


Software Quality Management

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Plan of the Talk



- Introduction to Quality Engineering.
- Quality control and Quality Assurance
- ISO 9000
- SEI CMM
- Summary

Introduction



- Traditional definition of quality:
 - Fitness of purpose:
 - A quality product does exactly what the users want it to do.

Fitness of Purpose

- Fitness of purpose for software products:
 - Satisfaction of the requirements specified in SRS document.

Fitness of Purpose

- A satisfactory definition of quality for many products:
 - A car, a table fan, a food mixer, microwave oven, etc.
- But, not satisfactory for software products.
 - Why?

Quality for Software Products

- Consider a software product:
 - Functionally correct:
 - Performs all functions as specified in the SRS document.
 - But, has an almost unusable user interface.
 - Cannot be considered as a quality product.

Quality for Software Products

- Consider another example:
 - A product which does everything that users want.
 - But has an almost incomprehensible and unmaintainable code.
 - Will you call it a quality product?

Modern View of Quality

- Several quality factors are associated with a software product :
 - Correctness
 - Reliability
 - Efficiency (includes efficiency of resource utilization)
 - Portability
 - Usability
 - Reusability
 - Maintainability

Correctness



- A software product is correct:
 - If different requirements as specified in the SRS document have been correctly implemented.
 - Results are accurate.

Portability

- A software product is said to be portable:
 - If it can be easily made to work
 - In different operating systems.
 - In different machines,
 - With other software products, etc.

Reusability



- A software product has good reusability:
 - If different modules of the product can easily be reused to develop new products.

Usability



- A software product has good usability:
 - If different categories of users (i.e. both expert and novice users) can easily invoke the functions of the product.

Maintainability



- A software product is maintainable:
 - If errors can be easily corrected as and when they show up,
 - New functions can be easily added to the product,
 - Functionalities of the product can be easily modified.

Software Quality Management System

- Quality management system (or quality system):
 - Principal methodology used by organizations to ensure that the products have desired quality.

Quality System



- A quality system consists of the following:
 - Managerial Structure
 - Individual Responsibilities.
- Responsibility of the organization as a whole.

Quality System

- Every quality conscious organization has an independent quality department:
 - Performs several quality system activities.
 - Needs support of top management.
 - Without support at a high level in a company:
 - Many employees may not take the quality system seriously.

Quality System Activities

- Auditing of projects
- Development of:
 - standards, procedures, and guidelines.
- Production of reports for the top management:
 - Summarizing the effectiveness of the quality system in the organization.
- Review of the quality system itself.

Quality System

- A good quality system must be well documented.
 - Without a properly documented quality system,
 - Application of quality procedures become ad hoc,
 - Results in large variations in the quality of the products delivered.

Quality System

- An undocumented quality system:
 - Sends clear messages to the staff about the attitude of the organization towards quality assurance.
- International standards such as ISO 9000 provide:
 - Guidance on how to organize a quality system.

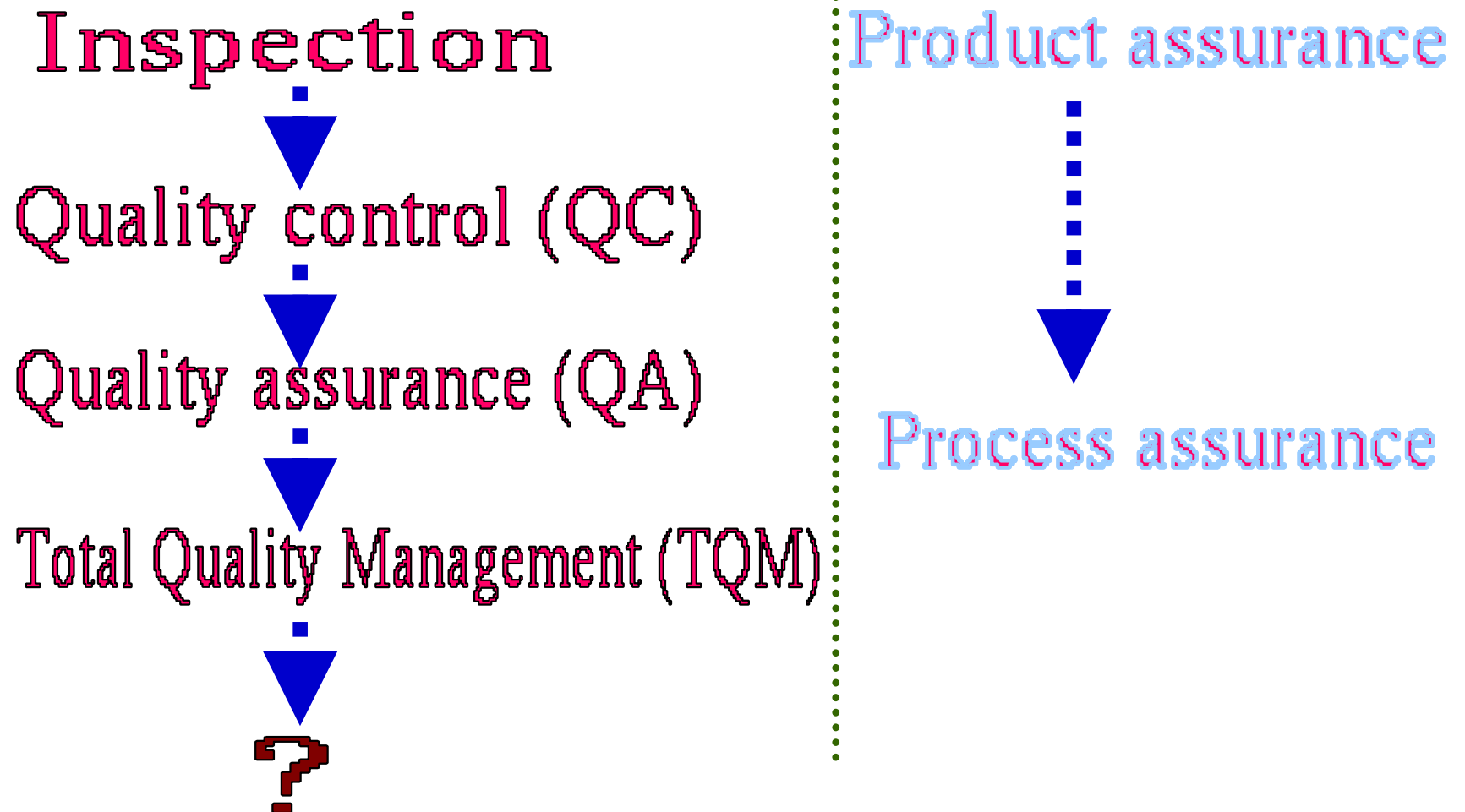
Evolution of Quality Systems

- Quality systems have evolved:
 - Over the last six decades.
- Prior to World War II:
 - Accepted way to produce quality products:
 - Inspect the finished products
 - Eliminate defective products.

Evolution of Quality Systems

- Since World war II,
 - Quality systems of organizations have undergone:
 - Four stages of evolution.
- Many advances came from Japanese:
 - Helped resurrect Japanese economy.

Evolution of Quality Systems



Evolution of Quality Systems

- Initial product inspection method:
 - Gave way to **quality control (QC)**.
- Quality control:
 - Not only detect the defective products and eliminate them
 - But also determine the causes behind the defects.

Quality Control (QC)

- Quality control aims at correcting the causes of errors:
 - Not just rejecting defective products.
- Statistical quality control (SQC):
 - Quality of the output of the process is inferred using statistical methods.
 - In stead of inspection or testing of all products.

Quality Control (QC)



- The next breakthrough:
 - Development of **quality assurance principles.**

Quality Assurance



- Basic premise of modern quality assurance:
 - If an organization's processes are good and are followed rigorously:
 - The products are bound to be of good quality.

