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(Revision of
IEEE Std 1012-1998)

1012™

IEEE Standard for Software Verification and Validation

IEEE Computer Society

Sponsored by the
Software Engineering Standards Committee

IEEE

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Abstract: Software verification and validation (V&V) processes determine whether the development products of a given activity conform to the requirements of that activity and whether the software satisfies its intended use and user needs. Software V&V life cycle process requirements are specified for different software integrity levels. The scope of V&V processes encompasses software-based systems, computer software, hardware, and interfaces. This standard applies to software being developed, maintained, or reused [legacy, commercial off-the-shelf (COTS), non-developmental items]. The term software also includes firmware, microcode, and documentation. Software V&V processes include analysis, evaluation, review, inspection, assessment, and testing of software products.
Keywords: IV&V, software integrity level, software life cycle, V&V, validation, verification

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Introduction

This introduction is not part of IEEE Std 1012-2004, IEEE Standard for Software Verification and Validation.

Software verification and validation (V&V) is a technical discipline of systems engineering. The purpose of software V&V is to help the development organization build quality into the software during the software life cycle. V&V processes provide an objective assessment of software products and processes throughout the software life cycle. This assessment demonstrates whether the software requirements and system requirements (i.e., those allocated to software) are correct, complete, accurate, consistent, and testable. The software V&V processes determine whether the development products of a given activity conform to the requirements of that activity and whether the software satisfies its intended use and user needs. The determination includes assessment, analysis, evaluation, review, inspection, and testing of software products and processes. Software V&V is performed in parallel with software development, not at the conclusion of the development effort.

Software V&V is an extension of program management and systems engineering that employs a rigorous methodology to identify objective data and conclusions to provide feedback about software quality, performance, and schedule to the development organization. This feedback consists of anomaly resolutions, performance improvements, and quality improvements not only for expected operating conditions, but also across the full spectrum of the system and its interfaces. Early feedback results allow the development organization to modify the software products in a timely fashion and thereby reduce overall project and schedule impacts. Without a proactive approach, anomalies and associated software system changes are typically delayed to later in the program schedule, resulting in greater program costs and schedule delays.

IEEE Std 1012-2004 is a process standard that defines the V&V processes in terms of specific activities and related tasks. The standard also defines the contents of the *software v&v plan* (SVVP), including an example format.

This version of the standard contains minor changes to IEEE Std 1012-1998. Following is a summary:

a) Revised Clause 1 to conform to IEEE style and
   1) Moved the description of the verification process and validation process from 1.3 to 1.1.
   2) Expanded 1.2 to discuss the importance of performing the software V&V from a systems perspective—software and its interaction with the system of which it is a part.
b) Moved Figure 3 into the definition of V&V effort (see 3.1.37) with no figure reference.
c) Clarified Clause 4 concept of software integrity and selection of software integrity levels.
d) Revised Clause 6 to contain all of the normative documentation requirements (see 6.1) that were in Clause 7.
e) Revised Clause 7 to consolidate IEEE 1012A™-1998 [B6] into the revision of this standard.
f) Revised Table 1 as follows:
   1) Added “security analysis” to the required V&V tasks.
   2) Reformatted test tasks to uniquely identify requirements for each test type—no normative changes were made to the test tasks.
   3) Added a subtask to the “scoping of V&V” in the Acquisition support V&V activity to determine the extent of V&V on reused software.
   4) Corrected previous editorial errors.
g) Added mapping of IEEE 1012 tasks to CMMI Engineering Process Groups in Annex A.
h) Added a definition of integrated independent V&V (IV&V) to Annex C.
i) Clarified treatment of reuse software in Annex D.
j) Added sample measures to Annex E.
k) Removed Annex I and moved the definitions into 3.1.

The following key concepts are emphasized in this standard:

— *Software integrity levels.* Defines four software integrity levels to describe the importance of the software, varying from high integrity to low integrity, to the user.

— *Minimum V&V tasks for each software integrity level.* Defines the minimum V&V tasks required for each of the four software integrity levels. Includes a table of optional V&V tasks for tailoring the V&V effort to address project needs and application specific characteristics.

— *Intensity and rigor applied to V&V tasks.* Introduces the notion that the intensity and rigor applied to the V&V tasks vary according to the software integrity level. Higher software integrity levels require the application of greater intensity and rigor to the V&V task. Intensity includes greater scope of analysis across all normal and abnormal system operating conditions. Rigor includes more formal techniques and recording procedures.

— *Detailed criteria for V&V tasks.* Defines specific criteria for each V&V task, including minimum criteria for correctness, consistency, completeness, accuracy, readability, and testability. The V&V task descriptions include a list of the required task inputs and outputs.

