

Recent trends on Software Verification and Validation Testing

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1. Introduction

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 processes include the analysis, evaluation, review, inspection, assessment, and testing of products. Especially testing is an important method to verify and validate software. Software V&V testing covers test planning to execution. IEEE Std. 1012 is a standard on the software V&V. Recently, IEEE Std. 1012-2012 was published. This standard is a major revision to IEEE Std. 1012-2004 which defines only software V&V. It expands the scope of the V&V processes to include system and hardware as well as software. This standard describes the scope of V&V testing according to integrity level. In addition, independent V&V requirement related to software V&V testing in IEEE 7-4.3.2-2010 have been revised. This paper provides a recent trend of software V&V testing by reviewing of IEEE Std. 1012-2012 and IEEE 7-4.3.2-2010.

2. Software V&V testing

In this section Software V&V testing activities and tasks defined by IEEE 1012-2012 are described [1]. Software V&V testing includes Software component, integration, qualification, and acceptance testing. V&V testing tasks are V&V of test plan, test design, test case, test procedure, and test execution. The software V&V testing activity addresses testing in several of the software life cycle processes, including the software construction process, the software integration process, and the software qualification testing process. IEEE 1012-2012 requires a minimum level for V&V testing dependent on the integrity level.

2.1 Software Component testing

Software component testing is testing of individual software component which is one of the parts that make up a system. In software design, software requirements are transformed into an architecture and a detailed design for each software component. The followings are software component testing tasks related to V&V activities.

- Activity: Software Design V&V

- Software Component Test Plan V&V
- Software Component Test Design V&V
- Activity: Software Construction V&V
 - Software Component Test Case V&V
 - Software Component Test Procedure V&V
 - Software Component Test Execution V&V

2.2 Software Integration testing

The objective of software integration V&V testing is to assure that the software requirements and system requirements allocated to software are validated as each software component is incrementally integrated. The followings are software integration testing tasks related to V&V activities.

- Activity: Software Design V&V
 - Software Integration Test Plan V&V
 - Software Integration Test Design V&V
- Activity: Software Construction V&V
 - Software Integration Test Case V&V
 - Software Integration Test Procedure V&V
- Activity: Software Integration Test V&V
 - Software Integration Test Execution V&V
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2.3 Software Qualification testing

The objective of software qualification V&V testing is to assure that the integrated software product satisfies its requirements. The followings are software qualification testing tasks related to V&V activities.

- Activity: Software Requirements V&V
 - Software Qualification Test Plan V&V
- Activity: Software Design V&V
 - Software Qualification Test Design V&V
- Activity: Software Construction V&V
 - Software Qualification Test Case V&V
 - Software Qualification Test Procedure V&V
- Activity: Software Qualification Test V&V
 - Software Qualification Test Execution V&V

2.4 Software Acceptance testing

The objective of software acceptance V&V testing is to assure that the software satisfies its acceptance criteria and to enable the customer to determine whether or not to accept the integrated software product. The followings are software acceptance testing tasks related to V&V activities.

- Activity: Software Requirements V&V
 - Software Acceptance Test Plan V&V
- Activity: Software Design V&V
 - Software Acceptance Test Design V&V
- Activity: Software Construction V&V
 - Software Acceptance Test Case V&V
- Activity: Software Acceptance Test V&V
 - Software Acceptance Test Procedure V&V
 - Software Acceptance Test Execution V&V

2.5 Comparison IEEE 1012-2012 and IEEE 1012-2004

Basically there are no major changes of software V&V testing activities and tasks in IEEE 1012-2012 compared with IEEE 1012-2004. But the positions on the responsibility to perform software V&V testing are changed. They are discussed in the next section.

3. The positions on responsibility to perform software V&V testing

In this section, the positions of IEEE 1012-2012 and IEEE 7-4.3.2-2010 on responsibility to perform software V&V testing are described.

3.1 Responsibility to perform V&V testing (IEEE 1012-2012)

This standard newly describes the minimum level for software V&V testing for the types of the testing and integrity level in Table 1 [1]. This table describes the position on responsibility to perform V&V testing.

Table 1. Minimum level for software V&V testing by integrity level

Software	V&V testing by integrity level			
	4	3	2	1
V&V Software Component Testing	Perform	Perform	Review	No action
V&V Software Integration Testing	Perform	Perform	Review	Review
V&V Software Qualification Testing	Perform	Perform	Review	Review
V&V Software Acceptance Testing	Perform	Perform	Review	No action

The term *perform* means that the V&V organization specifies and creates its testing products (i.e., test plan, test design, test cases, and test procedures) and either conducts that testing or analyzes the results of that testing if it is conducted by another organization. The term *review* means that the V&V organization reviews the testing plans and analyzes the results of tests. For example, V&V Software Qualification Testing can be conducted by not V&V organization but another organization such as development organization. The results of that testing such test report shall be analyzed

by V&V organization. However, IEEE 1012-2004 requires that V&V organization shall conduct all of V&V testing activities for software integrity level 3 & 4. Therefore IEEE 1012-2012 provides the flexibility of conduct of V&V testing [2].

3.2 V&V Independence requirements (IEEE 7-4.3.2-2010)

Independent V&V is required for safety-related software. 5.3.4 V&V independence requirements of IEEE 7-4.3.2 are required for independence V&V [3]. One of the requirements is that the development activities and tests shall be verified and validated by individuals or groups with appropriate technical competence, other than who developed the original design. In addition, this standard newly defines as follows: Testing throughout the life cycle process may be conducted by the V&V organization or the design organization or both. Regardless of who actually writes the procedures and/or conducts the tests, the test procedures and reports shall be independently verified by the alternate organization. This position is different with IEEE 1012-2012.

3. Conclusions

There are no major changes of software V&V testing activities and tasks in IEEE 1012-2012 compared with IEEE 1012-2004. But the positions on the responsibility to perform software V&V testing are changed. In addition IEEE 7-4.3.2-2010 newly describes the positions on responsibility to perform Software V&V Testing. However, the positions of these standards on the V&V testing are different. For integrity level 3&4, IEEE 1012-2012 basically requires that V&V organization shall conduct all of V&V testing tasks such as test plan, test design, test case, and test procedure except test execution. If V&V testing is conducted by not V&V but another organization, the results of that testing shall be analyzed by the V&V organization. For safety-related software, IEEE 7-4.3.2-2010 requires that test procedures and reports shall be independently verified by the alternate organization regardless of who writes the procedures and/or conducts the tests. According to IEEE 1012-2012 and IEEE 7-4.3.2-2010, we found these standards provide the flexibility of conduct of V&V testing.

REFERENCES

- [1] IEEE Std.1012-2012, Standard for System and Software Verification and Validation
- [2] IEEE Std.1012-2004, Standard for Software Verification and Validation
- [3] IEEE Std.7-4.3.2-2010, Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations