CHAPTER 2: Software Quality Standards

In this section the key work and terms used in this report will be defined. Further more the concept behind the software quality standards (e.g. for SEI, ISO and SPICE) will be defined. This section will also provide a brief overview of the quality standards in discussion. Finally the trend of the software development will be discussed.

2.1 Software Quality Standards

It's worth noticing the Quality Function Deployment (QFD). QFD is a system for designing a product or service, and the processes that go into its production is based on customer needs and expectation (Gilmour, Hunt , 93, P 79). The American Supplier Institute defines QFD as 'a system for translating customer requirements into appropriate company requirements'. Its intents to incorporate the Voice of customers (VOC) in all phases of the product development/modification cycle through production and into the marketplace.

There is no common definition of a Software Quality. Even the existing software quality standards available (such as ISO, SEI and SPICE) do not have a consistent definition. Apart from a software quality definition, quality itself have many definitions. For this research report the software quality definition adopted is that put forward by Ralph (96). He defines quality as the "ability of a product, including a service to meet or to exceed customer expectation." (Ralph,96) . Hence the IT Quality can be deduced as " the ability of a software product to meet or exceed a customer's expectation".

The definition of ISO will be taken from the publication of SIRIM who defines the quality standards, assesses and certifies firms for the ISO certification for Malaysia (also referred to as MS ISO). The reason for selecting the MS ISO is because they are supported by the Organization of Internal Standards (ISO) and recognized by the Malaysian government.

This chapter is divided into a 2 sub section that will describe the meaning of IT Quality, the main types of quality standards that exist, IT quality standards requirement of ISO9000, SEI and SPICE, what is ISO15504. The CMM model is discussed here too.

An article "Does quality have its limits" (Younis 97) identifies 3 groups categorized that influence the quality limits. The 3 groups are: where limiting factors are influenced by customers; where limiting factors are influenced by customers and suppliers, and; where limiting factors are not influenced by the customers. Younis further identified and examined the limiting factors which he identified as: customer awareness, conceptual limits, the limits of tolerance, limits imposed by personal and collective values, the limits of empowerment, commercial limits, the politics of quality and structural limits.

2.2 ISO software Quality Standards

ISO 9000 is an internationally recognized series of Quality System Standards that are adopted by many countries as National Standards and is used as a framework for a continuous improvement and is the most widely used quality standard.

ISO 9000 is a group of generic standards which specify: "what should be in a company's quality system", whatever the product or service, whether it is a small or a large company. Set by the International Standards Organization (ISO) in Geneva, the European Community (EC) chose ISO 9000 standards in 1989 to provide a universal framework for quality assurance among its 12 member-nations.

ISO 9000 series consists of five (5) parts :-

- ISO 9000: provides some basic definitions and is a guide to the four (4) other standards.

- ISO 9001: (1994) Quality Systems -model for Quality Assurance in research, design, build, ship, install and service products.
- ISO 9002: (1994) Quality Systems - model for Quality Assurance in production, installation and servicing. This standard is particularly relevant to process industries, such as chemicals and food, where requirements for products are stated in terms of an established design or specification.
- ISO 9003: (1994) Quality Systems - model for Quality Assurance in final inspection and testing. This standard concerns equipment distributors that inspect and test the products they supply or laboratories.
- ISO 9004: Quality Management & Quality System Elements - contains general guidelines for developing and implementing the kinds of quality management systems defined in ISO 9001, 9002 and 9003.

ISO 9000-1 (Quality Management and Quality Assurance Standards Part 1: Guidelines for selection and use) and ISO 9000-4 (Quality Management & Quality System Elements Part 1: Guidelines) are the non-Contractual Parts of ISO 9000 series

A broad scope of quality system elements are covered by ISO 9000 series, such as: management responsibility, contract review, document control, purchasing, process control, inspection and testing, design control, control of non-conforming products, corrective action, handling, storage, packaging and delivery, quality records, internal quality audits, training and servicing.

Of the ISO standards that will be covered within the scope of this thesis are the ISO 9001 standards and the underdevelopment ISO 15504 Standards. Both these standards (ISO 9001 and ISO 15504) identifies the software quality standards. For this thesis the MS (Malaysian Standards) ISO 9001

(MS ISO 9001, 1994) will be referred. There is no equivalent of the MS for ISO 15504.

