INTRODUCTION

Software Quality

Conformance to explicitly stated functional and performance requirements, explicitly documented development standards and implicit characteristics that are expected of all professionally develop software

Three (3) important points to remember on software quality

1. Software requirements are the foundation from which quality is measured. Lack of conformance to requirements is lack of quality.
2. Specified standards define a set of development criteria that guide the manner in which software is engineered. If the criteria are not followed, lack of quality will almost surely result.
3. There is a set of implicit requirements that often goes unmentioned (e.g., the desire for good maintainability). If software conforms to its explicit requirements, but fails to meet implicit requirements.

Quality Characteristics

Is any property or element that can be used to define the nature of a product. Each characteristic can be physical or chemical properties such as size, weight, volume, color or composition.

Software Quality

1. Is achieved through a disciplined approach - called software engineering SE
2. Can be defined, described, and measured
3. Can be assessed before any code has been written

4 Cannot be tested into a product

Software quality challenges

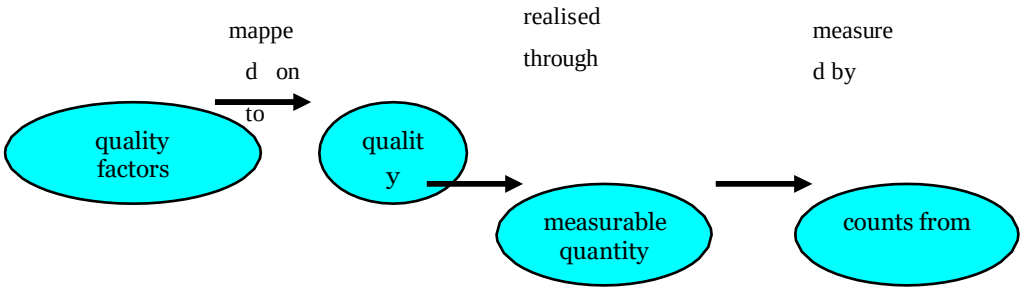
1. Defining it
2. Describing it (qualitatively)
3. Measuring it (quantitatively)
4. Achieving it (technically)

Designing software is a *creative* task, and like most such tasks, success is more likely if

the designer follows what might be termed a set of *rules of form.*The rules of form also provide some way of assessing the *quality* of the eventual product, and possibly of the processes that led to it.

REALISING QUALITY

A set of abstract quality factors (‘the *ilities*’) has been defined. These cannot be measured directly but do relate to the ultimate goal.



Software Quality Factors (by McCall)

1) **Product Revision (changing it)**

- *Flexibility (can I change it?)*

  The effort required to modify an operational program. Change and enhancement of the system should be easily implementable.

- *Maintainability (can I fix it?)*

  The effort required to locate and fix an error in a program. The system should be easy to keep up for its intended use. Changes for improving operational efficiency should be easy to implement. Failed operations should be easy to restore to satisfactory condition.

- *Testability (can I test it?)*

  The effort required to test a program to ensure that it performs its intended function . The ability of the system to produce quality product units should be easily testable. Useful messages should be generated for testing and debugging purposes.

2) Product Transition (modifying it to work in a different environment)

Interoperability (Will I be able to interface it with another system?)

The effort required to couple one system to another.

- *Portability (Will I be able to use it on another machine?)*

  The effort required to transfer the program from one hardware and/or software system environment to another. The system should be portable among people and among machines. Attainment of theother quality characteristics greatly facilitates portability.

- *Reusability (Will I be able to reuse some of the software?)*

The extent to which a program (or part of a program) can be reused in other applications-related to the packaging and scope of the functions that the program performs.

3) Product Operations (using it)

- *Correctness (Does it do what I want?)*
  The extent to which a program satisfies its specification and fulfills the customer's mission objectives. The extent to which software is free from design defects and from coding defects.; that is fault-free.

- *Reliability (Does it do it accurately all of the time?)*
  The extent to which a program can be expected to perform its intended function with required precisions under stated conditions for a stated period of time.

- *Efficiency (Will it run on my hardware as well as it can?)*
  The extent to which a software performs its function.with a minimum consumption of computing resources. It should not use any hardware components or peripheral equipment unnecessarily.

- *Integrity (Is it secure?)*
  The extent to which access to software or data by unauthorized persons can be controlled.

- *Usability (Is it designed for the use?)*
  The effort required to learn, operate, prepare input, and interpret output of a program.

Software Quality Assurance (SQA)

Software quality assurance is a planned effort to ensure that a software product fulfills these criteria and has additional attributes specific to the project, e.g., portability, efficiency, reusability, and flexibility. It is the collection of activities and functions used to monitor and control a software project so that specific objectives are achieved with

the desired level of confidence. It is not the sole responsibility of the software quality assurance group but is determined by the consensus of the project manager, project leader, project personnel, and users.

A formal definition of software quality assurance is that is 'the systematic activities providing evidence of the fitness for use of the total software product." Software quality assurance is achieved through the use of established guidelines.for quality control to ensure the Integrity and prolonged life of software. The relationships between quality assurance, quality control, the auditing function, and software testing are often confused.

Quality assurance is the set of support activities needed to provide adequate confidence that processes are established and continuously improved in order to products that meet specifications and are fit for use. Quality control is the process by which product quality is compared with applicable standards and the action taken when nonconformance is detected. Auditing is the inspection/ assessment activity that verifies compliance with plans, policies, and procedures.

SQAActivities

SQA is ensured through a Quality Management System (QMS), QMS is made of several components; it is a system integrated in the bigger system of software development, which comprises project, process and product management systems.

The Software Engineering Institute (SEI) recommends a set of activities, which, when implemented effectively, assures the designed quality. These activities include:

- Quality assurance planning
- Data gathering on key quality defining parameters
- Data analysis and reporting
- Quality control mechanisms

The first and foremost requirement in SQA is that it is a separate group responsible for quality in the organization. They set the goals, standards and mechanisms (systems) for SQA. The role of the SQA group is to assist the software development team in managing

the quality requirements of the software. Every software has certain quality goals specified by the customer. These quality goals are to be achieved by the development team by introducing a set of activities or ensuring the delivery of quality to the customer.