— *Systems viewpoints.* Includes minimum V&V tasks to address system issues. These tasks include hazard analysis, security analysis, risk analysis, migration assessment, and retirement assessment. Specific system issues are contained in individual V&V task criteria.

— *Conformance to international and IEEE standards.* Defines the V&V processes to conform to life cycle process standards such as ISO/IEC Std 12207:1995 [B13], IEEE Std 1074™-1997 [B10], and IEEE/EIA Std 12207.0™-1996 [B12], as well as the entire family of IEEE software engineering standards. This standard addresses the full software life cycle processes, including acquisition, supply, development, operation, and maintenance. This standard is compatible with all life cycle models; however, not all life cycle models use all of the life cycle processes described in this standard.

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IEEE Standards Project Editor

Contents

IEEE Standard for Software Verification and Validation

1. Overview

This verification and validation (V&V) standard is a process standard that addresses all software life cycle processes including acquisition, supply, development, operation, and maintenance. This standard is compatible with all life cycle models; however, not all life cycle models use all of the life cycle processes listed in this standard.

Software V&V processes determine whether the development products of a given activity conform to the requirements of that activity and whether the software satisfies its intended use and user needs. This determination may include analysis, evaluation, review, inspection, assessment, and testing of software products and processes.

The user of this standard may invoke those software life cycle processes and the associated V&V processes that apply to the project. A description of software life cycle processes may be found in ISO/IEC 12207:1995 [B13],[1] IEEE Std 1074™-1997 [B10], and IEEE/EIA Std 12207.0™-1996 [B12]. Annex A maps ISO/IEC 12207:1995 [B13] (Table A.1.1) and IEEE Std 1074-1997 [B10] (Table A.2.1) to the V&V activities and tasks defined in this standard.

1.1 Scope

This standard applies to software being acquired, developed, maintained, or reused [legacy, modified, commercial off-the-shelf (COTS), non-developmental items (NDI)]. The term software also includes firmware, microcode, and documentation.

Software V&V processes consist of the verification process and validation process. The verification process provides objective evidence whether the software and its associated products and processes

a) Conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance)

b) Satisfy standards, practices, and conventions during life cycle processes

c) Successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities (e.g., building the software correctly)

[1]The numbers in brackets correspond to those of the bibliography in Annex H.

The validation process provides evidence whether the software and its associated products and processes

1) Satisfy system requirements allocated to software at the end of each life cycle activity
2) Solve the right problem (e.g., correctly model physical laws, implement business rules, use the proper system assumptions)
3) Satisfy intended use and user needs

The verification process and the validation process are interrelated and complementary processes that use each other's process results to establish better completion criteria and analysis, evaluation, review, inspection, assessment, and test V&V tasks for each software life cycle activity. The V&V task criteria described in Table 1 uniquely define the conformance requirements for V&V processes.

The development of a reasonable body of evidence requires a trade-off between the amount of time spent and a finite set of system conditions and assumptions against which to perform the V&V tasks. Each project should define criteria for a reasonable body of evidence (i.e., selecting a software integrity level establishes one of the basic parameters), time schedule, and scope of the V&V analysis and test tasks (i.e., range of system conditions and assumptions).

This standard does not assign the responsibility for performing the V&V tasks to any specific organization. The analysis, evaluation, and test activities may be performed by multiple organizations; however, the methods and purpose will differ for each organization's functional objectives.

ISO/IEC 12207:1995 [B13] or IEEE/EIA 12207.0-1996 [B12] require that the developer perform various testing and evaluation tasks as an integral part of the development process. Even though the tests and evaluations are not part of the V&V processes, the techniques described in this standard may be useful in performing them. Therefore, whenever this standard mentions the developer's performance of a verification or validation activity, it is to be understood that the reference applies to the integral test and evaluation tasks of the development process.

1.2 Purpose

The purpose of this standard is to

— Establish a common framework for V&V processes, activities, and tasks in support of all software life cycle processes, including acquisition, supply, development, operation, and maintenance processes
— Define the V&V tasks, required inputs, and required outputs
— Identify the minimum V&V tasks corresponding to a four-level software integrity scheme
— Define the content of a *software V&V plan* (SVVP)

1.3 Field of application

This standard applies to all applications of software. When conducting the software V&V process, it is important to examine the software in its interactions with the system of which it is a part. This standard identifies the important system considerations that software V&V processes and tasks address in determining software correctness and other software V&V attributes (e.g., completeness, accuracy, consistency, testability).

The dynamics of software and the multitude of different logic paths available within software in response to varying system stimuli and conditions demand that the software V&V effort examine the correctness of the code for each possible variation in system conditions. The ability to model complex real world conditions will be limited, and thus the software V&V effort must examine whether the limits of the modeling are realistic and reasonable for the desired solution. The unlimited combination of system conditions presents

