

IEEE Standard for System and Software Verification and Validation

IEEE Computer Society

Sponsored by the
Software & Systems Engineering Standards Committee (C/S2ESC)

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1012™-2012
(Revision of
IEEE Std 1012-2004)

25 May 2012

Currently in preview, click buy full version

IEEE Std 1012™-2012

(Revision of
IEEE Std 1012-2004)

IEEE Standard for System and Software Verification and Validation

Sponsor

Software & Systems Engineering Standards Committee (C/S2ESC)

of the

IEEE Computer Society

Approved 29 March 2012

IEEE-SA Standards Board

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

Keywords: environmental verification and validation (V&V) factors, hardware V&V, IEEE 1012, integrity level, independent V&V (IV&V), risk/hazard/security analyses, software life cycle, software V&V, system life cycle, system V&V, V&V, V&V measures, V&V of reuse software

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

Copyright © 2012 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 25 May 2012. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-0-7381-7268-2 STD97243
Print: ISBN 978-0-7381-7374-0 STDPD97243

IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.
No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Notice and Disclaimer of Liability Concerning the Use of IEEE Documents: IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon any IEEE Standard document.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied "AS IS."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE standard is subjected to review at least every ten years. If a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Translations: The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official Statements: A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At conferences, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on Standards: Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important to ensure that any response to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. Any person who would like to participate in evaluating comments or revisions to an IEEE standard is welcome to join the relevant IEEE working group at <http://standards.ieee.org/develop/wg/>.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

Photocopies: Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Notice to users

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at <http://standards.ieee.org/index.html> or contact the IEEE at the address listed previously. For more information about the IEEE Standards Association or the IEEE standards development process, visit IEEE-SA Website at <http://standards.ieee.org/index.html>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/findstd/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patent Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this standard was submitted to the IEEE-SA Standards Board for approval, the Std for Software Verification and Validation Working Group (C/S2ESC/1012_WG) Working Group had the following membership:

Roger U. Fujii, *Chair*
Kenneth A. Costello, *Vice Chair*
Edward A. Addy, *Secretary*

Stephen Allott
Susan M. Burgess
Tiffany Burgess
William Burgess
Milton Concepcion
Darrell Cooksey
Paul D. Croll
David H. Daniel
Taz Daughtrey
Jon Davis
Ronald Dean
Josiah Devasirvatham
Harpal Dhama
Stephen Driskell
Christof Ebert

Uma Ferrell
Kevin R. Finlay
Eva Freund
Ron Greenthaler
Jon D. Hagar
George Hughes
Lisa A. Jensen
Lance Kelson
Thomas M. Kurihara
Carol Long
Charles R. Martin
Dan McCaugherty
Robert R. Moniri
James W. Moore
Kevin Morgam

Jeff Northey
Nitin Patel
Robert A. Peterson
Michael D. Prendergast
Laura Pullum
Steven R. Rakitin
Scott W. Schield
Raymond Senechal
Luca Sporno
Eric Sylvan
Gina T...
Jasso Von Bredow
Michael E. Waterman
Kurt Woodham
Steve Yang

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

Edward A. Addy
Johann Amsenga
T. Ankrum
Chris Bagge
Charles Barest
H. Stephen Berger
Juris Borzovs
Pieter Botman
Susan M. Burgess
Mark Bushnell
Juan Carreon
Sue Carroll
Lawrence Catchpole
Keith Chow
Darrell Cooksey
Kenneth A. Costello
Paul D. Croll
David H. Daniel
Geoffrey Darnton
Jonathan Dean
Josiah Devasirvatham
Thomas Dineen
Randall Dotson
Sourav Dutta
Andrew Fieldsend
Gregory Fleming
Andre Fournier
Eva Freund
David Friscia

Roger U. Fujii
David Fusch
Lewis Gra...
Ron Greenthaler
J. Gregory
Daniel Groves
Jon D. Hagar
John Harauz
Mark Henley
David Herrell
Rutger A. Heunks
Frank Hill
Werner Hoelzl
George Hughes
Peter Hung
Noriyuki Ikeuchi
Atsushi Ito
Mark Jaeger
Cheryl Jones
Anatol Kark
Piotr Karocki
Yuri Khersonsky
Dwayne Knirk
Thomas M. Kurihara
George Kyle
Susan Land
Claude Laporte
J. Dennis Lawrence
David Leciston

Daniel Lindberg
Vincent Lipsio
Greg Luri
Wayne W. Manges
Edward McCall
Dan McCaugherty
Robert R. Moniri
James W. Moore
Michael S. Newman
Warren Odess-Gillett
Robert A. Peterson
William Petit
Michael D. Prendergast
Julian Profir
Laura Pullum
Steven Rakitin
Annette Reilly
Robert Robinson
Keith Roseberry
Terence Rout
Randall Safier
Bartien Sayogo
Robert Schaff
Hans Schaefer
Scott W. Schield
David Schultz
Stephen Schwarm
Raymond Senechal
John Short