SQA activities operate on the normal activities of quality management. These activities play the role of monitoring, tracking, evaluations, auditing and reviews to ensure that the quality policy of the organization is implemented. These activities are independently carried out, and feedback is given to the development team. The responsibility of delivering the required quality to the customer rests with the development team. The development team has an obligation to implement quality policy in terms of goals, objectives, procedures, checks and controls, documentation and feedback to management. For example, the quality policy stipulates preparation of a test plan for stages for development as well as at the end of the development process. SQA has a variety of tools to implement the policy.

They are

- Auditing
- Inspection

Verify compliance with those norms and practices specified in QA policy; deviations are set right. Ensure that deviations are documented and reported and put into the QA database for guidance. Design and architecture is reviewed to ensure that standards are met and customer quality is assured. Implement change management. Collect data on various observations in the process of auditing, inspection and reviews to build QA database and to improve various standards.

Software Defects

The causes for not meeting the quality commonly are

- Imprecise requirement and software specifications
- Lack of understanding of customer requirements
- International deviations
- Violation of standards (Design, Programming)
- Erroneous data representation

- Improper interface
- Faulty logic in rules and processes
- Erroneous testing
- Incomplete and defective documentation
- H&S platforms not coping up to required standards
- Lack of domain knowledge

Statistical analysis of errors or defects helps to focus and concentrate on probable areas where SQA efforts are necessary.

SQA is also concerned with two other aspects namely, software reliability and software safety. Software reliability is defined as the probability of failure free operation of a computer program in a specified environment for a specified time.

The nature of failure may be such that one error may require only a few repair, and other may need hours. SQA collects data on these failures and examines why these failures could not be prevented through earlier SQA activities.

A simple measure of reliability is Mean Time between Failure (MTBF).
MTBF = MTTF + MTTR
Where MTTF is Mean Time to Failure and MTTR is Mean Time to Repair.

Software safety deals with identification and assessment of potential hazards of software failing, and its impact on the system or in the environment in which it operates. Software safety needs are more crucial in process control systems, health care systems, defense and so on. SQA activities concentrate on such areas of software where failure affects the customer system adversely. In short, SQA efforts assure software quality, reliability, availability and safety.

Software Quality Assurance Components

The SQA Components that are used by the Software Quality Assurance System can be classified into

six different categories; each of which is necessary to guarantee maximum quality and to ensure the compliance with the standards and procedures.

"The environment in which software development and maintenance is undertaken directly influences the SQA components. Alongside this various errors will also affect the SQA components; therefore it is usually necessary to include all of the components."

casd.csie.ncku.edu.tw/sq/ch04.ppt

The six different components are broken down into the following categories

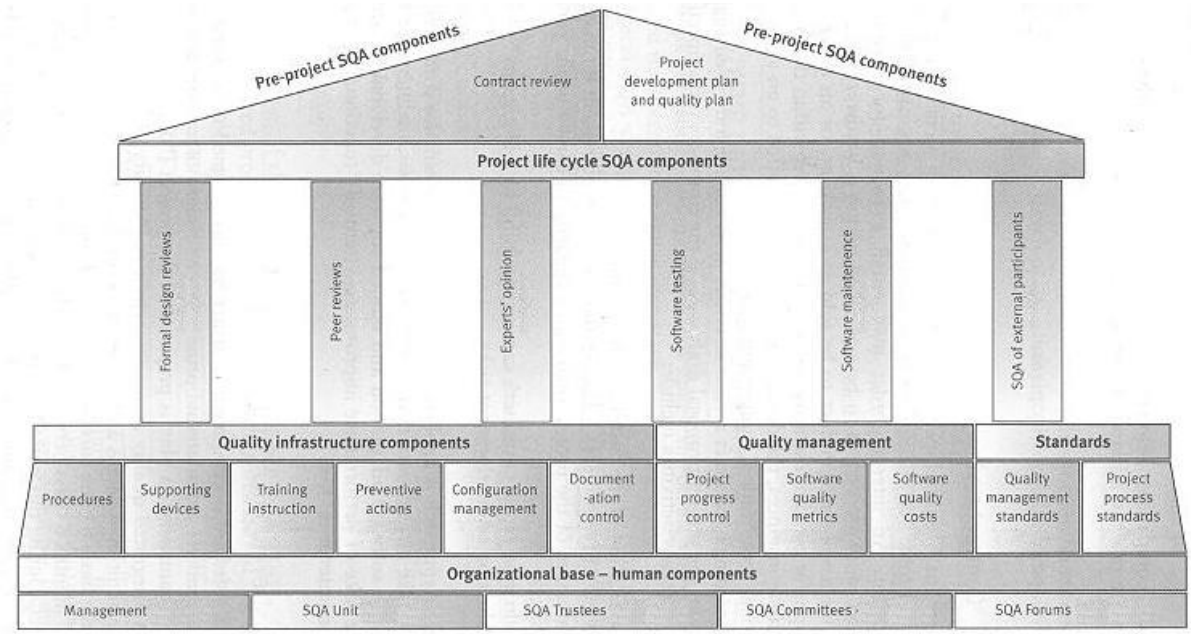


Figure 1: The SQA System Overview

1. Pre-project Components

The Pre-Project component ensures that the project has been adequately defined ensuring that the resources available, budget and so forth have not been misinterpreted by the client or the organisation. This improves the preliminary steps taken prior to initiating work on the project itself, thus leading to fewer errors later in the development phase.

There are two key concepts to this component;

1.1 Contract Review

The Contract Review begins the negotiations of a contract between the company and the client. One of the key focuses is on the areas or points that could go wrong, known as development risks.

The contract ensures that commitments have been documented including an agreement upon the functional specification, budget and the schedule.

The contract review activities must include a detailed examination of the project proposal draft

and the contract draft, each of which have different objectives, to ensure that the commitments have been properly and clearly defined. A checklist is often used by reviewers to make this stage easier and it is expected that the review stage will occur more than once.

The outcome from this stage is a documented agreement between the company and client stating the projects requirements, budgets and so on ensuring that no new changes have been added to the contract draft.

