THESIS

USING CAPABILITY MATURITY MODEL TO ASSESS THE EFFECTIVENESS OF ISO 9001:2000 IMPLEMENTATION: CASE STUDY AT SANYO SEMICONDUCTOR (THAILAND) CO., LTD.

SAKULRAT SONGNISAI

GRADUATE SCHOOL, KASETSART UNIVERSITY

2008

THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Engineering (Engineering Management)

DEGREE

Engineering Management — **FIELD**

Industrial Engineering — **DEPARTMENT**

TITLE: Using Capability Maturity Model to Assess the Effectiveness of ISO 9001:2000 Implementation: Case Study at Sanyo Semiconductor (Thailand) Co., Ltd

NAME: Ms. Sakulrat Songnisai

THIS THESIS HAS BEEN APPROVED BY

THESIS ADVISOR

(Associate Professor Kongkiti Phusavat, Ph.D.)

COMMITTEE MEMBER

(Mr. Pornthep Anussornnitisarn, Ph.D.)

COMMITTEE MEMBER

(Assistant Professor Pirawat Watanapongse, Ph.D.)

DEPARTMENT HEAD

(Associate Professor Anan Mungwattana, Ph.D.)

APPROVED BY THE GRADUATE SCHOOL ON .....

DEAN

(Associate Professor Gunjana Theeragool, D.Agr.)

THESIS

USING CAPABILITY MATURITY MODEL TO ASSESS THE EFFECTIVENESS OF ISO 9001:2000 IMPLEMENTATION: CASE STUDY AT SANYO SEMICONDUCTOR (THAILAND) CO., LTD

SAKULRAT SONGNISAI

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Engineering (Engineering Management)
Graduate School, Kasetsart University
2008

Sakulrat Songnisai 2008: Using Capability Maturity Model to Assess the Effectiveness of ISO 9001:2000 Implementation: Case Study at Sanyo Semiconductor (Thailand) Co., Ltd. Master of Engineering (Engineering Management), Major Field: Engineering Management, Department of Industrial Engineering. Thesis Advisor: Associate Professor Kongkiti Phusavat, Ph.D. 100 pages.

This research illustrates the application of the System Engineering – Capability Maturity Model (SE-CMM) for maintaining and improving the Quality Management System (QMS) of ISO 9001:2000 implementation. This research takes place at Sanyo Semiconductor (Thailand) or the SSTH during June – December 2007 with extensive support and cooperation from its top management. The checklist, adapted from the SE-CMM and uniquely designed for the SSTH, is developed to evaluate the strength of ISO 9001:2000 implementation among the organization's core functional units.

The results show that the Production functional unit exceeds the SE-CMM level 4. The overall findings are generally consistent with top management's viewpoint. The research benefits include the ability to maintain and strengthen the organization's QMS, to facilitate knowledge sharing in regard to ISO 9001:2000 implementation across core functional units. Furthermore, the SE-CMM framework helps prepare the organization for a future accreditation (on top of certification). In conclusion, the SE-CMM helps maintain and strengthen the SSTH's QMS.

_____ _____ ___ / ___ / ___

Student's signature Thesis Advisor's signature

ACKNOWLEDGEMENTS

I would like to grateful thank and deeply indebted to Associate Professor Dr. Kongkiti Phusavat, my thesis advisor for advice, encouragement and valuable suggestion for completely writing of thesis. I would sincerely like to thank Dr. Pornthep Anussornnitisarn, and Assistant Professor Dr. Pirawat Watanapongse my committees, and also Associate Professor Dr. Mongkol Raksapatcharawong from Graduate School for their valuable comments and suggestion.

I would sincerely like to thank Sanyo Semiconductor (Thailand) Co., Ltd., which provided all data for this research, all of the organization's executives who commented on the research applicability, and all of organization staffs who helped for gathering the data.

I would heartfelt like to thank Mr. Montian Putphan, Mr. Rattapoom Jirakajorn, and Mr. Teeradet Soontornwipat for their enthusiastic support and assistance.

I am especially appreciated my parents, my brother, and all of my friends for their continuing encouragements.

Sakulrat Songnisai

May 2008

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF ABBREVIATIONS

APQC	=	American Productivity & Quality Center
APQP	=	Advanced Production Quality Planning
CCD	=	Charge Couple Device
CMM	=	Capability Maturity Model
ISO	=	International Organization of Standardization
JCIA	=	Joint Commission International Accreditation
LSI	=	Large Scale Integrated Circuit
MiPS	=	Mitsubishi Production System
NADCAP	=	The National Aerospace and Defense Contractor Accreditation Program
OJT	=	On-the-job Training
PCF	=	Process Classification Framework
PDCA	=	Plan-Do-Check-Action
PPAP	=	Production Part Approval Process
QMS	=	Quality Management System
SE-CMM	=	System Engineering - Capability Maturity Model
SSTH	=	Sanyo Semiconductor (Thailand) Co., Ltd.
THA	=	Thai Hospital Accreditation
TISI	=	Thai Industrial Standards Institute
TR	=	Transistor

USING CAPABILITY MATURITY MODEL TO ASSESS THE EFFECTIVENESS OF ISO 9001:2000 IMPLEMENTATION: CASE STUDY AT SANYO SEMICONDUCTOR (THAILAND) CO., LTD

INTRODUCTION

Many organizations around the world register ISO 9001:2000 to promote their quality management system (QMS) as world class organization. Organizations apply and aim to fulfill ISO 9001:2000 requirements. For ISO 9001:2000 implementation, it is necessary to direct and control organizational lead and operation in a systematic and transparent manner. Success can result from implementing and maintaining a QMS that is designed for continuous improvement. Initially, ISO 9001:2000 implementation intends to prevent nonconformity to achieve certification. Nowadays, the application of ISO 9001:2000 does not only directly benefit from certification but also makes important to maintain and improve organizational QMS.

Specifically, the requirements in ISO 9001:2000 help identify key processes for a QMS. These requirements are general and can be applied for all business types. A certified organization has to establish and maintain own specific procedures, work instructions, and standards for certification. Nevertheless, one of the key shortcomings for the ISO 9001:2000 certification is that it mainly focuses on requirements' conformity but does not indicate the strength of ISO 9001:2000 implementation that is important to maintain and improve QMS. For maintaining and improving QMS, the desirable behavior and excellent practices should be observed and shared to prepare an organization for possible accreditation (on top of certification).

