Software Quality Assurance: VI Standards

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VI Standards

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VI.1 Introduction

The benefits of use of standards:

- The ability to apply methodologies and procedures of the highest professional level.
- Better mutual understanding and coordination among development teams but especially between development and maintenance teams.
- Greater cooperation between the software developer and external participants in the project.
- Better understanding and cooperation between suppliers and customers, based on the adoption of standards as part of the contract.

[Galin2004]
## Classes of Standards

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Quality Management Standards</th>
<th>Project Process Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>The target unit</td>
<td>Management of software development and/or maintenance and the specific <strong>SQA units</strong></td>
<td>A software development and/or maintenance project <strong>team</strong></td>
</tr>
<tr>
<td>The main focus</td>
<td>Organization of SQA systems, infrastructure and requirements</td>
<td>Methodologies for carrying out software development and maintenance projects</td>
</tr>
<tr>
<td>Standard’s objective</td>
<td>“What” to achieve</td>
<td>“How” to perform</td>
</tr>
<tr>
<td>Standard's goal</td>
<td>Assuring supplier’s software quality and assessing its software process capability</td>
<td>Assuring the quality of a specific software project’s products</td>
</tr>
</tbody>
</table>
Organizations involved in SQA Standards Development

Most prominent developers of SQA standards:

- IEEE (Institute of Electric and Electronic Engineers) Computer Society
- ISO (International Standards Organization)
- DOD (US Department of Defense)
- ANSI (American National Standards Institute)
- IEC (International Electrotechnical Commission)
- EIA (Electronic Industries Association)

[Galin2004]
VI.2 Quality Management Standards

- The scope of quality management standards
- ISO 9001 and ISO 9000-3
- Certification according to ISO 9000-3
- Capability Maturity Models
- The SPICE project and the ISO/IEC 15504 software process assessment standard
The Scope of Quality Management Standards

Certification standards:

- **Enable** a software development organization to demonstrate consistent ability to assure acceptable quality of its software products or maintenance services. Certification is granted by an external body.

- **Serve** as an agreed-upon basis for customer and supplier evaluation of the supplier’s quality management system. Accomplished by performance of a quality audit by the customer.

- **Support** the organization's efforts to improve its quality management system through compliance with the standard’s requirements.
The Scope of Quality Management Standards

Assessment standards:

- **Serve** organizations as a tool for self-assessment of their ability to carry out software development projects.
- **Serve** for improvement of development and maintenance processes by application of the standard directions.
- **Help** purchasing organizations determine the capabilities of potential suppliers.
- **Guide** training of assessor by delineating qualifications and training program curricula.
ISO 9000-3 Principles

- Customer focus
- Leadership
- Involvement of people
- Process approach
- System approach to management
- Continual improvement
- Factual approach to decision making
- Mutually supportive supplier relationships
## ISO 9000-3: Requirements Classification

<table>
<thead>
<tr>
<th>Requirement Subjects</th>
<th>Requirement Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Quality management system</td>
<td>4.1 General requirements</td>
</tr>
<tr>
<td></td>
<td>4.2 Documentation requirements</td>
</tr>
<tr>
<td>5. Management responsibilities</td>
<td>5.1 Management commitments</td>
</tr>
<tr>
<td></td>
<td>5.2 Customer focus</td>
</tr>
<tr>
<td></td>
<td>5.3 Quality policy</td>
</tr>
<tr>
<td></td>
<td>5.4 Planning</td>
</tr>
<tr>
<td></td>
<td>5.5 Responsibility, authority and communication</td>
</tr>
<tr>
<td></td>
<td>5.6 Management review</td>
</tr>
<tr>
<td>6. Resource management</td>
<td>6.1 Provision of resources</td>
</tr>
<tr>
<td></td>
<td>6.2 Human resources</td>
</tr>
<tr>
<td></td>
<td>6.3 Infrastructure</td>
</tr>
<tr>
<td></td>
<td>6.4 Work environment</td>
</tr>
<tr>
<td>7. Product realization</td>
<td>7.1 Planning of product realization</td>
</tr>
<tr>
<td></td>
<td>7.2 Customer-related processes</td>
</tr>
<tr>
<td></td>
<td>7.3 Design and development</td>
</tr>
<tr>
<td></td>
<td>7.4 Purchasing</td>
</tr>
<tr>
<td></td>
<td>7.5 Production and service provision</td>
</tr>
<tr>
<td></td>
<td>7.6 Control of monitoring and measuring devices</td>
</tr>
<tr>
<td>8. Measurement, analysis and improvement</td>
<td>8.1 General</td>
</tr>
<tr>
<td></td>
<td>8.2 Monitoring and measurement</td>
</tr>
<tr>
<td></td>
<td>8.3 Control of nonconforming product</td>
</tr>
<tr>
<td></td>
<td>8.4 Analysis of data</td>
</tr>
<tr>
<td></td>
<td>8.5 Improvement</td>
</tr>
</tbody>
</table>