Gil Shultz
Carl Singer
James Sivak
Michael Smith
Kapil Sood
Luca Spotorno
Friedrich Stallinger
Thomas Starai
Walter Strupler

Gerald Stueve
Marcy Stutzman
Steven Tilden
Thomas Tullia
Vincent Tume
Mark-Rene Uchida
John Vergis
David Walden

Charlene Walrad
John Walz
Michael E. Waterman
Stephen Webb
Simone Youngblood
Jian Yu
Oren Yuen
Janusz Zalewski
Daidi Zhong

When the IEEE-SA Standards Board approved this standard on 29 March 2012, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert Grow, *Past Chair*
Judith Gorman, *Secretary*

Satish Aggarwal
Masayuki Ariyoshi
Peter Balma
William Bartley
Ted Burse
Clint Chaplin
Wael Diab
Jean-Philippe Faure

Alexander Gelman
Paul Houz e
Jim Hughes
Young Kyun Kim
Joseph L. Koepfinger*
David J. Law
Thomas Lee
Hung Ling

Oleg Logvinov
Ted Olsen
George Robison
John Walter Rosdahl
Mark Seavey
Yatin Trivedi
Phil Winston
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DCE Representative*
Michael Januszko, *VIST Representative*

Don Messina
IEEE Standards Program Manager, Document Development

Malia Zaman
IEEE Standards Program Manager, Technical Program Development

Introduction

This introduction is not part of IEEE Std 1012-2012, IEEE Standard for System and Software Verification and Validation.

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

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 quality, performance, and schedule to the supplier. 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 products in a timely fashion and thereby reduce overall project and schedule impact. Without a proactive approach, the anomalies and associated system changes are typically detected later in the program schedule, resulting in greater program costs and schedule delays.

IEEE Std 1012™-2012 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 V&V plan (VVP), including example formats.

V&V may be performed at the level of the system, software element, or hardware element, or on any combination of these. V&V may also be performed on an element of a system, including a subordinate system (i.e., subsystem). Throughout this standard, the term *hardware* means an electronic or mechanical hardware element. In each case, the V&V processes are invoked, either in parallel or recursively, across the full life cycle of the system or element.

This version of the standard is a major revision to IEEE Std 1012™-2004 [B5].^a The earliest version of this standard (1986) described the content of a software V&V plan, with subsequent versions (1998 and 2004) changing the focus from the software V&V plan to software V&V processes. This revision expands the scope of the V&V processes to include systems and hardware as well as software. It also aligns the terminology and structure to be consistent with ISO/IEC 15288:2008 [B16] and ISO/IEC 12207:2008 [B11]. The following is a summary of the changes made in this version:

- a) No new software V&V activities or tasks have been added, and the use of IEEE Std 1012-2004 [B5] is consistent with the software V&V clauses of this standard. Some software V&V activities and tasks have been rearranged to facilitate the understanding and ease of use.
- b) System V&V activities and tasks and hardware V&V activities and tasks were added to the existing software V&V standard.
- c) The standard was restructured to allow for the performance of system, software, and hardware V&V individually or in any combination. The standard contains separate clauses that address common, system, software, and hardware V&V activities.
- d) The terminology, structure, and mappings were revised to be consistent with ISO/IEC 12207:2008 [B11]. The new system V&V terminology, structure, and mappings are consistent with ISO/IEC 15288:2008 [B16].

^a The numbers in brackets correspond to those of the bibliography in Annex M.

The following key concepts are emphasized in this standard:

- *Integrity levels.* Defines four integrity levels to describe the importance of the system, software, and hardware, varying from high integrity to low integrity, to the user.
- *Minimum V&V tasks for each integrity level.* Defines the minimum V&V tasks required for each of the four integrity levels. Includes a table of optional V&V tasks for tailoring the V&V effort to address the project needs and application-specific characteristics.
- *Intensity and rigor applied to V&V tasks.* Includes the concept that the intensity and rigor applied to the V&V tasks vary according to the integrity level. Higher integrity levels require the application of greater intensity and rigor to the V&V task. Intensity includes a 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 software and hardware 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 15288:2008 [B16], IEEE Std 1074™-2006 [B9], and ISO/IEC 12207:2008 [B11], as well as the entire family of IEEE software engineering standards. This standard addresses all system and software life cycle processes, including the Agreement, Organizational Project-Enabling, Project, Technical, Software Implementation, Software Support, and Software Reuse process groups. 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.