Promoting ISO 9001:2000 has become urgent among key public organizations (e.g.., Department of Industrial Promotion, Department of Export Promotion, etc.) in Thailand. This promotion stems from intense competition and customer demands. Creating awareness and having certified manufacturers and service providers used to represent an important milestone for the movement on QMS in Thailand. Thai Industrial Standards Institute [TISI] (2007) reports that there are a total of 7,281 organizations that have been ISO 9001:2000 certified in Thailand as of December 2007. In addition, Thai public organizations and their key working partners (e.g., Federation of Thai Industries and Thailand Productivity Center) find ways in order to maintain and improve QMS implementation. They are; for examples, the development of the Thailand Quality Awards (an adaptation of the U.S. Malcolm Balridge Award), an integration with ISO 14001 on environmental management system and/or OHSAS 18001 on occupational health and safety management system, a creation of Thailand Brand, etc. Recently, focus in industries, ranging from manufacturing firms to service providers, has been shifted from certification to accreditation. From operators' viewpoint, accreditation helps ensure the ability to improve their process management. According to Thai Hospital Accreditation [THA] in conjunction with a Joint Commission International Accreditation [JCIA], the accreditation's purposes are to ensure that there exists high-standard implementation, and mechanisms in-place for continuous performance improvement. In other words, accreditation implies that process management will be under more scrutiny. At this point, it is important to point out that, in Thailand, the roles of accreditation appear to receive more attention from the service sectors, especially in the healthcare and tourism sectors (Phusavat *et al*., 2007). For manufacturing firms, there exists the National Aerospace and Defense Contractors Accreditation Program (NADCAP). The NADCAP is the leading cooperative program of major organizations designed to provide continuous improvement within the aerospace industry. Given this ongoing shift towards accreditation, one of the challenges among Thai organizations that are ISO 9001:2000 certified is to assess the strengths and weaknesses regarding their QMS implementation.

Sanyo Semiconductor (Thailand) [SSTH] is recognized as one of the leading semiconductors in Thailand (see Appendix A for the SSTH's profiles and background). Due to current competition from local producers as well as anticipated impacts from globalization (e.g., Free Trade Agreements), the SSTH top management realizes that having the ISO 9001:2000 certificate alone is not sufficient. Assessing ISO 9001:2000 implementation represents a next phase for maintaining and improving QMS. This phase illustrates a comprehensive effort within the SSTH to move ISO 9001:2000 implementation forward from a viewpoint of merely conformities in accordance with the requirements. There is a strong sense that organizational long-term competitiveness greatly depends on various factors such as investment in new technology, market understanding, energy management, business logistics, etc. More importantly, the SSTH future success will be based on its ability to improve and strengthen ISO 9001:2000 implementation. During the past years, the SSTH top management has examined many possibilities to maintain and improve ISO 9001:2000 implementation. The previous strategy was to apply for international and local standards, awards, and recognition. This was expected to motivate staffs to look for new challenges regularly. However, the SSTH top management was not fully satisfied with the outcome. Most of the organization's top managers have concluded that relying on external pressure from award evaluators' visits may not be helpful in maintaining the improvement in ISO 9001:2000 implementation. In addition, the SSTH top management has consistently expressed the need to evaluate the effectiveness of ISO 9001:2000 implementation. This evaluation should provide useful feedback on the organization's ISO 9001:2000 implementation as well as future its preparation for a future accreditation (on top of certification).

It is important to mention that, during the discussion session with the organization's top management, various ideas and conceptual frameworks to be possibly deployed for evaluating QMS implementation are examined. One idea is to apply the Plan-Do-Check-Act cycle when assessing the effectiveness of QMS implementation in each core functional unit. However, this idea is discarded after a lack of implementation clarity. In addition, a benchmarking project is raised. Eventually, this idea is dropped due to the amount of time and staff requirements.

Finally, the Capability Maturity Model (CMM) concept is brought up to the SSTH management attention. Its application is widely discussed, especially on benefits and merits (e.g., clarity, improvement roadmap, focus on process management, etc.) and difficulties (e.g., implementation, credibility of the findings, etc.). The SSTH top management agrees on applying the CMM concept. The reason is that the CMM reflect the progress in process management. For the CMM application, the SSTH top management has decided to adapt the Systems Engineering CMM [SE-CMM] for evaluating the organization's ISO 9001:2000 implementation and the SE-CMM description or process behavior within the context of the SSTH is expressed in Appendix B.

Problem Statement

Organizations are certified the International Standard of ISO 9001:2000 and implement ISO 9001:2000 requirements throughout their certified scope. Requirements of ISO 9001:2000 are established to determine basic needs of QMS for world class organization. These requirements are general needs and they are not specific procedures that can be applied for all business types. The certified organization establishes, implements, maintains, and improves own specific procedures to conform requirements. The ISO 9001:2000 certification evaluates requirements' conformity but does not indicate the strength of ISO 9001:2000 implementation in each core functional unit that is important to maintain and improve QMS. The SSTH is also a certified ISO 9001:2000 that needs to maintain and improve ISO 9001:2000 implementation for increasing competitiveness. The SE-CMM is adapted for assessing the strength of ISO 9001:2000 implementation to facilitate knowledge sharing and to prepare an organization for possible accreditation (on top of certification). This study takes place during June - December 2007.

Research Scope

1. Core functional units imply high impacts on business activities and deal with customers.

2. The CMM concept that is applied in this study is the SE-CMM.

OBJECTIVES

Given the need to maintain and improve the effectiveness of ISO 9001:2000 implementation within the SSTH, the primary purpose of this research is to assess the strength of QMS implementation among the organization's core functional units. The expected benefits from the study include the ability to maintain and strengthen the SSTH's QMS, to facilitate knowledge sharing across functional units, and to prepare the organization for a future accreditation (on top of certification).

LITERATURE REVIEW

The literature review consists of five parts: ISO 9001:2000, quality self-assessment, the CMM, the correlations between ISO 9001 and the CMM, and quality maintaining and improvement.

ISO 9001:2000

ISO 9001:2000 was widely accepted around the world. Motivation for the introduction of this standard differed considerably and was most often connected with demands, requested by customers in supply chains (Piskar and Dolinsek , 2006). ISO (2000) stated that ISO 9001:2000 was a standard in ISO 9000 and was consisted from four standards as below.