Quality Assurance



- All modern quality paradigms include:
 - Guidance for recognizing, defining, analyzing, and improving the production process.

Total Quality Management (TQM)

- TQM advocates:
 - Continuous process improvements through process measurements.

Business Process Reengineering

- BPR: A term related to TQM.
- Process reengineering goes a step further than quality assurance:
 - Aims at continuous process improvement.

Business Process Reengineering

- TQM focuses on reengineering of the software process.
 - Whereas BPR aims at reengineering the way business is carried out in any organization:
 - Not just software development.

Total Quality Management (TQM)

- TQM goes beyond documenting processes
 - Optimizes them through redesign.
- Over the years the quality paradigm has shifted:
 - From product assurance to process assurance.

Process Improvement



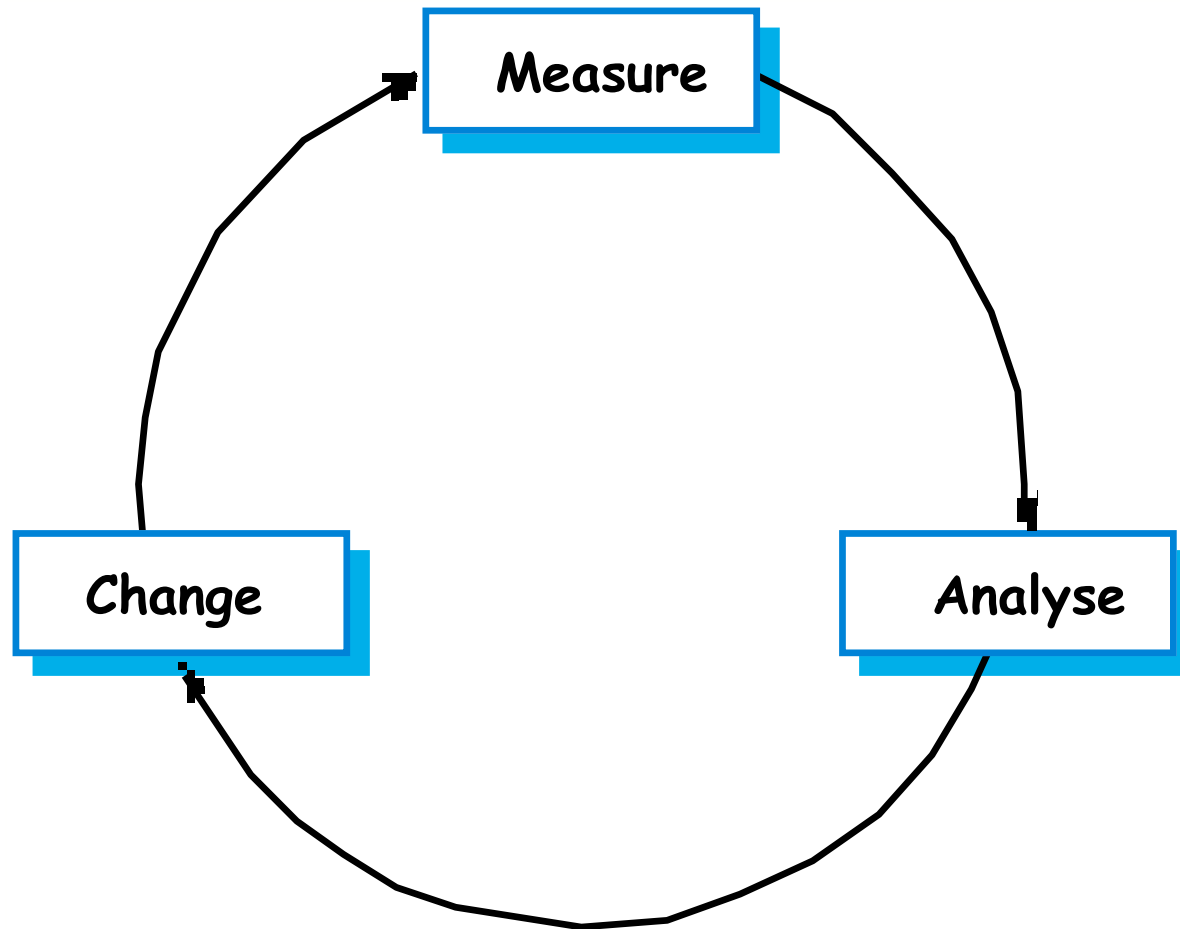
- Implies introducing process changes to improve:
 - Product quality
 - Reduce costs
 - Accelerate schedules.
- Most process improvement work so far has focused on defect reduction.