1.2 Development and Quality Plans

The development and Quality Plans stage occurs once an agreement has been made and a software development contract has been signed. The time between a proposal, the contract review and the signing of the contract could be prolonged and during this time changes may occur. Consequently proposal materials need to be revised and new plans are required; a development plan and a quality plan.

The development plan focuses on eleven specific elements, some of which are; the products of the project i.e. software products and design documents specifying deliverables. Project interfaces detailing what, if any, interfaces the product will have with existing software packages. The methodology clearly states which methodology should be used at each phase of the project.

The quality plan has four main elements; however, how many of these are used is dependent upon the project. Quality Goals refers to the goals of the product, it is always better to have more goals as it is easier to see how well the system performs. Planned review activities are a listing of all the planned reviews such as Design Reviews (DR) and Code Inspections. Planned software tests details all the software tests that are to be performed with details such as the unit, integration or complete system to be tested. Finally, planned acceptance tests for externally developed software; this is only necessary for products not developed in-house.

Approval of the two plans is necessary and is approved or rejected according to the procedures within the organisation.

2. *Project Lifecycle Activities and Assessment*

This component has two main stages; 1. The Development Lifecycle stage which aims to detect design and programming errors. 2. The Operation-Maintenance stage focuses on maintenance tasks that improve functionality.

When developing the product there are a number of activities that take place, these are reviews, such as formal design reviews and peer reviews, expert opinions, software testing, software maintenance and finally, the assurance of the quality of external participants' work which ensures that any efforts by

external members meet the quality and standards of the organisation.

The reviews occur during the design phase of the development process and should be conducted at any milestone. The formal Design Review (DR) is a very important document as the project cannot continue until a formal approval by the DR committee has been received. The document itself includes a list of action items (corrections) that are required. The peer review, guided by checklists, standards and past problems, is a document that reviews short documents or sections to attempt to detect design and programming faults documenting a list of its findings.

'Expert Opinions' is the use of an external member to review in-house work; it can reinforce the internal (in-house) quality assurance activities. Although not all organisations may use this approach it is useful for small organisations which may not have sufficient professional capabilities in-house or for a replacement to the regular in-house professional for whatever reasons. The outcome from this is often a document similar to a formal design review.

"Software Testing is a formal process carried out by a specialized team in which a software unit, several integrated software units or an entire software package are examined by running the programs on a computer. All associated tests are performed according to the approved test procedures on approved test cases"

D.Galin (2003)

In general, Software Testing is aimed at reviewing the running and functionality of the software in which the testing is based on a prepared list of test cases.

Software Maintenance specifies three categories in which maintenance for a system can fall into. The first is corrective maintenance in which the correction of failed software, for whatever reason, occurs. The second is adaptive maintenance in which maintenance occurs to the system it needs to be adapted; however the basic functionality of the system is left untouched. Finally, the third is functionality improvement where the system is modified to add improvements, this could significantly change the system compared to the other two points.

3. Infrastructure components for error prevention and Improvement

The main goal of this component is to reduce the number of errors in the system and improve productivity. This is achieved through the use of a number of sub-components.

1. Procedures and Work Instructions

A procedure describes how the process, a specific development activity, is performed whilst a work instruction is more specific and provides detailed directions for the use of methods. Having a

detailed guideline ensures that all members know how to achieve some goal.

"Work instructions and procedures contribute to the correct and effective performance of established technologies and routines"

http://kur2003.if.itb.ac.id/file/SW%20Quality%20Components.pdf

2. Supporting Quality Devices

'Quality Devices' are used to maximise efficiency and quality. A quality device could be a template or a checklist which saves time as the document will be complete and will not have to be developed, from scratch each time.

Using Quality Devices offers an improved form of communication and provides standardisation within the organisation as each document will be of the same nature.

3. Staff Training, Instruction and Certification

Staff training is a vital element to avoiding errors throughout the development of the system. Having well trained professional staff enables efficient and high quality performance from each member.

New staff have to be trained in respect to the standards and procedures of the organisation and existing staff should be re-trained when assignments change.

4. Preventive and Corrective Actions

Studying existing data for similar faults and failures can enable future ones to be solved easily either by correcting it once it has occurred or by preventing it from happening.

The data should be recorded, or found, in design review reports, software test reports or customer complaints. It should be managed effectively so that if it occurs in the future the solution, if one was found, can be easily accessible.

5. Configuration Management

This deals with the dangers of version releases. With intense work focusing on new versions and new software releases dangers arise when different members carry out the same tasks. This can lead to misidentification or the versions or releases or loss of records or development activities.

Configuration management introduces procedures that are used to control the change process and monitor it.

6. Documentation Control

Document Control is necessary to ensure long term availability of controlled documents. Controlled documents are maintained and updated. They are formally approved and contain evidence of the systems performance.

4. Software Quality Management

Quality management not only focuses on product quality but also the means in which it can be

achieved.

Some of the components used to support the managerial control of software development projects are the Project Progress Control, Software Quality Metrics and Software Quality costs.

The aim of Project Progress Control is simply to monitor the progress of the project to ensure that it does not deviate from its initial plans. It focuses particularly on monitoring resource usages, schedules (whether they are being met), risk management activities and the budget.

A Software Quality Metric is a measurement that is used to evaluate software quality in a system. The software is the input, and the output is a numeric value which represents the **degree to which the software possesses a given quality attribute.** The measures can apply to functional quality, productivity and the organization side of the project.

The Software Quality Costs are the costs that incur throughout the entire project; the total cost is calculated from the costs of control and the costs of failure. The organisations main interest is the sum of the total costs which will determine a success or failure.

5. SQA Standards, System Certification, and Assessment Components

This component focuses on using external tools to achieve the, in-house, goals of software quality assurance. There are three main objectives, D.Galin (2003):

1. Utilization of international professional knowledge
2. Improvement of coordination with other organizations quality systems
3. Objective professional evaluation and measurement of the achievements of the organizations quality systems

The standards available to achieve the above objectives can be classified into two sub-classes

1. Quality Management Standards – 'what' is required
2. Project Process Standards – 'how' it is done

The outcome of this component is simply to use external tools, i.e. staff, to achieve the desired in-house software quality assurance complying with the standards of the organization.