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	2
1.3 Field of application	3
1.4 V&V objectives	4
1.5 Organization of the standard	4
1.6 Audience	6
1.7 Conformance	7
1.8 Disclaimer	7
2. Normative references	7
3. Definitions, abbreviations, and acronyms	7
3.1 Definitions	7
3.2 Abbreviations and acronyms	11
4. Relationships between V&V and life cycle processes	12
5. Integrity levels	15
6. V&V processes overview	17
6.1 General	17
6.2 V&V testing	18
7. Common V&V activities	19
7.1 Activity: V&V Management	19
7.2 Activity: Acquisition Support V&V	20
7.3 Activity: Supply Planning V&V	21
7.4 Activity: Project Planning V&V	21
7.5 Activity: Configuration Management V&V	21
8. System V&V activities	33
8.1 Activity: Stakeholder Requirements Definition V&V	33
8.2 Activity: Requirements Analysis V&V	33
8.3 Activity: Architectural Design V&V	34
8.4 Activity: Implementation V&V	35
8.5 Activity: Integration V&V	35
8.6 Activity: Transition V&V	36
8.7 Activity: Operation V&V	36
8.8 Activity: Maintenance V&V	37
8.9 Activity: Disposal V&V	38
9. Software V&V activities	68
9.1 Activity: Software Concept V&V	68
9.2 Activity: Software Requirements V&V	68
9.3 Activity: Software Design V&V	69
9.4 Activity: Software Construction V&V	69
9.5 Activity: Software Integration Test V&V	70
9.6 Activity: Software Qualification Test V&V	70
9.7 Activity: Software Acceptance Test V&V	71
9.8 Activity: Software Installation and Checkout V&V	71
9.9 Activity: Software Operation V&V	72

9.10 Activity: Software Maintenance V&V	72
9.11 Activity: Software Disposal V&V	73
10. Hardware V&V activities	110
10.1 Activity: Hardware Concept V&V	110
10.2 Activity: Hardware Requirements V&V	110
10.3 Activity: Hardware Design V&V	111
10.4 Activity: Hardware Fabrication V&V	111
10.5 Activity: Hardware Integration Test V&V	112
10.6 Activity: Hardware Qualification Test V&V	112
10.7 Activity: Hardware Acceptance Test V&V	113
10.8 Activity: Hardware Transition V&V	113
10.9 Activity: Hardware Operation V&V	114
10.10 Activity: Hardware Maintenance V&V	114
10.11 Activity: Hardware Disposal V&V	115
11. V&V reporting, administrative, and documentation requirements	147
11.1 V&V reporting requirements	147
11.2 V&V administrative requirements	150
11.3 V&V documentation requirements	150
12. V&V plan outline	151
12.1 Overview	151
12.2 VVP Section 1: Purpose	152
12.3 VVP Section 2: Referenced documents	152
12.4 VVP Section 3: Definitions	152
12.5 VVP Section 4: V&V overview	152
12.6 VVP Section 5: V&V processes	154
12.7 VVP Section 6: V&V reporting requirements	154
12.8 VVP Section 7: V&V administrative requirements	154
12.9 VVP Section 8: V&V test documentation requirements	155
Annex A (informative) Mapping of IEEE 1012 V&V activities and tasks	156
Annex B (informative) A risk-based, integrity-level scheme	163
Annex C (informative) Definition of independent V&V (IV&V)	165
Annex D (informative) V&V of reuse software	168
Annex E (informative) V&V measures	175
Annex F (informative) Example of V&V relationships to other project responsibilities	178
Annex G (informative) Optional V&V tasks	179
Annex H (informative) Environmental factors considerations	185
Annex I (informative) V&V of system, software, and hardware integration	188
Annex J (informative) Hazard, security, and risk analyses	193

Annex K (informative) Example of assigning and changing the system integrity level of “supporting system functions”	198
Annex L (informative) Mapping of ISO/IEC/IEEE 15288 and IEEE 12207 process outcomes to V&V tasks	200
Annex M (informative) Bibliography.....	209

IEEE Standard for System and Software Verification and Validation

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

1. Overview

1.1 Scope

This verification and validation (V&V) standard is a process standard that addresses all system and software life cycle processes including the Agreement, Organizational Project-Enabling, Project, Technical, Software Implementation, Software Support, and Software Reuse process groups. This standard is compatible with all life cycle models (e.g., system, software, and hardware); however, not all life cycle models use all of the processes listed in this standard.

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

The user of this standard may invoke those life cycle processes and the associated V&V processes that apply to the project. A description of system life cycle processes may be found in ISO/IEC 15288:2008 [B16],¹ and a description of software life cycle processes may be found in ISO/IEC 12207:2008 [B11] and IEEE Std 1074™-2006 [B9]. Annex A maps ISO/IEC 15288:2008(E) [B16] (Table A.1 and Table A.2) and ISO/IEC 12207:2008 [B11] (Table A.3 and Table A.4) to the V&V activities and tasks defined in this standard.

¹ The numbers in brackets correspond to those of the bibliography in Annex M.