Process Attributes




Process characteristic	Description
Understandability	To what extent is the process explicitly defined and how easy is it to understand the process definition?
Visibility	Do the process activities culminate in clear results so that the progress of the process is externally visible?
Supportability	To what extent can CASE tools be used to support the process activities?
Acceptability	Is the defined process acceptable to and usable by the engineers responsible for producing the software product?
Reliability	Is the process designed in such a way that process errors are avoided or trapped before they result in product errors?
Robustness	Can the process continue in spite of unexpected problems?
Maintainability	Can the process evolve to reflect changing organisational requirements or identified process improvements?
Rapidity	How fast can the process of delivering a system from a given specification be completed?

The Process Improvement Cycle



Process Improvement Stages



- **Process measurement**
 - Attributes of the process are measured.
 - Form a baseline for assessing improvements.
- **Process analysis**
 - The process is assessed and bottlenecks and weaknesses are identified.
- **Process change**
 - Changes to the process that have been identified during the analysis are introduced.

Process and Product Quality

- A good process is usually required to produce a good product.
- For manufactured goods, process is the principal quality determinant.
- For design-based activity, other factors are also involved:
 - For example, the capabilities of the designers.

ISO 9000



- ISO (international Standards Organization):
 - a consortium of 63 countries established to formulate and foster standardization.
- ISO published its 9000 series of standards in 1987.

What is ISO 9000 Certification?

- ISO 9000 certification:
 - Serves as a reference for contract between independent parties.
- The ISO 9000 standard:
 - Specifies guidelines for maintaining a quality system.

What is ISO 9000 Certification?

- ISO 9000 specifies:
 - Guidelines for repeatable and high quality product development.
 - Also addresses organizational aspects
 - Responsibilities, reporting, procedures, processes, and resources for implementing quality management.

ISO 9000



- A set of guidelines for the production process.
 - Not directly concerned about the product it self.
 - A series of three standards:
 - ISO 9001, ISO 9002, and ISO 9003.

ISO 9000



- Based on the premise:
 - If a proper process is followed for production:
 - Good quality products are bound to follow.

ISO 9001



- Applies to:
 - Organizations engaged in design, development, production, and servicing of goods.
 - Applicable to most software development organizations.

ISO 9002



- ISO 9002 applies to:
 - Organizations who do not design products:
 - but are only involved in production.
- Examples of this category of industries:
 - Steel or car manufacturing industries
 - Buy the product and plant designs from external sources:
 - only manufacture products.
 - Not applicable to software development organizations.

ISO 9003



- ISO 9003 applies to:
 - Organizations involved only in installation and testing of the products.

ISO 9000 for Software Industry

- ISO 9000 is a generic standard:
 - Applicable to many industries,
 - Starting from a steel manufacturing industry to a service rendering company.
- Many clauses of ISO 9000 documents:
 - Use generic terminologies
 - Very difficult to interpret them in the context of software organizations.

Software vs. Other Industries

- Very difficult to interpret many clauses for software industry:
 - Software development is radically different from development of other products.