The 20 Quality System element (requirement) as per defined in the MS ISO 9001 Software quality Standards is summarized as below:

Section (elements)	Description
4.1	Management Responsibility
4.2	Quality System
4.3	Contract Review
4.4	Design Control
4.5	Document and data control
4.6	Purchasing
4.7	Control of customer supplied product
4.8	Product Identification and traceability
4.9	process Control
4.10	Inspection and Testing
4.11	Control of inspection, measuring and test equipment
4.12	Inspection and test status
4.13	Control on nonconforming product
4.14	Corrective and preventive action
4.15	handling, storage, packaging, preservation and delivery
4.16	Control of quality records
4.17	Internal Quality Audit
4.18	Training
4.19	Servicing
4.20	Statistical techniques

The details of each sections above are beyond the scope of this thesis and shall not be dealt in depth unless if there is a need to do so.

2.3 SEI/CMM Software Quality Standards

Most of the CMM definitions and explanations are taken from Dymond's (1995) book "A Guide to the CMM". Dymond's work is in line with Paulk's work which is in line with the SEI, Carnegie Mellon University definition of SEI. In addition the CMM definition is somewhat universally accepted (because of the sound definition by SEI to remove ambiguity).

In this report the phrase SEI/CMM, CMM or SEI will be used interchangeable and they all mean the same referring to the Capability maturity Model (CMM) developed by SEI (Software Engineering Institute)

In 1982 the U.S. Functions of Defense formed a joint service task force to review it's software problems. This resulted in the establishment of the Software Engineering Institute (SEI) at Carnegie Mellon University in December 1984. Beginning in 1986, the SEI and the Mitre Corporation, led by Watts Humphery, began developing a process maturity framework (Humphrey, 89). That initial work has now become the Capability Maturity Model V1.1 (CMM). The CMM consists of two documents, the model (tr24) and a key practices document (tr25). The model describes the framework of the CMM and outlines the Key Practice Area's. The key practice's documents, describes the Key Practice Areas in more detail.

The Software Engineering Institute (or SEI in short) is a federally funded research and development center sponsored by the US functions of Defense through the Office of the Under Secretary of Defense for Acquisition and Technology . The SEI contract was competitively awarded to Carnegie Mellon University in December 1984. The reason Software Engineering Institute (SEI) was established was to advance the practice of software engineering because quality software that is produced on schedule and within budget is a critical component of the U.S. defense systems. The SEI mission is to provide leadership in advancing the state of the practice of software engineering to improve the quality of systems that depend on software.

The goal of software process management is to enable an organization to produce software that meets cost, schedule, and quality objectives to cultivate an ability to produce better software (Humphrey, 89).

SEI treats the entire software development effort as a process that can be controlled, measured, and improved. Therefore, an organization must have a clear goal and understanding of the measures of improvement in the software development process that can be reasonably attained. An assessment of the development process establishes the company present position for improvement priorities. The SEI, using the above principles, is helping organizations develop effective software processes.

The goals of CMM are: commitment to perform, ability to perform, Activities Performed, Measurement and Analysis and Verifying Implementation. Commitment to Perform describes the actions the organization must take to ensure that the process is established and will endure. It typically involves establishing organizational policies and getting senior management sponsorship and commitment. The Ability to Perform describes the preconditions that must exist in the project or an organization to implement the software process competently. It typically involves resources, organizational structures, and training. Activities Performed describes the roles and procedures necessary to implement a key process area. It involves establishing plans and procedures, performing the work, tracking it, and taking corrective actions as necessary. Measurement and Analysis describes the need to measure the process and analyze the measurements. It includes examples of the measurements that could be taken to determine the status and effectiveness of the Activities Performed. Verifying Implementation describes the steps to ensure that the activities are performed in compliance with the process that has been established. It encompasses reviews and audits by management and software quality assurance.

SEI CMM is very new to countries outside the United States and hence a brief introduction to this is a must. This section will list what are SEI and CMM and

what are the quality initiatives for these. A brief history of SEI will be listed (since it is not well known outside the US)

The main accomplishment of the SEI was the move of the evolution of software engineering from an ad hoc, labor-intensive activity to a discipline that is well managed and supported by technology.

Within these broad areas of work, the SEI has defined specific initiatives that addresses pervasive and significant issues impeding the ability of organizations to acquire, build, and evolve software-intensive systems predictably on time, within expected cost, and with expected functionality.