ISO 9000:2005, Quality management system – Fundamentals and vocabulary

ISO 9001:2000, Quality management system – Requirements

ISO 9004:2000, Quality management system – Guidelines for performance improvements

ISO 19011:2002, Guidelines on quality and/or environmental management auditing

For ISO 9000 series, ISO 9001:2000 was the only one standard to use for certification of QMS. The requirements of ISO 9001:2000 was complemented with nine clauses as follow.

Clause 0: Introduction,
Clause 1: Scope,
Clause 2: Normative Reference,
Clause 3: Terms and Definitions,
Clause 4: Quality Management System,
Clause 5: Management Responsibility,
Clause 6: Resource Management,
Clause 7: Product Realization, and
Clause 8: Measurement, Analysis and Improvement.

These requirements was specifies requirements for QMS of organization to demonstrate the ability to consistently provide product that met customer and applicable regulatory requirements, and aimed to enhance customer satisfaction through effective application, continuous improvement and assurance of conformity. This standard also promoted the adoption of a process approach, which was the systematic identification and management of the processes employed within an organization and particularly the interaction between such processes. The model of a process-based QMS that was applied from the plan-do-check-action (PDCA) concept was illustrated in Figure 1 (ISO, 2000).

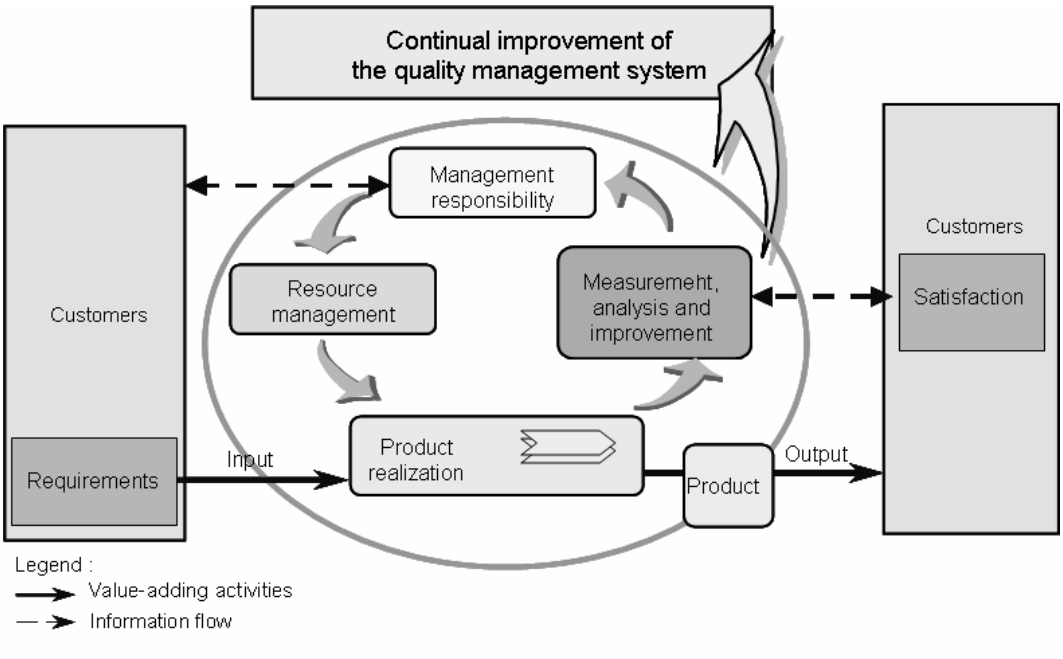


Figure 1 Model of a process-based quality management system

Source: ISO (2000)

Piskar and Dolinsek (2006) stated that the requirements of ISO 9001:2000 made a particular impact on five of the quality management practices as:

(1) management responsibility affected leadership,

(2) information control and analysis,

(3) quality goals and quality plans influenced strategic quality planning,

(4) human resource development was affected by the identification of training needs and the provision of training for all personnel who performed activities that affect quality, and

(5) new product design review, specification and process control, preventive maintenance, and quality control had an effect on quality assurance.

There was not best model fit for each and every organization, but the model should be adapted to the specific organization, its culture, its market, its technology. The steps to develop QMS of ISO 9001:2000 were guided as:

(1) determination of the needs and expectation of customer and other interested parties,

(2) establishment of the quality policy and quality objectives of organization,

(3) determination of the processes and responsibilities necessary to achieve the objectives,

(4) determination and provision of the resources necessary to achieve the objectives,

(5) establishment of method to measure the effectiveness and efficiency of each process,

(6) application of measurement method,

(7) determination of preventive action to eliminate nonconformities and their causes, and

(8) establishment and application of a process for continuous improvement (Wadsworth *et al.*, 2002).

Aldowaisa *et al.* (2006) also developed the one shot to ISO 9001:2000 realization in Figure 2 and incremental approach to ISO 9001:2000 realization in Figure 3 .

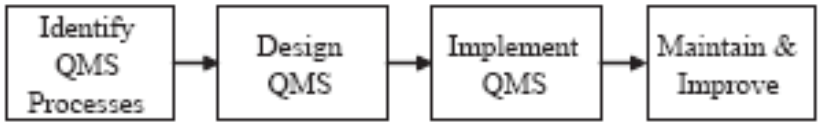


Figure 2 One-shot approach to ISO 9001:2000 realization
Source: Aldowaisa *et al.* (2006)