6. Organizing for SQA – The Human Components

SQA cannot be directly applied to an organization; instead an organizational base is required. The organizational base is collectively made up of the SQA Unit, SQA trustees, committees and forums along with the continuous support of the management.

The SQA Unit focuses purely on Software Quality Assurance, thus ensuring that all standards, procedures

and components are efficiently and correctly in use. This is, in part, done through the audits and quality programs that the SQA Unit is required to produce.

Management must ensure that all staff are aware of the quality policy, they are required to define sufficient resources and accurately assign an adequate number of staff to the tasks.

The SQA organizational base has three main objects

1. To aid the development and implementation of the SQA system
2. To detect and prevent deviations from organizational standards and procedures
3. To continuously suggest improvements that will benefit the SQA components

How to Design and Implement a Basic Quality Assurance Plan

A quality assurance plan should generally include two basic areas: how to address errors (quality-related events), and how to improve practice before an error occurs (continuous quality improvement). This document outlines steps to take in establishing a QA plan plan.

I. Design a means to effectively document quality-related events (QREs) and educate staff appropriately

1. Collect all relevant details of the event, identify the root cause(s), and make a plan to avoid the same error in the future (consider the example provided on the Board of Pharmacy's website)

2. Always educate staff on documented QREs and their resulting plans. 3. Many errors reported to the Board are due to poor customer service in resolving the issueconsider including training on how to handle an error as part of your plan

II. Identify one or two quality related parameters you would like to measure and improve. You might consider two categories of parameters:

1. Areas known to require improvement. a. These areas may be identified through a previous dispensing or procedural error, a deficiency notice from the Board, or observations of pharmacy staff. b. Monitoring will be with the intent to track successful

improvement.

2. Areas expected to be satisfactory a. These areas may be identified as perceived strengths in your pharmacy. b. The intent of monitoring may be to verify that processes are done correctly and to identify unsuspected weaknesses.

III. Design a method to measure the identified areas. Here are some tips:

1. Focus on quantitative measures that can show clear results

2. Utilize your computer system's capabilities where appropriate

3. Use random samples where appropriate (e.g. you don't necessarily have to go through the entire prescription log book to quantify counseling documentation)

4. Consider a method that can be accomplished in a reasonable amount of time by appropriate staff. Keep it simple.

5. Consider a method that can be done consistently as part of normal procedures.

6. Determine how often the measurement will be repeated and make plans to ensure it is not forgotten.

IV. Set appropriate goals

1. Perfection is not always a realistic goal. Determine what is acceptable for your practice.

2. Set an attainable goal and be prepared to update the goal when it is achieved.

3. Include instructions on what the person taking the measurement should do if the goal is not met (e.g. who to contact)

V. Be prepared to make new plans when goals are not met

1. Set a deadline for when unmet goals will be addressed 2. Be prepared to change policies or procedures in order to improve areas of deficiency

VI. Educate your staff on the Quality Assurance Plan, both at inception and at regular intervals. Include:

1. Why it is being done

2. What is being tracked

3. How to perform measurements

4. Progress in areas being monitored, including improvements implemented as a result thereof

5. Updates on any QREs, including the plan to avoid those errors in the future

VII. Quality assurance never ends

1. Continue to update your plan as necessary. Over time, the entire prescription process can be monitored and improved.

CMM and ISO

The ISO 9000 standards developed by the International Standards Organization are both concerned with quality and process management. The specific ISO standard of concern to software organizations is ISO 9001.

Questions frequently asked are:

- At what CMM level is an ISO compliant organiza- tion?
- Can a Level 2 or (3) organization be considered ISO compliant?
- Should SPI be based on CMM or ISO?

The ISO series of standards is a set of documents dealing with quality systems that can be used for external quality assurance purposes. They specify quality system requirements for use where a contract between two parties requires the demonstration of the supplier's capability to design and supply a product.The two parties could be an external client and a sup- plier, or they could both be internal.

ISO 9000 is a guideline that clarifies the distinctions and interrelationships between quality concepts and provides guidelines for the selection and use of a series of international standards on quality systems that can be used for internal quality management pur- poses (ISO 9004) and for external quality purposes (ISO 9001, 9002, and 9003).

The quality concepts addressed by these standards are:

- An organization should achieve and sustain the qual- ity of the product or service produced to continually meet the purchaser's stated or implied needs
- An organization should provide confidence to its own management that the intended quality is achieved
- An organization should provide confidence to the purchaser that the intended quality is being achieved in the delivered product or service provided

ISO 9001, "Quality systems-Model for quality assur- ance in desig.development, production, installation, and servicing," is the ISO standard that applies to software development and maintenance. There is a guideline, ISO 9000-3, for applying ISO 9001 to soft- ware processes. A British guide [TickIT] for 9001 provides additional guidelines on using ISO9000-3 and 9001 in the software area.

Mapping ISO 9001 to the CMM

Here, twenty clauses of ISO 9001 are mapped to practices of CMM

Clause 4.1 - Management responsibility

Addressed primarily by SQA and partly by SPP and SPTO (Level 2)

Clause 4.2 - Quality system

Addressed primarily by SQA and SPP (Level 2)

Clause 4.3 - Contract review

Addressed primarily by RM and SPP (Level 2)

Clause 4.4 - Design control

Addressed primarily by SPE, SPP, SPTO, and PR (Levels 2 and 3)

Clause 4.5 - Documentation and data control Addressed primarily by

SCM (Level)

Clause 4.6 - Purchasing

Addressed by SSM (Level 2)

Clause 4.7 - Control of customer-supplied product Addressed weakly by ISM (Level 3).