CMM surround around Mature and Immature software organizations. It identifies the fundamental concept that underlines the process maturity. It categorizes software process maturity into 5 levels namely

- Initial Maturity Level
- Repeatable Maturity Level
- Defined Maturity Level
- Managed Maturity Level
- Optimizing Maturity Level

CMM categorizes an organization into one of 5 levels of organizational maturity for Software Development organizations. The 5 software maturity levels are: Initial, Repeatable, Defined, Managed, and Optimizing. Within each of these maturity levels there are specific key process areas (KPA) that characterizes that level. Each KPA consists of Goals, Commitment, Ability, Measurement, and Verification. SEI CMM uses these guidelines to access the maturity of an organization. The maturity levels are also used as a roadmap for advancement in the maturity of the software development organization. Once you have been assessed, you can then look to your shortcomings and strive to reach the next level. They KPAs are organized so that the KPAs of a level build on the structure/processes built up in the previous level.

SEI Level 1 (or the initial software maturity level) is the starting point for all firms. Organizations in these level are referred to as chaotic and at the lowest level of the software maturity level. There are no KPAs attached to this level and all organizations fall in this level before it is accessed.

SEI Level 2 or the 'Repeatable' maturity level are organizations that have excelled in reusability of its tools and processes. The KPAs for these level are as follows:

- Requirements Management
- Software Project Planning
- Software Project Tracking and Oversight
- Software Sub-Contract Management
- Software Quality Assurance
- Software Configuration Management

SEI Level 3 or the 'Defined' maturity level are organizations that have excelled in the following areas. Organizations in this level are said to be organized. The KPAs for these level are as follows:

- Organization Process Focus
- Organization Process Definition
- Training Program
- Integrated Software Management
- Software Product Engineering
- Inter-group Coordination
- Peer Reviews

SEI Level 4 or the 'Managed' maturity level are organizations that have excelled in the following areas. Organizations in this level are said to be organized. The KPAs for these levels are as follows:

- Process Measurement and Analysis
- Quality Management

SEI Level 5 or the 'Optimizing' maturity level are organizations that have excelled in the following areas. Organizations in this level are said to be optimizing their IT resources. The KPAs for these level are as follows:

- Defect Prevention
- Technology Innovation
- Process Change Management

The Goals for Each Key Process Area (KPA) is as follows:

- KPA for Level 2: Repeatable
- KPA for Level 3: Defined
- KPA for Level 4: Managed
- KPA for Level 5: Optimizing

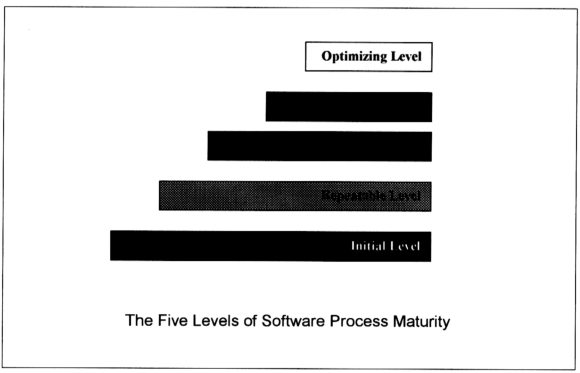
The table and picture that follows define the summary view of the SEI levels.

SEI LEVEL	Maturity Level	Key Process Area (KPA) (or Key Practices)
1	Initial	< None>
2	Repeatable	• Requirements Management, • Software Project Planning, • Software Project Tracking, • Software Subcontract Management, • Software Quality Assurance and • Software Configuration Management.
3	Defined	• Organization Process Focus • Organization Process Definition • Training Program • Integrated Software Management • Software Product Engineering

		• Inter-group Coordination • Peer Reviews
4	Managed	• Quantitative Process Management • Software Quality Management
5	Optimizing	• Defect Prevention • Technology Change Management • Process Change Management

Table : SEI MATURITY LEVEL and corresponding KPA

SEI/CMM levels can be pictorial represented as in the following diagram that follows.



The Five Levels of Software Process Maturity

According to Paulk (94) finding SEI and ISO 9001 are almost complimentary, and the only difference is that SEI tend to show greater strength in IT proactive.

2.4 SPICE software Quality Standards

SPICE refers to the new ISO standards, namely ISO 15504, its the ISO version of CMM called SPICE, and provide the framework for: Information Technology - Software Process Assessment. This ISO standard have not been officially released yet. SPICE definition is pretty much established by Organization of International Standards (ISO) and was built on the merger of the SEI-CMM (version 1.1) and the ISO 9001. Clifford's Inwood (Inwood, 93) defines SPICE (which stands for: Software Process Improvement and Capability Determination) as a new software engineering that uses ISO (International Standards Organization) as it's basic foundation (that from the top-level umbrella Document) attempts to identify the lower level documents and their relationships. SPICE includes process assessment, capability evaluation, and assessor training and quality guides. Much of the material will be drawn from the process maturity model developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. To overcome the conceptual flaws of SEI, SPICE will need to define process models for each project class. Focusing on applicable activity sets, it associates them with typical classes of projects. This will enable more legitimate comparisons. Maturity could then be defined based on the productivity and quality levels achieved.