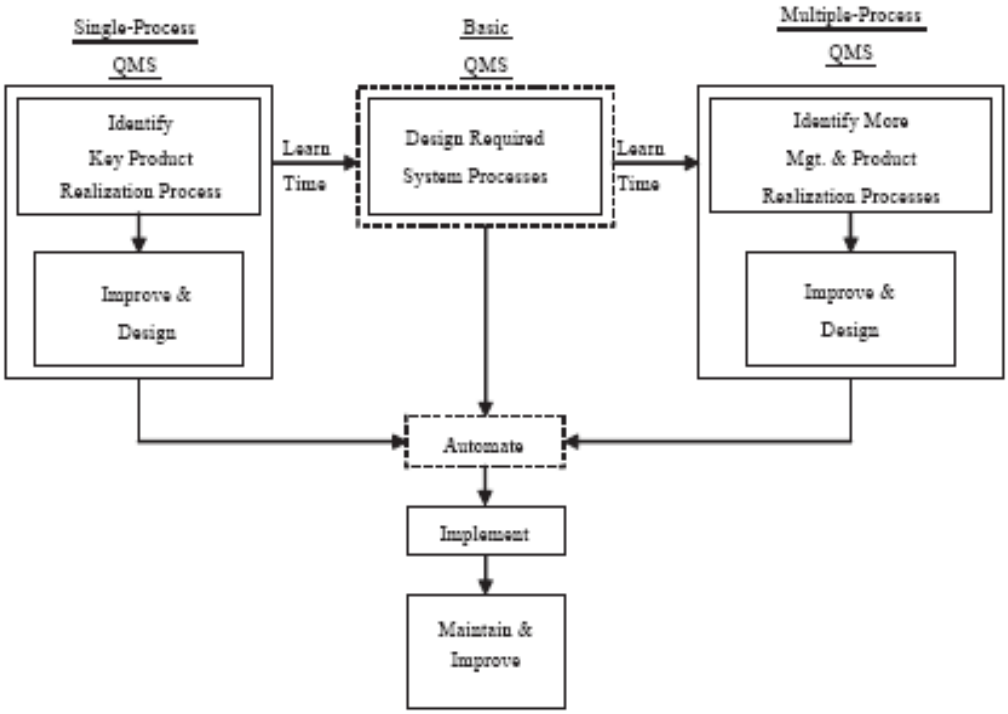


Figure 3 Incremental approach to ISO 9001:2000 realization
Source: Aldowaisa *et al.* (2006)

In addition, Yang (2001) provided ISO 9001 implementation steps. There were eight steps to implement ISO 9001 as follow.

1. Establishment of full commitment to the ISO 9001 program which included both management and employee

This first step was to get management and employee commitment to establish the ISO 9001 based quality program. This would involve defining the organization's objectives, understanding the ISO 9001 requirements and standards, and establishing a management team responsible for the program implementation. This step should result in definition of the responsibilities and authority for the program allocation of the budget, establishment of the management review process and most importantly, and commitment at all management an employee levels.

2. Definition and documentation of a high-level QMS structure, and writing a quality manual

The purpose of the QMS was to establish a documented structure for the complete product life cycle and supporting activities.

3. Definition of the foundation elements of QMS

This step established foundation processes including document control, corrective and preventive actions, control of quality records, and training for an effective ISO 9001 implementation. The organization needed to define how documentation should be formatted, numbered, and stored. A formal reporting and tracking procedure for the documentation needed to be established. At this point, the description of the objectives and general structure of the quality program should be defined and communicated to all organizational members.

4. Definition of the development methodologies

This step included design control, product identification and traceability, contract review, process control, inspections and testing, and inspection and test status.

5. Definition of major supporting elements

The remaining activities in a organization dealt with mainly with supporting activities including activities that dealt with issues of control of nonconforming products, handling, storage, packaging, preservation and delivery, purchasing, and servicing.

6. Definition of remaining supporting elements

The step of supporting activities included internal quality audit, control of customer-supplier products, control of inspection, measuring and test equipments, and statistical techniques.

7. Conduction of a pre-assessment audit and correction of nonconformities found during the pre-assessment audit

Once an organization had documented its processes and selected a registrar, a pre-assessment audit might be conducted. The preliminary audit was not a required step in registration, but it provided an opportunity to find areas of nonconformity in the established processes before the final audit.

8. A registration audit success

Once an organization had resolved all of the problems found during the pre-assessment audit, a final audit was conducted. After acceptable proof had been received, the auditors prepared a final report with a recommendation for registration and submitted it to certification body.

Moreover, the needs to develop QMS are quality policy, management responsibilities and commitment to apply and monitor QMS, and activities of quality assurance and control to assure the product will fulfill its quality requirements (Bicego and Kuvaja, 1996). Management team should be explicitly involved in the design and implemented QMS (Trienekens *et al.*, 2005).

There were five significant factors impacting on quality as:

(1) the role of top management to support in the system (even where management support was high, quality had taken on a different emphasis to focus on better business systems and processes),

(2) the driving force behind the QMS implementation over the long term,

(3) the human infrastructure (employee participation and teamwork, communication and many other elements of various quality approaches),

(4) the direction, monitor, and reviewed QMS implementation process, and

(5) the role of audits and assessments (Wiele and Brown, 2002).

ISO 9001:2000 required that customer had a process for determining customer requirements and the top management was to ensure that all personnel understood the importance of meeting customer requirements. Organization was requires to define and document the way it did business, compliance could provide the basic quality system structure that could be improved further to achieve world class quality. The documentation requirements were generally resource intensive. (Kartha, 2004). The validity of ISO 9001:2000 had contributed to its development and maintenance. The success of the framework depended on improvement of QMS, an assignment of top management to be quality management representative, the necessary knowledge and skills in quality, and justifiable certification (Aldowaisa *et al.*, 2006).

The QMS was periodically reassessed by third party that was independent organization as a certification body to ensure compliance with requirements (Bicego and Kuvaja, 1996). The independent certified auditor from a certification body determined that the conforming requirements of the ISO 9001 had been effectively implemented (Lewis *et al.*, 2006). While reassessment ensured a functioning QMS, it might implicitly hinder improvement that introduced change to the QMS. Moreover, improvements induced instability before changes had been institutionalized (Dahlberg and Jarvinen, 1997). As a result, several certification bodies had begun to explore different alternatives to help maintain and improved the QMS (Manasserian, 2005). Continuous improvement in QMS became a new challenge, especially in competitive and global environment (Kumar and Lie, 2005; and Prajogo, 2007). The reason was that maintaining the strength implementation in QMS could not simply rely on internal quality audits, external audits, and certification assessment (Traver and Wilcock, 2006). It also required an integration of knowledge management and innovation in process management (Melton *et al*., 2006). As a result, continuous improvement in ISO 9001:2000 implementation was considered to be a key prerequisite for advancing product and service quality and organizational competitiveness.