[Galin2004]
ISO 9000-3: Certification Process

**Organization requesting certification**
- The decision
  - Planning process leading to certification
  - Development of the organization’s SQA system
  - Implementation of organization’s SQA system
  - Carry out performance improvements of SQA management system
  - ISO 9000-3 certification

**The certifying organization**
- Organization’s quality manual and SQA procedures
  - Review of the quality manual and SQA procedures
    - Do the quality manual and procedures comply with ISO 9000-3?
      - Yes
        - Performance audit of SQA management system
          - Does the performance of the SQA system comply with ISO 9000-3?
            - Yes
  - ISO 9000-3 certification
Software Capability Maturity Model (CMM)

- In the late 1980s, the Software Engineering Institute (SEI), Carnegie Mellon University, developed the SW-CMM (Software Capability Maturity Model) to help organizations build effective software engineering processes.

- It has been widely adopted in industry, primarily by large software development organizations.
CMM Assessment: Principles

- Quantitative management methods increases the organization's capability to control the quality and improve the productivity.
- Application of the five-level capability maturity model model that enables to evaluate the achievements and determine the efforts needed to reach the next capability.
- Generic process areas that define the “what” — not “how” enables the model's applicability to a wide range of implementation organizations:
  - It allows use of any life cycle model.
  - It allows use of any design methodology, development tool and programming language.
  - It does not specify any particular documentation standard.

[Galin2004]
## SW-CMM Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5: Optimizing</td>
<td>Continuous Process Improvement</td>
<td>Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.</td>
</tr>
<tr>
<td>4: Managed</td>
<td>Product and Process Quality</td>
<td>Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled.</td>
</tr>
<tr>
<td>3: Defined</td>
<td>Engineering Process</td>
<td>The software process for both management and engineering activities is documented, standardized, and integrated into a standard software process for the organization. All projects use an approved, tailored version of the organization's standard software process for developing and maintaining software.</td>
</tr>
<tr>
<td>2: Repeatable</td>
<td>Project Management</td>
<td>Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.</td>
</tr>
<tr>
<td>1: Initial</td>
<td>No Focus</td>
<td>Project success primary depends on individuals and their heroics.</td>
</tr>
</tbody>
</table>
SW-CMM Assessment

1342 organizations [SEMA 2003]

- Initial: 13.3%
- Repeatable: 43.5%
- Defined: 25.6%
- Managed: 8.5%
- Optimizing: 9.2%
## Time Required to Progress to the Next CMM Level

<table>
<thead>
<tr>
<th>Capability level transition</th>
<th>Mean time (months)</th>
<th>No. of organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 to level 2</td>
<td>24</td>
<td>125</td>
</tr>
<tr>
<td>Level 2 to level 3</td>
<td>21.5</td>
<td>124</td>
</tr>
<tr>
<td>Level 3 to level 4</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>Level 4 to level 5</td>
<td>18</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: [Gartner2001]
### Project resources distribution by CMM capability level

<table>
<thead>
<tr>
<th>CMM capability level</th>
<th>Original work</th>
<th>Reworking</th>
<th>Testing and quality assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>76</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

see Raytheon [Galin2004]
Versions of CMMI (Capability Maturity Model Integration)

- **CMMI-SE/SW**
  - System Engineering CMM (SE-CMM)
  - Software Engineering CMM (SW-CMM)

- **CMMI-SE/SW/IPPD/SS**
  - System Engineering CMM (SE-CMM)
  - Software Engineering CMM (SW-CMM)
  - Integrated Product/Process Development (IPPD-CMM)
  - Supplier Sourcing

- **CMMI-SE/SW/IPPD**
  - System Engineering CMM (SE-CMM)
  - Software Engineering CMM (SW-CMM)
  - Integrated Product/Process Development (IPPD-CMM)

[Galin2004]
ISO/IEC 15504 Process Assessment Model

Level 5: Optimizing process
Level 4: Predictable process
Level 3: Established processes
Level 2: Managed process
Level 1: Performed process
Level 0: Incomplete

Process change
Continuous improvement
Measurement
Process control
Process definition
Process resource
Performance management
Work product management
Process performance
No requirements

[Galin2004]
ISO/IEC 15504: Principles

- **Harmonize** the many existing “independent” assessment methodologies by providing a comprehensive framework model (“what” has to be accomplished rather than “how” it has to be done).

- **Be universal** to serve all or almost all categories of software suppliers, customers and software categories.

- **Be highly professional.**

- **Aim at reaching international acceptance** as world standard. To save suppliers' resources by eliminating the need to perform several different capability assessments in response to different customer requirements.
### SPICE Project Rating & Levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Rating</th>
<th>Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>F (fully)</td>
<td>86-100%</td>
<td>Systematic and complete or almost complete performance of process attributes.</td>
</tr>
<tr>
<td>L (largely)</td>
<td>51-85%</td>
<td>Significant achievements and systematic approach are evident. Some areas of low performance exist</td>
</tr>
<tr>
<td>P (partially)</td>
<td>16-50%</td>
<td>Some achievements and partial adoptions of systematic approach are evident. Other aspects of process attributes are uncontrolled</td>
</tr>
<tr>
<td>N (not)</td>
<td>0-15%</td>
<td>Little or no achievements of the process attributes</td>
</tr>
</tbody>
</table>

- **F** or **L** for the process attributes of the level
- **and F** for all preceding levels

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[Galin2004]
Goals of the SPICE Project Trials

- To validate the ISO/IEC 15504 model's conformity with current standards.
- To verify its usability in determining whether software satisfies user requirements.
- To gain experience in applying the ISO/IEC 15504 model.