Software vs. Other Industries

- Software is intangible:
 - Therefore difficult to control.
 - It is difficult to control anything that we cannot see and feel.
 - In contrast, in a car manufacturing unit:
 - We can see a product being developed through stages such as fitting engine, fitting doors, etc.
 - One can accurately tell about the status of the product at any time.
 - Software project management is an altogether different ball game.


Software vs. Other Industries

- During software development:
 - The only raw material consumed is data.
- For any other product development:
 - Lot of raw materials consumed
 - e.g. Steel industry consumes large volumes of iron ore, coal, limestone, etc.
- ISO 9000 standards have many clauses corresponding to raw material control .
 - Not relevant to software organizations.

Software vs. Other Industries

- Radical differences exist between software and other product development:
 - Difficult to interpret various clauses of the original ISO standard in the context of software industry.

ISO 9000 Part-3




- ISO released a separate document called ISO 9000 part-3 in 1991:
 - To help interpret the ISO standard for software industry.
- At present:
 - Official guidance is inadequate.

ISO 9000: 2000

- *ISO 9001:2000:*
 - Combines the three standards 9001, 9002, and 9003 into one.
- Design and development procedures are required:
 - Only if a company does in fact engage in the creation of new products.
- The 2000 version sought to make a radical change in thinking:
 - By actually highlighting the concept of process management.

ISO 9000: 2000



- Another goal is to improve effectiveness via **process performance metrics**:
 - Numerical measurement of the effectiveness of tasks and activities.
 - **Continual process improvement** and tracking customer satisfaction were made explicit.

Why Get ISO 9000 Certification?

- Several benefits:
 - Confidence of customers in an organization increases.
 - If organization qualified for ISO 9001 certification.
 - This is especially true in the international market.

Why Get ISO 9000 Certification?

- Many international software development contracts insist:
 - Development organization to have ISO 9000 certification.

Why Get ISO 9000 Certification?

- Requires:
 - A well-documented software production process to be in place.
 - Contributes to repeatable and higher quality software.
- Makes development process:
 - Focussed, efficient, and cost-effective

Why Get ISO 9000 Certification?

- Points out the weakness of an organizations:
 - Recommends remedial action.
- Sets the basic framework:
 - For development of an optimal process and TQM.

How to Get ISO 9000 Certification?

- An organization intending to obtain ISO 9000 certification:
 - Applies to a ISO 9000 registrar for registration.
- ISO 9000 registration process consists of several stages.

How to Get ISO 9000 Certification?

- Application stage:
 - Applies to a registrar for registration.
- Pre-assessment:
 - The registrar makes a rough assessment of the organization.

How to Get ISO 9000 Certification?

- Document review and adequacy audit:
 - Process and quality-related documents.
 - The registrar reviews the documents.
 - Makes suggestions for improvements.

How to Get ISO 9000 Certification?

- Compliance audit: The registrar checks:
 - Whether the suggestions made by it during review have been complied.

How to Get ISO 9000 Certification?

- **Registration:**

- The registrar awards ISO 9000 certificate after successful completions of all previous phases.

- **Continued surveillance:**

- The registrar continues monitoring the organization periodically.

ISO 9000 Certification

- An ISO certified organization :
 - Can use the certificate for corporate advertizements.
 - Cannot use the certificate to advertize its products.
 - ISO 9000 certifies organization's process
 - Not any product of the organization.
 - An organization using ISO certificate for product advertizements:
 - Risks withdrawal of the certificate.

Summary of ISO 9001 Requirements

- **Management responsibility(4.1):**
 - Management must have an effective quality policy.
 - The responsibility and authority of all those whose work affects quality:
 - Must be defined and documented.

Management Responsibility(4.1)

- Responsibility of the quality system.
 - Independent of the development process.
 - Can work in an unbiased manner.
- The effectiveness of the quality system:
 - Must be periodically by audited.

Quality System (4.2) and Contract Reviews (4.3):

- A quality system must be maintained and documented.
- Contract reviews (4.3):
 - Before entering into a contract, an organization must review the contract
 - Ensure that it is understood,
 - Organization has the capability for carrying out its obligations.