The benefit of the ISO 9001 certification had been to assure customers the credibility of certain suppliers: a marketing advantage. Many organizations considered that ISO 9001 certification yielded a particular set of benefits and evidence of advertising campaigns (Wiele *et al.*, 2001). It also had benefits such as improved corporate image, quality improvement, increased customer satisfaction, and improved internal procedures. In addition, the main advantages gained by the organization after the ISO 9001 quality system had been introduced as:

(1) improved overview of processes was achieved,

(2) quality of product and service had improved,

(3) organization reputation had improved,

(4) customer satisfaction had improved,

(5) information system had improved,

(6) cooperation with buyer had improved,

(7) employees satisfaction and effect on morale and behavior had improved,

(8) heightened employee motivation for improving the quality of services rendered had been achieved,

(9) the number of innovations in business process had improved (continuous improvement),

(10) business results had improved, and

(11) customer loyalty had improved (Piskar and Dolinsek , 2006).

Quality self-assessment

It had stimulated the development and use of many tools and techniques which could be used to improve quality and prevent problems. Alternatively, quality as adopted through some fundamental principles liked continuous improvement (Wiele and Brown, 2002). It was important to note that, in the past, there had been numerous attempts to assess and evaluate the strengths or the effectiveness of practices relating to QMS. Patti *et al*. (2001) suggested the use of workers' perceptions on key features such as extensive use of quality tools, organizational cultures, and knowledge transfer and sharing as a means for the assessment on quality management. Amaratunga *et al*. (2002a) explicitly adapted the CMM framework. Their research focused on examining a management infrastructure - whether it would allow staffs to perform operational processes successfully. Ivanovic and Majstorovic (2006) demonstrated the evolution of quality-management practices in accordance with the inspection- process control- total quality management- integrated management system chain. Pearn and Kotz (2006) proposed a behavior-based framework to examine the capability of process management. Robinson *et al*. (2006) offered a maturity roadmap to help advance corporate sustainability on knowledge management. Tiku *et al*. (2007) illustrated the use of the CMM framework to gain better insights into process management for electronics companies. Finally, Dayan and Evans (2006) showed the CMM applicability when evaluating the maturity of knowledge-management practices. On the other hand, for some, instead of relying on or adapting from the CMM frameworks, they have opted to propose unique frameworks for specific applications. Hillson (2003) developed the maturity model for assessing the effectiveness of project management. Assessment measured impact evaluation, the strengths and weaknesses to improve implementation. Maturity model provided the insight that an organization required in order to recognize where it was situated in comparison with best practices in these critical processes (Duffy, 2001). The best practices were regarded to accelerate the continuous improvement process toward the ideal state of maturity (Chung, 2001).

Karapetrovic and Willborn (2001) compared ISO 9001 internal audit and self-assesment in quality management. These two performance evaluation methodologies had received significant attention in managerial circle. While the internal audit examined the conformity of a QMS with ISO 9001 standard and its suitability to achieve stated objectives, self-assessment measured organization performance against business excellence model. The main purpose of self-assessment was to identify core strength and improvement opportunities. Self-assessment had ability to incorporate its outcome directly the business planning process. However, self-assessment might be performed in the manner similar to that of an internal audit, when one functional unit of an organization evaluated another functional unit of the same organization. The reference point requirements for audit and self-assessment were illustrated in Figure 4.

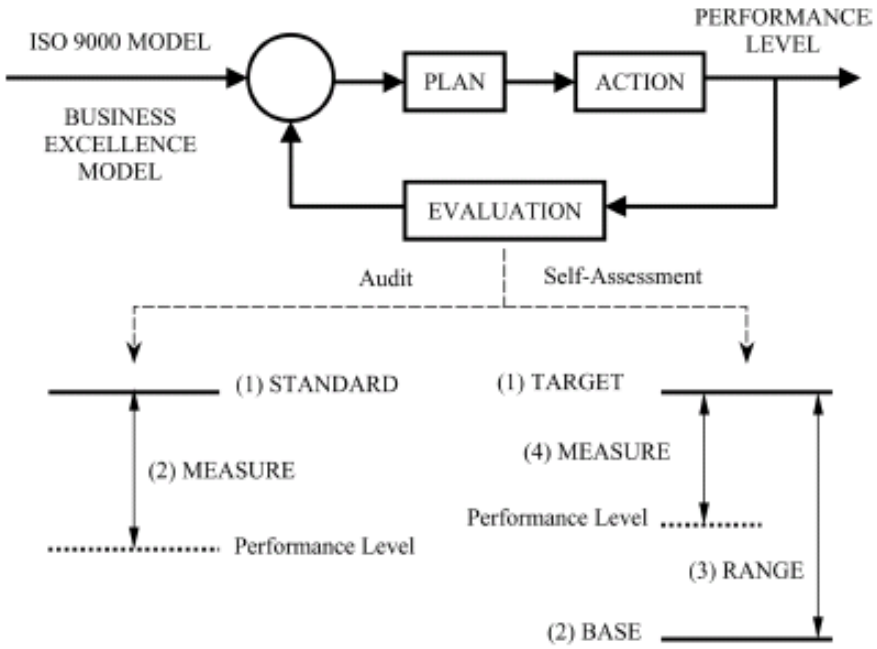


Figure 4 The reference point requirements for audit and self-assessment
Source: Karapetrovic and Willborn (2001)

Before the assessment, the organization should define the scope and formality of the assessment based on its needs and requirements. The purpose of assessment was to identify strengths, weaknesses, and capability of the current processes so as to provide reference points for making improvements. Process assessment typically contained the following activities:

(1) defining the scope of the process assessment,
(2) determining the method and criteria for process assessment,
(3) planning, scheduling, and preparing for the process assessment,
(4) conducting the process assessment, and
(5) documenting the assessment activities and findings.

All of the surveyed assessment tools and some of the problem analysis tools also provided a data collection function (Leung *et al.*, 2007).

Wiele *et al.* (2000) stated that the implementation of self-assessment against an excellence model should focus on the whole organization and on continuous improvement in every aspect of the organization. This process involved many people. Organizations interested in using self-assessment against an excellence model must have clearer defined goals and objectives and be aware of the costs and resources required. Implementing self-assessment against the award criteria was an organizational change process involving deep changes and it could be expected that there would be resistance to the change. Self-assessment provided such a framework. This method, employed against an excellence model, was being given a considerable amount of attention by organizations throughout the world. The decision to undertake self-assessment needed to be fully considered. The five most important reasons for organizations starting self-assessment were to:

(1) find opportunities for improvement,
(2) create a focus on an excellence model,
(3) direct the improvement process,
(4) provide new motivation for the improvement process, and
(5) manage the business.