[Galin2004]
VI.3 Process Standards

IEEE software engineering standards:

- The structure and content of IEEE software engineering standards
- IEEE/EIA Std. 12207
  - Software life cycle processes
- IEEE Std. 1012
  - Verification and validation
- IEEE Std. 1028
  - Reviews
Classes of IEEE Standards

A Conceptual standards.
Guiding principles and overall approach
- IEEE 1061 – Software Quality Metrics Methodology
- IEEE/EIA 12207.0 — Information Technology Software Life Cycle Processes

B Prescriptive standards of conformance.
Requirements to which a software developer must conform.
- IEEE 829 — Software Test Documentation
- IEEE 1012 – Software Verification And Validation
- IEEE 1028 – Software Reviews

C Guidance standards.
Implementation of class B standards.
- IEEE 1233 – Guide for Developing System Requirement Specifications
Purpose of IEEE/EIA Std 12207

- To establish an internationally recognized model of common software life cycle processes that can be referenced by the software industry worldwide.
- To promote understanding among business parties by application of commonly recognized processes, activities and tasks.

[Galin2004]
IEEE/EIA Std 12207
Software life cycle processes

Source: IEEE (1992). From IEEE Std 10 45-19992. Copyright 1992 IEEE. All rights reserved.
IEEE/EIA Std 12207.0 Concepts

General concepts
- Applicability of the standard in general and its adaptation by tailoring
- Applicability for all participants in the software life cycle
- Flexibility and responsiveness to technological change
- Software links to the system
- TQM consistency
- No certification requirements
- Baselining

Task-related concepts
- Responsibility for activities and tasks
- Modularity of components of software life cycle
- Levels of required conformance
- Nature of evaluation task

[Galin2004]
Purpose of IEEE Std 1012

- **Establish** a common framework for V&V activities and tasks for all software life cycle processes.
- **Define** V&V requirements, including their inputs and outputs.
- **Define** software integrity levels and the appropriate V&V tasks.
- **Define** the content of a SVVP (software V&V Plan) document.

[Galin2004]
IEEE Std 1012 Concepts

- Broad definition of V&V activities
- Software integrity levels and their V&V requirements
- Prescriptive requirements
  - Detailed description of the performance methodology.
  - Required inputs.
  - Required outputs.
  - Definition of integrity levels for which performance of the task is not mandatory.
  - Optional V&V tasks to be performed during selected life cycle process.
- Independence of V&V activities
- Compliance and compatibility with international standards
- Special characteristics of reusable software V&V
- Application of V&V metrics
- Quantitative criteria for V&V tasks
Processes Covered by IEEE Std 1012

(1) Management
(2) Acquisition
(3) Supply
(4) Development
(5) Operation
(6) Maintenance

A three level tree architecture:
- Processes (each includes 1-6 activities)
- Activities (each includes 3-10 tasks)
- Tasks

[GalIn2004]
IEEE Std 1028

Purpose: to define systematic review procedures that are:
- Applicable for reviews performed throughout the software life cycle
- Conform with the review requirements defined by other standards

Concepts:
- High formality
- Follow-up of corrections
- Compliance with international and IEEE standards
IEEE Std 1028: Types of Reviews

- Management reviews
- Technical reviews
- Inspections
- Walkthroughs
- Audits

[Galin2004]
Review Document Structure:

(1) Introduction
(2) Responsibilities  The responsibilities of the participants in the review.
(3) Input  Mandatory and optional data items.
(4) Entry criteria  Common criteria: a. a statement of the review's objectives. b. Availability of the required input data.
(5) Procedure  Required to include: management preparations, planning, team preparation, examination of the products, follow up of corrections.
(6) Exit criteria  What must be accomplished before the review can be concluded.
(7) Output items
(8) Data collection recommendations  To be used to study the effectiveness and efficiency of current practices.
(9) Improvements  Formulate improved procedures, checklists and development processes.
VI.4 Discussion & Summary

The benefits of using of standards is the ability to apply methodologies and procedures of the highest professional level that facilitate better mutual understanding and coordination

- among development teams but especially between development and maintenance teams.
- between the software developer and external participants in the project.
- between suppliers and customers, based on the adoption of standards as part of the contract.

- Quality Management Standards targeting the Management of software development and/or maintenance and the specific SQA units and focus on “What” to achieve.

- Project Process Standards is targeting a software development and/or maintenance project team and focus on “How” to perform
VI.5 Bibliography