CMM change request written

Clause 4.8 - Product identification and traceability Addressed primarily by SCM and by SPE (Levels 2 and 3)

Clause 4.9 - Process control

Addressed by SPP, SPE, and SQA (Levels 2 and 3)

Clause 4.10 - Inspection and testing Addresses by SPE

and in PR (Level 3)

Clause 4.11 - Control of Inspection, Measuring, and Test Equipment

Addressed by SPE (Level 3)

Clause 4.12 - Inspection and test status Addressed by SPE and SCM (Levels 2 and 3)

Clause 4.13 - Control of nonconforming product Addressed by SPE and SCM (Levels 2 and 3)

Clause 4.14 - Corrective and preventive actions Addressed by SCM and SQA (Level 2)

Clause 4.15 - Handling storage, packaging, and pres- ervation delivery
Addressed partly by SCM, but actual delivery and installation not covered in present CMM (CMM change request written) (Level 2)

Clause 4.16 - Control of quality records
Addressed by SPE, SCM, and PR (Levels 2 and 3)

Clause 4.17 - Internal quality audits
Addressed by SQA (Level 2)

Clause 4.18 - Training
Addressed by TP (Level 3)

Clause 4.19 - Servicing
Not really addressed by CMM since maintenance is not a separate issue in CMM. Will be addressed in next version of CMM

Clause 4.20 - Statistical techniques
Practices described throughout CMM. Perhaps spe- cifically addressed by OPD, QPM, and SQM (Lev- els 3 and 4)

Contrasting ISO 9001 and CMM

Some issues in ISO 9001 are not covered in CMM, and vice versa. The levels of detail differ. Chapter 4 in ISO 9001 is 5 pages long, sections 5, 6, and 7 in ISO 9000-3 comprise 11 pages; CMM is over 500 pages long.

The ISO 9001 clauses with no strong relationship to CMM KPAs are control of customer-supplied prod- ucts and handling, packaging, preservation and deliv- ery

The clause in ISO 9001 that is addresses in CMM in a completely distributed fashion is servicing. There is significant debate about the exact relationships to CMM for corrective and preventive action and statis- tical techniques.

The biggest difference is the emphasis in CMM on continuous process improvement. ISO only addresses minimum criteria for an acceptable quality system.

CMM focuses strictly on software, while ISO 9001 has includes hardware, software, processed materials, and services.

For both CMM and ISO 9001, the bottom line is "Say what you do; do what you say."

Every Level 2 KPA is strongly related to ISO 9001 Every KPA is at least weakly related to ISO 9001

A CMM Level-1 organization can be ISO 9001 certi- fied; that organization would have significant Level-2 process strengths and noticeable Level-3 strengths.Given a reasonable implementation of the software process, a ISO 9001 certified organization should be at least close to CMM Level-2.

Can a CMM Level-3 organization be considered ISO 9001 compliant? Even a Level-3 organization would need to ensure that delivery and installation are addressed, but even a Level-2 organization would have comparatively little difficulty in obtaining ISO 9001 certification.

How ISO 9001 Fits into the Software

World (F. Coallier, *IEEE Software***, Janu- ary 1994)**

ISO 9001 has a strong emphasis on traditional manu- facturing quality control. It assumes products are pur- chased in a formal, contractual environment with detailed specifications that are correct. Such an envi- ronment is not the case for consumer or mass-market products, however, and it is naive to assume such conditions for complex products like those that incorporate software.

CMM/ISO 9001 -1

Software products are inherently complex and chal- lenging to scope, develop, implement, verify, validate, and maintain. This requires a total-quality approach focused on customer satisfaction and continuous improvement. In ISO 9001, continuous improvement is almost totally absent. It merely addresses the control of a nonconforming product and recommends corrective and preventive action.For an organization that develops and manufactures embedded software products, an ISO 9001 certifica- tion tells very little about its software development capability. Certification means only that some basic practices are in place.

CMM is a more comprehensive model to measure software development capability. It covers more pro- cesses and has a five-level rating system that empha- sizes continuous improvement.With ISO 9001, once you are certified, your challenge is only to maintain certification.

CMM can be used as a self-assessment. ISO 9001 certification requires auditors, which places emphasis on opinions of outsiders whose abilities may be unknown or marginal. ISO certification is usually prompted because certification is needed to get contracts. CMM review is usually done to improve and involves a more detailed study than does an ISO review.

ISO 9001 can still be worthwhile if: The auditors are good

- If the organization is CMM Level 1 or 2 because ISO 9001 covers the basics and can help the Organization grow.

The Malcolm Baldrige Criteria for Performance Excellence

In the early and mid-1980s, many industry and government leaders saw the need for a renewed emphasis on quality for doing business in an ever expanding, and more demanding, competitive world market. The Malcolm Baldrige National Quality Award was envisioned as a standard of excellence that would help U.S. organizations achieve world-class quality. The Malcolm Baldrige Criteria for Performance Excellence have played a major role in achieving the goals established for the Baldrige Award. They now are accepted widely, not only in the United States but also around the world, as the standard for performance excellence.

For over 20 years, the Baldrige Criteria have been used by thousands of U.S. organizations to stay abreast of ever-increasing competition and to improve performance. In today's business, health care, education, nonprofit, and government environments, the Criteria help organizations respond to current challenges: openness and transparency in governance and ethics; the need to create value for the business and its customers, patients, or students; and the challenges of rapid innovation and capitalizing on knowledge assets. Whether an organization is small or large, is for-profit or not-for- profit, or has one location or multiple sites across the globe, the Criteria provide a valuable framework that can help plan and achieve in an uncertain environment. The Criteria help to assess performance on a wide range of key business indicators: customer, product and service, financial, human resource, and operational. The Criteria can help to align resources and approaches, such as ISO9000, Lean Enterprise, Balanced Scorecard, Six Sigma, and regulatory requirements; improve communication, productivity, and effectiveness; and achieve strategic goals.

The Criteria are built upon a set of interrelated core values and concepts found in high-performing organizations. These core values and concepts are embodied in seven linked categories. Together they provide the foundation for an organization to integrate key business requirements within a results-oriented framework to create a basis for action and feedback.

The Criteria for Performance Excellence Fact Sheet

What are the Baldrige criteria?

The Baldrige Criteria for Performance Excellence are a framework that any organization can use to improve overall performance. While the Criteria characteristics, goals, and purposes remain constant, the Criteria have evolved significantly over time to help organizations address current economic and marketplace challenges and opportunities.

The Criteria Characteristics:

- Focus on results in all areas of organizational performance to ensure that all strategies are balanced.
- Are non-prescriptive and adaptable to promote creative and flexible approaches for meeting requirements, and to foster incremental and breakthrough improvements.
- Support a systems perspective to maintain organization-wide goal alignment.
- Support goal-based diagnosis on a profile of performance oriented strengths and opportunities for improvement.