The concept of self-assessment had much to do with culture change and the development of employee attitudes and behavior in the organization and making best use of their knowledge and skills. The self-assessment steps were guided into eight steps as follow.

1. ISO 9000 series registration/process control

A logical starting point for organization was ISO 9001 certification or a comparable level of process control maturity and quality system development. Another reason for taking this as the baseline was continuous improvement. It was only effective if an organization understood the processes. The ISO 9001 forced an organization to describe its key processes and made them more transparent.

2. Vision based on an excellence model

After attaining ISO 9001 registration an organization should study an excellence model to gain an insight into what was necessary to develop the business. This was especially important if there was a lack of organizational history with respect to structured continuous improvement or a low awareness of the importance of quality. In this situation, the first action to take was to develop such awareness amongst employees and to ensure their involvement in improvement activities.

3. Develop a plan to put the basic elements

Having identified the gap the organization then needed to look at the various methods, both prescriptive and non-prescriptive. After the organization had become familiar with improvement activities and a number of the basic elements had been put into place such as an improvement infrastructure, development and deployment of vision and mission statements and organization values, establishment of improvement teams, use and application of tools and techniques within a structured problem solving methodology, and assessment of employee and customer views on management and organization performance.

4. Develop the commitment to self-assessment

Once the decision had been made to carry out self-assessment, the first step was to develop appropriate awareness amongst the management team with regard to the details of the excellence model which was being used. As part of this step it could be helpful for senior management to develop a maturity matrix in which, for each category of the excellence model, the criteria are specified according to an appropriate level of maturity in terms which were meaningful within the organization. In developing the matrix, management will develop a good understanding of the model.

5. Start self-assessment

The next step was to create, within the organization, appropriated expertise on self-assessment. One method was to send managers for assessor training to develop their understanding and gain experience on the self-assessment process. In this way these managers would form the critical mass within the organization to start internal assessor training for the remainder of the management group. If considered appropriate this initial training could be supported by an external management consultant. After the first group of managers had been trained, the training should be cascaded down through the organization. This typically involved the role of the external consultant being decreased and an increasing number of managers being

involved in the training of their own staff. It was also important to invest sufficient resources, to give managers and employees the necessary time required for the self-assessment activities. In the first attempt at self-assessment it took some effort to gather the required data. The method and approach of assessment would also have to be selected and agreed. Often an organization would start with one of the simpler methods, like a workshop, and build up gradually to the use of more complex methods, such as the award simulation approach.

6. Full self-assessment

After a small number of pilots had been undertaken a decision which model, criteria, and self-assessment process were to be applied throughout the whole organization. The only way to get every business unit involved was by the application of pressure, either by creating a link with the managerial bonus or by edict from the chairman making self-assessment part of every manager's job. It should also not be overlooked that senior management themselves had to apply the self-assessment process to their own role and activities.

7. Self-assessment cycles

Self-assessment needs to become a regular activity to measure the maturity of the organization and as a stimulus to create structured, planned and continuous improvement activities. After self-assessment activities had been started in all business units, the learning between them could be stimulated by, for example, peer assessment and by making managers of one unit responsible for helping in the self-assessment of another. In this way the creation of best practices and their transfer throughout the organization was facilitated. At this stage the data and results of the self-assessments needed to be shared in order to create organizational learning. A key to the success of self-assessment was that the assessments had to be written down by the assessors. If the assessments were purely verbal they appear to have less power. Something written down had a life of its own and could be referred to again and

again. Written assessments also meant they would be taken much more seriously by both assessors and those assessed.

8. Linking self-assessment to business planning

A full implementation of self-assessment would be reached only when the process was linked into the normal business planning and policy deployment processes. The outcomes of the self-assessments should result in improvement plans. The vision and mission of the organization had to be translated into strategies and goals, which needed to be linked with the excellence model.

Ivanovic and Majstorovic (2006) guided the model for assessment that must contain the general organization's structure of processes and process management maturity model. The implementation methodology of the presented model comprised the following: the assessment of the management level of individual processes might be achieved by decomposition of the entire organization in agreement with presented general structure of processes, following which the level of management in individual processes might be determined by means of the obtained scale. With the analysis of obtained results the management profile of the organization might be made, i.e. get the answer whether the uniform management paradigm had been implemented in all processes or not.

During assessment, an organization's process was reviewed in comparison to some vision of how such processes should be performed. An in many technical activities, an assessment required that the basic requirements were met. A good assessment involved a competent team, leadership, and a cooperative organization. In addition, there were some special considerations which should be viewed and given importance. There were: the need for process model as a basic for the improvement and assessment, requirements of confidentiality, senior management involvement, an attitude of respect for the view of the people in organization being assessed, and an action orientation (Saiedian and Chennupati, 1999).

The CMM

According to Blanchard and Fabrycky (1998) and Blanchard (2004), the CMM was developed by Carnegie Mellon University, Pittsburgh, PA in 1986. This effort was initiated in response to the request of the U.S. Government to provide a method for assessing the potential risk of its major contractors. The CMM could be viewed as a framework describing the key elements of an effective process. It provides a foundation for process improvement. The CMM demonstrated an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process. The CMM contained the five levels of progressive process maturity (Initial, Repeatable, Defined, Managed, and Optimizing). A schematic representation of the model was illustrated in Figure 5 that had the arrows in diagram to symbolize and indicated the direction of progression from level to level (Kaner and Karni, 2004).