Design Control (4.4)




- The design process must be properly controlled:
 - This includes controlling coding also.
- A good configuration control system must be in place.

Design Control (4.4)



- Design inputs must be verified as adequate.
- Design must be verified.
- Design output must be of required quality.
- Design changes must be controlled.

Document Control (4.5)



- Proper procedures for:
 - Document approval, issue and removal.
- Document changes must be controlled.
 - Use of some configuration management tools is necessary.

Purchasing (4.6)



- Purchased material, including bought-in software:
 - Must be checked for conforming to requirements.

Purchaser Supplied Products (4.7)

- Material supplied by a purchaser:
 - For example,
 - Client-provided software must be properly managed and checked.

Product Identification (4.8)

- The product must be identifiable at all stages of the process.
 - In software development context this means configuration management.

Process Control (4.9)



- The development must be properly managed.
- Quality requirements must be identified in a quality plan.

Inspection and Testing (4.10)

- In software terms this requires effective testing i.e.,
 - Unit testing, integration testing and system testing.
- Test records must be maintained.

Inspection, Measuring and Test Equipment(4.11)

- If integration, measuring, and test equipments are used,
 - Must be properly maintained and calibrated.

Control of Nonconforming Product (4.13)

- In software terms,
 - Keeping untested or faulty software out of released product,
 - Or out of other places whether it might cause damage.

Corrective Action (4.14)



- This is both about correcting errors when found:
 - Investigating why they occurred
 - Improving the process to prevent further occurrences.
- If an error reoccurs despite the quality system:
 - The system needs improvement.

Handling (4.15) and Quality Audits (4.17):


- Handling (4.15) Deals with:
 - Storage, packing, and delivery of the software product.
- Quality Audits (4.17) :
 - Quality system audit must be carried out to ensure its effectiveness.

Training (4.18)



- Training needs must be identified and met.
- Most items of ISO standard:
 - Are largely common sense.

Salient Features of ISO 9001 Requirements:



- All documents concerned with the development of a software product:
 - Should be properly managed, authorized, and controlled.
- Proper plans should be prepared:
 - Progress against these plans should be monitored.

Salient Features of ISO 9001 Requirements

- Important documents independently checked and reviewed:
 - For effectiveness and correctness.
- The product should be tested :
 - Against specification.
- Several organizational aspects:
 - e.g., management reporting of the quality team.

Shortcomings of ISO 9001 Certification

- ISO 9000 requires a production process to be adhered to:
 - But does not guarantee the process to be of high quality.
 - Does not give any guideline for defining an appropriate process.

Shortcomings of ISO 9001 Certification cont...

- ISO 9000 certification process:
 - Not fool-proof
 - No international accreditation agency exists.
 - Likely variations in the norms of awarding certificates:
 - Among different accreditation agencies and among the registrars.

Shortcomings of ISO 9001 Certification (3)

- Organizations qualifying for ISO 9001 certification:
 - Tend to downplay domain expertise.
 - Tend to believe that since a good process is in place,
 - Any engineer is as effective as any other engineer in doing any particular activity relating to software development.

Shortcomings of ISO 9001 Certification (4)

- In manufacturing industry:
 - Clear link between process quality and product quality.
 - Once a process is calibrated:
 - Can be run again and again producing quality goods.
- Software development is a creative process:
 - Individual skills and experience is significant.

Shortcomings of ISO 9001 Certification (5)

- Many areas of software development are very specialized:
 - Special expertise and experience (domain expertise) required.
- ISO 9001:
 - Does not automatically lead to continuous process improvement,
 - Does not automatically lead to TQM.

Shortcomings of ISO 9001 Certification (6)

- ISO 9001 addresses mostly management aspects.
- Techniques specific to software development have been ignored:
 - Configuration management
 - Reviews
 - Release builds
 - Problem Notification system
 - Intranets