Criteria Goals: The Criteria are designed to help organizations use an integrated approach to organizational performance management that results in

- Delivery of ever-improving value to customers, contributing to marketplace success
- Improvement of overall organizational effectiveness and capabilities
- Organizational and personal learning

Criteria Purposes: The criteria are used by thousands of organizations of all kinds for self-assessment and training and as a tool to develop performance and business processes. For many organizations, using the criteria results in better employee relations, higher productivity, greater customer satisfaction, increased market share, and improved profitability. According to a report by the Conference Board, a business membership organization, –A majority of large U.S. firms have used the criteria of the Malcolm Baldrige National Quality Award for self-improvement, and the evidence suggests a long-term link between use of the Baldrige Criteria and improved business performance.‖

In addition, the Criteria have three important roles in strengthening U.S. competitiveness

- To help improve organizational performance practices, capabilities, and results
- To facilitate communication and sharing of best practices information among U.S. organizations of all types
- To serve as a working tool for understanding and managing performance and for guiding organizational planning and opportunities for learning

.

Seven categories make up the award criteria:

- **Leadership**—Examines how senior executives guide and sustain the organization and how the organization addresses Governance, ethical, legal and community responsibilities.
- **Strategic planning**—Examines how the organization sets strategic directions and how it determines and deploys key action plans.
- **Customer focus**—Examines how the organization determines requirements and

expectations of customers and markets; builds relationships with customers; and acquires, satisfies, and retains customers.

- **Measurement, analysis, and knowledge management**—Examines the management, use, analysis, and improvement of data and information to support key organization processes as well as how the organization reviews its performance.
- **Workforce focus**—Examines how the organization engages, manages, and develops all those actively involved in accomplishing the work of the organization to develop full potential and how the workforce is aligned with the organization's objectives.
- **Process management**—Examines aspects of how key production/delivery and support processes are designed, managed, and improved.
- **Results**—Examines the organization's performance and improvement in its key business areas: customer satisfaction, financial and marketplace performance, workforce, product/service, and operational effectiveness, and leadership. The category also examines how the organization performs relative to competitors.

Core Values and Concepts: The Criteria are built on a set of interrelated, embedded beliefs and behaviors found in high-performing organizations. The core values and concepts are the foundation for integrating key business requirements within a results-oriented framework that creates a basis for action and feedback.

Why Baldrige?

Why should an organization consider using the Baldrige Criteria?

Baldrige is the most comprehensive management framework available. It enables leaders to understand all of the internal and external forces that drive their business; to prioritize, enhance, and improve what is critical to success; and to select the courses of action that achieve, increase, and sustain the best possible overall performance. In short, implementing the Baldrige Criteria guide organizations to do the right things, at the right time, and in the right way.

Baldrige works for all types and sizes of organizations because it asks the questions that all high performing organizations consider and leaves the answers to those who can best determine them – the people who work in the organization. The knowledge gained promotes creativity and flexibility to order to deliver ever-improving value to customers and improve organizational effectiveness and capabilities.

Baldrige works if:

1) Leaders and the organization have the willingness and ability to develop an organizational culture based on the 11 core values of high performing organizations defined by the Criteria.
2) Leaders and the organization are willing to commit to a long-term journey of continuous learning and improvement.

What are the benefits compared to other tools and management systems?

Baldrige has a true systems perspective – it looks at all components of an organization with equal emphasis and focuses on how each part impacts and links with the others. It helps leaders align and integrate their leadership, strategy, customer & market focus, data analysis & knowledge management, workforce, and process management systems to produce the best overall results. Most other tools and management systems focus on one or a few of these components more than the rest. Other tools and management systems complement Baldrige and can provide more detailed guidance on ‑how‖ to implement than Baldrige does. Using Baldrige as your management system will help you determine which of these tools will most benefit your organization and when.

CMMI Representation

CMMI enables you to approach process improvement because it provides the latest best practices for product and service development and maintenance. The CMMI best practices enable organizations to do the following: • More explicitly link management and engineering activities to their business objectives • Expand the scope of and visibility into the product lifecycle and engineering activities to ensure that the producer or service meets customer expectations • Incorporate lessons learned from additional areas of best practice (e.g.,

measurement, risk management, and supplier management) • Implement more robust high maturity practices • Address additional organizational functions critical to their products and services • More fully comply with relevant ISO standards

Levels of the Capability Maturity model

There are five levels defined along the continuum of the CMM, and, according to the SEI: "Predictability, effectiveness, and control of an organization's processes are believed to improve as the organization moves up these five levels. While not rigorous, the empirical evidence to date supports this belief."

Level 1 Initial It is characteristic of processes at this level that they are (typically) undocumented and in a state of dynamic change, tending to be driven in an ad hoc, uncontrolled and reactive manner by users or events. This provides a chaotic or unstable environment for the processes.

Level 2 – Managed It is characteristic of processes at this level that some processes are repeatable, possibly with consistent results. Process discipline is unlikely to be rigorous, but where it exists it may help to ensure that existing processes are maintained during times of stress.

Level 3 – Defined It is characteristic of processes at this level that there are sets of defined and documented standard processes established and subject to some degree of improvement over time. These standard processes are in place (i.e., they are the AS-IS processes) and used to establish consistency of process performance across the organization.

Level 4- Quantitatively Managed It is characteristic of processes at this level that, using process metrics, management can effectively control the AS IS process (e.g., for software development). In particular, management can identify way to adjust and adapt the process to particular projects without measurable losses of quality or deviations from specifications. Process capability is established from this level.

Level 5- Optimizing It is a characteristic of processes at this level that the focus is on continually

improving process performance through both incremental and innovative technological changes/ improvements. At maturity level 5, processes are concerned with addressing statistical common causes of process (for example, shifting the mean of the process performance) to improve process performance. This would be done at the same time as

maintaining the likelihood of achieving the established quantitative process improvement objectives.