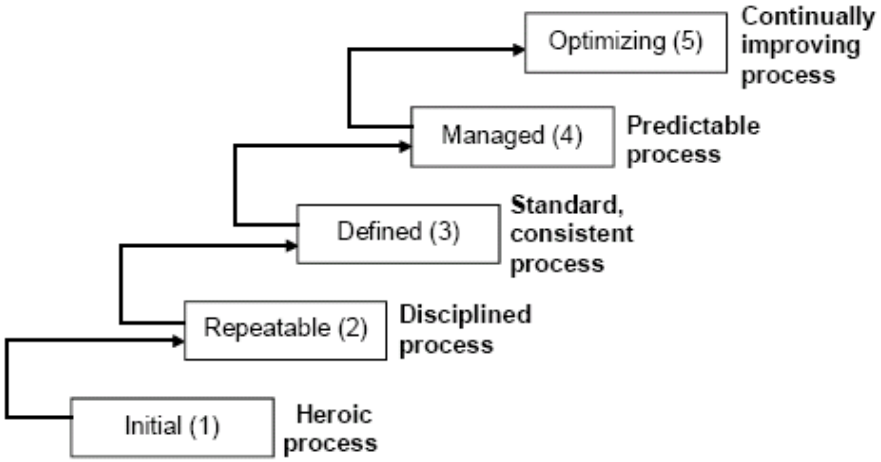


Figure 5 The capability maturity model

Source: Kaner and Karni (2004)

The process maturity was specified by this five levels, namely from level 1 to level 5. At level 1, there was a lack of written procedures and performance depended primarily on the capabilities and motivation of individuals. Level 2 was characterized by consistent and repeatable practices. Planning and managing were based on precedents or prior experience with similar output. Level 3 defined requirements and goals. There was a standardized and consistent documentation for activities and a common understanding among employees about their roles and responsibilities. At level 4, major improvement over the level 3 is defined and implemented. Level 5 was the best practice and focused on continuous improvement. The lessons learned from the feedback are incorporated in management process. Improvement could occur by incremental advances in the existing practices or through innovations using new technologies and methods (Tiku *et al.*, 2007).

Measurement was one of the important conditions to improve the organization's maturity from Level 2 to Level 3. The top level, that was Level 5, required an organization to make continuous efforts to achieve quality and productivity improvements (Azuma, 1996). It provided and guided necessary processes and requirements for what was needed to achieve a higher maturity level (khalfan *et al.*, 2001). However, if and organization was at level 1, but implemented some of key processes of level 3 or 4, it was still considered a level 1 organization. This was because each level laid successive foundations for the next. The model showed that the organization had little to gain by addressing issues at a higher level if all the key processes at the current level had not been implemented (Amaratunga *et al.*, 2002a). A major reference for the CMM was the concept of continuous improvement that followed five maturity levels (Bicego and Kuvaja, 1996). The CMM described the principles and practices improved the maturity of processes. It prescribed different types of processes and the application of process improvement (Trieneken et al., 2005). Continuous process improvement served to maintain and advance process maturity to new maturity levels. It was important note that trying to skip maturity levels was counter-productive, since each level built a foundation from which to achieve the subsequent level. An organization must evolve through this level to establish a culture of process excellence (Lockamy III and McCormark, 2004). Best-

in-class results in the measurement were noted as a critical success factor to gain credibility, which should lead to increased support involvement of higher level leadership (Aken *et al.*, 2005).

The structure of the CMM was based on maturity levels which are made up of Key Process Areas (KPAs) and Key Practices (KPs). It was important that in order to be at a maturity level, an organization has to satisfy the goals of each KPA at that maturity level (Saiedian and Chennupati, 1999). There are four primary applications of the CMM:

(1) software development,
(2) systems engineering,
(3) project management, and
(4) human resource management.

Finally, a single integrated CMM framework is suggested when dealing with systems engineering, software engineering, integrated product and process development, and supplier sourcing. This framework is known as the capability maturity model integration.

This research emphasizes to apply the systems engineering capability maturity model (SE-CMM) as a tool for assessing the ISO 9001:2000 implementation. Cusick (1997) stated that the SE-CMM was a tool designed to help organization measured and improved their system engineering processes. The architecture of the model was designed to provide the user with a lot of flexibility, and to not be overly prescriptive with regards to how organization should structure their improvement plans. The model contented into five stages of difficulty, termed improvement stages. Organizations could use these improvement stages as an additional data point or as guidance when they were evaluating or improving systems engineering processes.

The correlations between ISO 9001 and CMM

Both approached, ISO 9001 and CMM could be considered to have complementary philosophies regarding quality and process improvement and had a strong emphasis on business process and measurement (Trienekens *et al.*, 2005). Kuilbor and Ashrafi (2000) resulted that both ISO and CMM guidelines were primarily concerned with integrity and efficiency of the process and focused on getting internal processes under control before paying attention to external capability.

McGuire and McKeown (2001) recognized that the level of detail between the two models of ISO and CMM, and the appraisal methods applied to obtain certification would present challenges, both from a management and cultural perspective. 5 critical steps for adopting CMM in ISO environment as:

(1) establishing a process group,
(2) performing gap analysis,
(3) making a plan,
(4) providing the training, and
(5) establishing a metric program.

There were strong correlations between ISO 9001 and CMM level 2, particularly in relation to the focus on quality issues, and much of the adaptation at that level was concerned with mapping terminology between the two models. At level 3, the differences became more pronounced and profound. The concepts of continuous improvement, a formalized metrics program, and specific training requirements in the CMM were largely unaddressed in the organization's ISO 9001 implementation. By following this 5-step program, the organization successfully integrated the two models and achieved a CMM Level 3 rating.

In other research, Yang (2001) stated that ISO 9001 conforming organization was considered at level 3 in the CMM. The comparison of ISO 9001 and CMM provided a more detailed specification of quality characteristics and emphasized continuous improvement. However, the CMM was a self-assessment model while ISO 9001 provided more objective evaluation through an independent auditor.

Quality maintaining and improvement

Sandholm (1999) stated that was necessary to choose effective quality maintaining and improving strategies. These strategies were hands-on leadership from the top management of the organization, massive training aiming at culture change and new knowledge including customer focus and program for quality improvement. The strategy plan contained four components: commitment of top management, culture change, improvements, systematic approach. An effective program for improving quality had several components as follow.

1. Improvement procedure

The improvement process included several steps as collecting data and other information, selecting improvement projects, setting up project teams, analyzing symptoms and possible causes, deciding on cause, evaluating remedial measures, deciding on, implementing and following up measures. Procedures for these steps had to be prepared and put into effect.

2. Organizing for improvements

Effective quality improvement work had to be carried out in a project-by-project approach. Experience showed that in organizational terms it was advisable to divide the quality improvement work into a steering component, and an analytical and remedial component. The steering component included deciding priorities for quality improvement projects, initiating analyses and other investigations, setting up project teams, deciding to implement the measures proposed. The analytical and remedial component included carrying out analyses and other investigations, arriving at causes, proposing measures. The responsibility for the steering component must be with the executive group or part of the executive group forming a quality council. The analytical and remedial aspects of improvement activities should be delegated to a project team, one for each project. This team would be the owner of the improvement project. Once the improvement measure had been implemented the project team was dissolved.