The results of this study drove the establishment of the SPICE (Software Process Improvement and Capability dEtermination) project in 1993 to standardize and improve on the existing software assessment methodologies. The SPICE project is currently developing the ISO/IEC 15504 standard to address all processes involved in software acquisition, development, operation, supply, maintenance, and support and has been created to be aligned closely with ISO/IEC 12207:1995 "Software Life Cycle Processes." Twenty-three requirements were addressed in the first working draft published in June 1995.

This ISO 15504 standard is intended to be homogenous with the ISO 9000 and the SEI-CMM model.

2.5 Software Industry's Trend Analysis

One must not solely depend on the SWOT analysis to determine if the existing software quality standards are suitable for today and tomorrow. Some of the trends will show the weaknesses and strengths of ISO and SEI standards. Hence before performing SWOT analysis let's look at the trends of Information Technology.

There are three external forces that are causing the quality professions to rapidly transform as we head towards the 21st century, and they are (Wilson,96) :

- Technological changes
- Shift in product, service and market
- Increasing economic competitiveness

Information Technology (IT) is also changing the world's global shopping malls, giving customers the world best power of choice. The trend and requirement of the world class companies is to have 3 C's: concept (best/latest ideas/technology), competence (ability to execute) quality standard, and connections (Kanter, 96) . IT will be the tool of the 21st century to improve quality, reducing cycle time, providing convenience and increasing consumer choices.

Some of the visible trends in the software industry that can be summarized are: the emerging new programming tools (such as OOD); the new CASE tools (software development methodology); new emerging ; new emerging organizational structure changes and; emerging new tools for business such as GAME theory (Brandenburger, Nelebuff, 1995) . The key elements in the GAME theory are: player, added values, rules , tactics and scope. None of these elements are part of the software quality standards to give the competitive edge for those using this theory (which is becoming a greater part in our present business world).

New Programming Tools and Languages

The new 5th Generation IT languages that uses the OOP/OOD (Object Oriented Programming and design) technology is revolutionizing the software industry. These tools have drastically reduced software development cycle time as compared to the 3rd Generation programming languages. Most of the 3rd generation applications are converted on these new platforms. The current software quality standards do not seem to be very active in defining standards for the 4th and 5th programming languages. Applying the SEI/ISO or SPICE quality standards are proving to be quite an overhead and costly on the whole software development process.

In addition, the 5th Generation software languages tends to define their own quality standards where in many cases have a direct conflict with the ISO and SEI ones. For instance the definition of 'project plan' in the MS Project and the SEI /ISO are not the same.

New Software Development Tool (CASE tools)

The software development life cycle is generally defined as 3 main phases namely: Analysis, Design, Build and Implement (Pressman, 86). The analysis CASE (computer-aided software engineering) tools automates all the first 3 phases resulting in auto generating an application from the design phase definition (leaving programmers out of the picture). The "non-human" programmer (in this case the CASE tools) is not at all considered by any of the 3 software quality standards in discussion. There are studies such as that of Holsing & Yen (97) that have stated that CASE tools (and OOP), if their potentials are fully exploited, will dramatically influence software development methodologies resulting in reducing software cost and improving software quality.

Trend: New Technology

New technology such as Virtual Reality and Artificial Intelligence are emerging and more will come. The pioneer in grasping this new technology will be the leaders (at least for a start – like Netscape). Unfortunately the biggest

weakness of the existing software quality standards is that it does not have an element to promote technology innovation. According to Datamation's annual Information Technology Outlook survey, IS managers are concentrating on improving company productivity, quality, and general competitiveness (Moad, 94) .

Organizational Structure and formation

New organizational structures are emerging. Organizations are also decentralizing their operations. New terms such as "Organic organizational Structure", the "global organization structure" are emerging. IT functions form an integral part of these organizations. If the IT functions are not placed in the right place it will lose its focus in creating quality system and may be more ad-hoc in nature and not optimizing. These definitions of the SEI and ISO standards refer more to the hierarchical structured organizations and not the emerging new organizational structures.

New Marketing Analysis tool

One new emerging analysis tool that has an impact on the firm's Corporate Governance and ultimately the marketing plan is the GAME Theory. The GAME theory has a completely new focus and in a way does not support the ISO/SEI (or any other existing standards). One of the reasons is the high overhead and without long waiting time before positive results are seen.