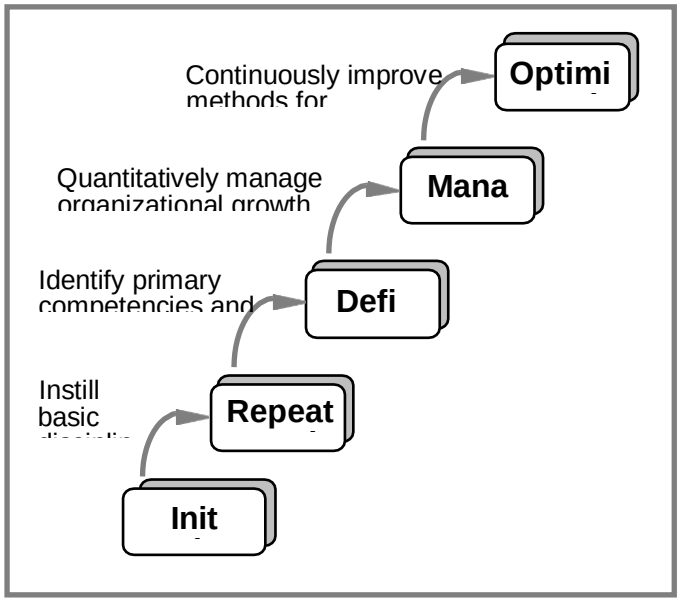
Definition of the P-CMM Maturity Levels

As a capability maturity model, the P-CMM guides organizations in establishing and improving their workforce practices through five evolutionary stages. Achieving each maturity level in the P-CMM institutionalizes new capabilities for developing the knowledge and skills of the workforce, resulting in an overall increase in the talent of the organization. Growth through the maturity levels creates fundamental changes in how people are developed and organized and in their working culture.

Figure 2.1 depicts the five maturity levels of the P-CMM. Each maturity level provides a layer in the foundation for continuous improvement of an organization's workforce practices. In maturing from the Initial to the Repeatable level, the organization installs the discipline of performing the basic practices. In maturing to the Defined level, these practices are tailored to enhance the particular knowledge, skills, and work methods that best support the organization's business. In maturing to the Managed level, the organization develops competency-based, high-performance teams and empirically evaluates how effectively its workforce practices are meeting objectives. In maturing to the Optimizing level, the organization looks continually for innovative ways to improve its workforce capability and to support individuals in their pursuit of professional excellence.

Level 1 - The Initial Level

At the Initial level, the performance of workforce activities is inconsistent. The organization typically provides forms for activities such as performance appraisals or position requisitions, but offers little guidance or training in conducting the activities supported by these forms. Typically managers have not been trained in performing most of their workforce responsibilities, so their ability to manage those who report to them is based on previous experience and their personal "people skills." These organizations are not necessarily abusive or inconsiderate. Their problem is that they do not have the ability to



systematically develop the competitive capability of their workforce.

Figure 2.1 The Five Maturity Levels of the P-CMM

In the worst circumstances, managers in Level 1 organizations do not accept developing the members of their unit as a primary personal responsibility. They perform workforce activities such as interviewing job candidates or conducting performance appraisals with little preparation, often resulting in poor staffing decisions or disgruntled employees. The human resources department too often imports practices and applies them with little analysis of their effectiveness. Individuals in most Level 1 organizations do not take workforce practices seriously, since they do not believe the practices have much relation to their real work and level of contribution to the organization.

The workforce capability of a Level 1 organization is unknown, since there is little effort to measure or improve it. Individuals are motivated to pursue their own agendas, since there are few incentives in place to align their motivations with the business objectives of the organization. Turnover is high when people feel there are better working conditions or growth potential in another organization. Consequently, the level of knowledge and skills available in the organization does not grow over time because of the need to replace experienced and knowledgeable individuals who have left the organization.

Level 2 - The Repeatable Level

The primary objectives at the Repeatable level are to eliminate problems that keep people from being able to perform their work responsibilities effectively and to establish a foundation of workforce practices that can be continuously improved in developing the workforce. The most frequent problems that keep people from being able to perform effectively in low- maturity organizations include

- environmental distractions
- unclear performance objectives
- lack of relevant knowledge or skill
- poor communication

In maturing to the Repeatable level, an organization establishes policies that commit it to developing its people. A primary objective in achieving a repeatable capability is to establish a sense of responsibility and discipline in performing basic workforce practices. These practices ensure that the people in each unit will have the knowledge and skills required to perform their current assignment. When these practices are institutionalized, the organization has laid a foundation on which it can build improved methods and practices.

At the Repeatable level, those who have been assigned responsibility for

performing workforce activities accept personal responsibility for ensuring that all workforce practices are implemented effectively. In doing so, they accept the growth and development of their staff as a primary responsibility of their position. When people take their workforce responsibilities seriously, they begin to develop repeatable methods for performing specific activities such as interviewing or establishing performance criteria. Individuals will notice greater consistency in the performance of workforce functions within their group, although different managers or groups may have individual variations in the specific methods they use.

The effort to implement improved workforce practices begins when executive management commits the organization to constantly improve the knowledge, skills, motivation, and performance of its workforce. The organization states that the continuous development of its workforce is a core value. The organization documents policies and develops basic workforce practices that the units will implement. Units develop plans for satisfying their workforce needs and responsibilities. These initial needs are in the areas of the work environment, communication, staffing, performance management, training, and compensation. Until these basic workforce practices become institutionalized, the organization will have difficulty adopting more sophisticated workforce practices.

Level 3 - The Defined Level

Organizations at the Repeatable level find that although they are performing basic workforce practices, there is inconsistency in how these practices are performed across units. The organization is not capitalizing on opportunities to standardize its best workforce practices, because it has not identified the common knowledge and skills needed across its units and the best practices to be used for developing them. The organization is motivated to achieve the Defined level in order to gain a strategic competitive advantage from its core competencies.

At the Defined level, the organization begins to adapt its workforce practices to the specific nature of its business. By analyzing the skills required by its workforce and the

business functions they perform, the organization identifies the core competencies required to perform its business. The organization then adapts its workforce practices to develop the specific knowledge and skills that compose these core competencies. The organization identifies best practices in its own workforce activities or those of other organizations and tailors them as the basis for adapting its workforce practices.

