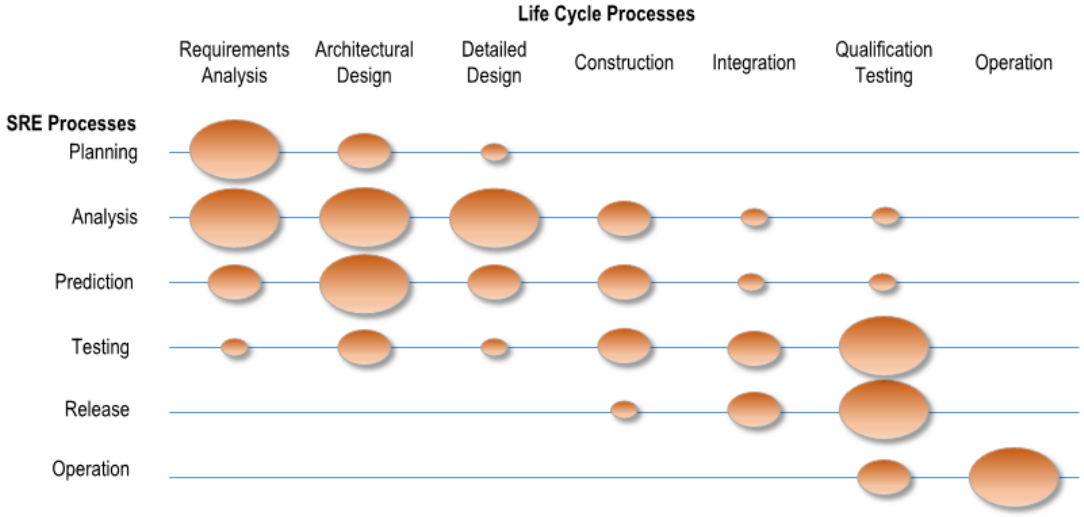

Figure 1—SRE focus by stage

The scope of this recommended practice is to address software reliability (SR). It does not specifically address systems reliability, software safety, or software security. However, it does recognize that safety and security requirements are part of the initial risk assessment. The recommended practice only briefly addresses software quality. This recommended practice provides a common baseline for discussion and prescribes methods for assessing and predicting the reliability of software. The recommended practice is intended to be used in support of designing, developing, and testing software and to provide a foundation on which practitioners can build consistent methods for assessing the reliability of software. It is intended to meet the needs of software practitioners and users who are confronted with varying terminology for reliability measurement and a plethora of models and data collection methods. This recommended practice contains information necessary for the application of SR measurement to a project. This includes SR activities throughout the software life cycle (SLC) starting at requirements generation by identifying the application, specifying and analyzing requirements, and continuing into the implementation.

This standard includes guidance on the following:

- Common terminology
- Assessment of software reliability risks that pertain to the software or project
- Software failure mode analyses that can help to identify and reduce the types of defects most likely to result in a system failure
- Models for predicting software reliability early in development
- Models for estimating software reliability in testing and operation
- Test coverage and test selection
- Data collection procedures to support SR estimation and prediction
- Determining when to release a software system, or to stop testing the software and implement corrections
- Identifying elements in a software system that are leading candidates for redesign to improve reliability

Revisions to the document and notes

- This document is a revision of IEEE Std 1633-2008.
- Addition of models that can be used early in development, before testing, to predict software reliability
- Addition of failure modes analysis
- Revision of the software reliability growth models so as to be more practical
- Addition of practical guidance for selecting the best models
- Addition of techniques for applying SRE in incremental development
- Addition of methods to assess the SRE related risks

Structure of the recommended practice

This recommended practice contains six clauses and seven annexes as follows:

- Clause 1 provides the overview.
- Clause 2 provides the normative references.
- Clause 3 provides the definitions, acronyms, and abbreviations
- Clause 4 provides the roles, approaches, and concepts related to SRE.
- Clause 5 provides the SRE procedures.
- Clause 6 provides the predictive and estimation SRE models.
- Annex A contains software failure modes effects analysis (SFMEA) templates.
- Annex B provides methods for predicting EKSLOC (Effective 1000 Source Lines of Code), which is necessary for the reliability predictions as well as for models that predict software defect density and defects prior to the testing phase.
- Annex C provides additional software reliability growth models and provides the results of a survey of most used software reliability growth models.
- Annex D provides the estimated cost of the SRE tasks.
- Annex E contains a list of tools that pertain to SRE tasks.
- Annex F contains examples.
- Annex G contains an informative Bibliography.

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Contents

IEEE Recommended Practice on Software Reliability

1. Overview

1.1 Scope

This recommended practice defines the software reliability engineering (SRE) processes, prediction models, growth models, tools, and practices of an organization. This document and its models and tools are useful to any development organization to identify the methods, equations, and criteria for quantitatively assessing the reliability of a software or firmware subsystem or product. Organizations that acquire software subsystems or products developed with consideration to this recommended practice will benefit by knowing the reliability of the software prior to acquisition. This document does not seek to certify either the software or firmware or the processes employed for developing the software or firmware.

1.2 Purpose

The purpose for assessing the reliability of a software or firmware subsystem or product is to determine whether the software has met an established reliability objective and facilitate improvement of product reliability. The document defines the recommended practices for predicting software reliability (SR) early in development so as to facilitate planning, sensitivity analysis and trade-offs. This document also defines the recommended practices for estimating SR during test and operation so as to establish whether the software or firmware meets an established objective for reliability.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 12207™-2008, ISO/IEC/IEEE Standard for Systems and Software Engineering—Software Life Cycle Processes.[1, 2]

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