The organization analyzes its business processes to determine the core competencies involved in its work and the knowledge and skills that constitute these competencies. The organization then develops strategic and near-term plans for developing these competencies across the organization. A program is defined for systematically developing core competencies, and individuals' career development strategies are planned to support competency development for each individual. The organization administers its workforce practices to develop and reward growth in its core competencies and to apply them to improve performance.

A common organizational culture can develop at the Defined level, because the organization becomes focused on developing and rewarding a set of core competencies. This culture places importance on growing the organization's capability in its core competencies, and the entire workforce begins sharing responsibility for this growth. Such a culture is reinforced when workforce practices are adapted to encourage and reward growth in the organization's core competencies. This culture can be enhanced by establishing a participatory environment where individuals and groups are involved in decisions regarding their work.

The workforce capability of organizations at the Defined level is based on having a workforce that possesses the basic knowledge and skills to perform the core business functions of the organization. Knowledge and skills in the organization's core competencies are more evenly spread across the organization. The organization has improved its ability to predict the performance of its work activities based on knowing the level of knowledge and skills available in its workforce. Also, it has established a foundation on which continuous development of knowledge and skills can be built.

Level 4 - The Managed Level

Organizations at the Defined level have established the foundation for continuously improving their workforce. At the Managed level, the organization takes the first steps in capitalizing on managing its core competencies as a strategic advantage. It sets quantitative objectives for growth in core competencies and for the alignment of performance across the individual, team, unit, and organizational levels. These measures establish the quantitative foundation for evaluating trends in the capability of the organization's workforce. Further, it seeks to maximize the effectiveness of applying these competencies by developing teams that integrate complementary knowledge and skills.

At the Managed level, high-performance teams composed of people with complementary knowledge and skills are developed where conditions support their functioning. Team-building activities are performed to improve the effectiveness of these teams. When applied to teams,Workforce practices are tailored to support team development and performance.

Mentors are made available to both individuals and teams. Mentors use their experience to provide personal support, guidance, and some skill development. Mentors also provide another way to retain and disseminate lessons learned across the organization. Organizational growth in each of the organization's core competencies is quantitatively managed. Data on the level of core competencies in the organization are analyzed to determine trends and capability. These competency trends are then used to evaluate the effectiveness of competency-related workforce practices. In addition, performance data are collected and analyzed for trends in the alignment of performance at the individual, team, unit, and organizational levels. Trends in the alignment of performance are used to evaluate the effectiveness of performance-related workforce practices. These trends are tracked against the objectives set in the strategic and near-term workforce plans.

The workforce capability of Level 4 organizations is predictable because the current capability of the workforce is known quantitatively. The organization has also developed a mechanism for deploying its competencies effectively through high-performance, competency-based teams. Future trends in workforce capability and performance can be predicted because the capability of the workforce practices to improve the knowledge and skills of the workforce is known quantitatively. This level of workforce capability provides

the organization with an important predictor of trends in its business capability.

Level 5 - The Optimizing Level

At the Optimizing level, there is a continuous focus on improving individual competencies and finding innovative ways to improve workforce motivation and capability. The organization supports individuals' effort toward continuous development of personal competencies. Coaches are provided to support further development of personal or team competencies.

Data on the effectiveness of workforce practices are used to identify needs for innovative workforce practices or technologies. Innovative practices and technologies are evaluated and the most promising are used in exploratory trials. Successful innovations are then transferred into use throughout the organization.

The workforce capability of Optimizing organizations is continuously improving because they are perpetually improving their workforce practices. Improvement occurs both by incremental advancements in their existing workforce practices and by adoption of innovative practices and methods that may have a dramatic impact. The culture created in an Optimizing organization is one in which all members of the workforce are striving to improve their own, their team's, and their unit's knowledge, skills, and motivation in order to improve the organization's overall performance. The workforce practices are honed to create a culture of performance excellence.

Six Sigma

Six Sigma is one of the most popular quality methods lately. It is the rating that signifies "best in class," with only 3.4 defects per million units or operations (DPMO). Its concept works and results in remarkable and tangible quality improvements when implemented wisely. Today, Six Sigma processes are being executed in a vast array of organization and in a wide variety of functions. Fueled by its success at large companies such as Motorola, General electric, Sony, and Allied Signal, the methodology is proving to be much than just a quality initiative.

Why are these large companies embracing Six Sigma? What makes this methodology different from the others?

The goal of Six Sigma is not to achieve six sigma levels of quality, but to improve profitability. Prior to Six Sigma, improvements brought about by quality programs, such as Total Quality Management (TOM) and ISO 9000, usually had no visible impact on a company's net income. In general, the consequences of immeasurable improvement and invisible impact caused these quality programs gradually to be. Six Sigma was originally developed as a set of practices designed to improve manufacturing processes and eliminate defects, but its application was subsequently extended to other types of business processes as well In Six Sigma, a defect is defined as anything that lead to customer dissatisfaction.

• Six Sigma stands for six standard deviation from mean (sigma is thee Greek letter used to represent standard deviation in statistics).

• Six Sigma methodologies provide the techniques and tools to improve the capability and reduce the defects in any process.

• Six Sigma strives for perfection. It allows for only 3.4 defects per million opportunities (or 99.999666 percent accuracy)

• Six Sigma improves the process performance decrease variation and maintains consistent quality of the process output. This leads to defect reduction and improvements in profits, product quality and customer satisfaction.

• Six Sigma incorporates the basic principles and techniques used in business, statistics and engineering.

• The objective of Six Sigma principle is to achieve zero defects products/ process. It allows and engineering.

• The objective of Six Sigma principle is to achieve zero defects products/ process. It allows 4.4 defects per million opportunities.

Features that St Six Sigma

Apart from previous quality improvement initiatives include— • A clear focus on achieving measurable and quantifiable financial returns from any Six Sigma project. • An increased emphasis on strong and passionate management leadership and support. • A special infrastructure of " Champions, " " Master black Belts, " "black Belts, " etc. to lead and implement the Six Sigma approach. • A clear commitment to making decisions on the basis of verifiable data, rather than assumptions and guesswork.