3. Training in improvement work

The members of the project teams must have a competence in the application of quality improvement tools and measures. If skills and knowledge were lacking, relevant training had to be provided.

4. Quality data

Effective improvement work was based on facts about the situation of the company. Such facts could be in the form a data of deficiencies and failures, customer complaints, poor quality costs, etc.

5. Quality assessment

By assessing the current situation and performance, opportunities for improvements were found. An effective tool in the assessment was the criteria included in a quality awards scheme, e.g. the Malcolm Baldrige National Quality Award, or the European Model for Business Excellence. Other means to get relevant information were quality auditing and benchmarking. To obtain facts on which the design of the strategic plan could be based, the top management seminar should be followed by a quality culture assessment. An assessment carried out during a relatively limited period of time was usually enough to show where the weaknesses lie and thus where the opportunities for developing the business exist. The result of the assessment could be presented to top management at a workshop. The aim of this workshop was to decide jointly what needs to be done to significantly improve the operational results. The strategic plan for the rest of the development work was drawn up here.

6. Operational results

It was easy to obtain information, using a limited effort, on the operational results of any organization. This could be reflected in the occurrence of faults and failures, complaints, process outputs, etc.

7. Problem identification

People in the organization found it easy to identify problems that need to be solved. A systematic identification of problems could thus serve as a useful start to the improvement work.

8. Process analysis

Studying and analyzing the company's processes could provide a valuable basis for the improvement activities.

9. Quality assessment

An assessment of the activities, for instance, with the aid of the criteria in a national quality award scheme, could indicate where improvements were needed.

10. Poor quality costs

Information on the costs of poor quality, i.e. the costs that could be avoided if all products and processes were perfect, was a good starting point for the improvement work. This type of information provided a common basis for deciding on the importance of alternative improvement projects.

11. Customer attitudes

The customers' attitudes to the organization's products and behavior were a key factor in determining how successful the organization would be. It was therefore important to measure these attitudes. The information thus obtained served as an important start of the improvement work.

12. Personnel attitudes

The attitudes of personnel towards the organization's activities were very important for the operational results. It was therefore important to obtain information on the attitudes of the personnel through surveys. The results of these surveys could also be used as a basis for the improvement activities.

13. Benchmarking

Benchmarking was a way of learning to become better by making comparisons with successful companies. This could be a useful point for starting the improvement process.

Amaratunga (2002b) also outlined eight directions of improvement which were applicable across all core processes. These directions were the details follow.

1. Commitment

The organization took action to ensure the process was established and was lasting. Typically, process implementation involved establishing policies shared by the whole organization. Some processes required sponsors or leaders in the organization. Commitment ensured that leadership positions were created and filled.

2. Ability

The condition must exist before a process could be implemented competently. Ability normally meant having adequate resources, and appropriated organizational structure, and training all in place.

3. Verification

A verification procedure checked that activities were performed in conformity with agreed process. Adopting verification emphasized the need for independent verification by management and quality assurance. The focus was on external verification of processes.

4. Evaluation

This involved basic internal process evaluation and reviews. These internal evaluations were used to help control and improve processes. During the early stages of maturity, this translated into efforts by team to improve existing processes. The focus here was on the project team's internal improvement efforts.

5. Activities

This described the activities, role and procedures necessary to implement processes. They typically involved establishing plans and procedures, performing the work, tracking it, and taking corrective action as necessary.

6. Senior management and department management interviews

The objective of the interviews was to understand the management views of the critical issues facing the department.

7. Supervisor and line employee workshops

The two workshops used an interactive polling tool designed to promote discussions relating to processes and their understanding of key strategic issues facing the directorate.

8. Document review

This was to establish whether the documents exist, what form the documents took and their availability of staff.

Leung *et al.* (2007) provided nine core functions that were required for quality improvement: data collection, problem identification, problem analysis, process tailoring, process assessment, process definition, solution identification, measuring results, and document management.

Organization which had met the requirements of ISO 9001 was looking towards the excellence models as the next step. For organizations with an improvement focus, Hill *et al.* (2001) stated that organizations seemed to conceptualize ISO 9001 accreditation as one milestone along the road ultimately leading towards business excellence. These organizations had an improvement focus and ISO 9001 certification clearly proved as significant learning exercise. Accreditation to the standard appeared to have facilitated in "learning how to learn" in progressing to higher orders of learning. For the business excellence, learning for all employees was seen as critical to best practices. This improved knowledge sharing into improved processes and performance (Samson and Challis, 2002).

Kenny (2006) stated that the learning was concerned with the development of effective organizational processes and structures, refinement of the goals and building of staff capability to implement the change. It was an individual and situational process. Different parts of an organization will adjust to change according to their own unique perspectives, rates of learning and capability sets. The change was unlikely to be uniform across an organization, and different units might well be operated at different points on this continuum. The core strategic learning goal was to explore the range of possibilities and continually monitor the environment in order to build organizational understanding of the situation to a point where management was sufficiently confident to proceed to the implementation phase. To ensure long-term sustainability, organizations had to develop appropriate strategic responses to change.

MATERIALS AND METHODS

Materials

The data collection

This research uses the data collection by questionnaires, checklist and interview.

Hardware

A personnel computer, CPU Pentium Centrino, Ram 256 MB, is used to process the raw data, analyze the data, and evaluate the statistical results.

Software

1. The Microsoft Word is used to create this research document.
2. The Microsoft Excel is used to create supporting documents and evaluate the statistical results.
3. Microsoft Explorer is used to search the internet data.
4. Lotus Notes is used to transfer the electronic data.

Methods

There are several steps taken to complete this study. The first step is to identify core functional units to be examined. The second step is to prepare a checklist for an assessment. The third step involves the interviews with functional managers/supervisors. The fourth step is to analyze and illustrate the findings. The fifth step is to verify these findings with top management. The last step deals with the conclusion and presents the lessons for the SSTH, including identifying practices that can be shared by other functions. The relationship of these six steps is illustrated in Figure 6.

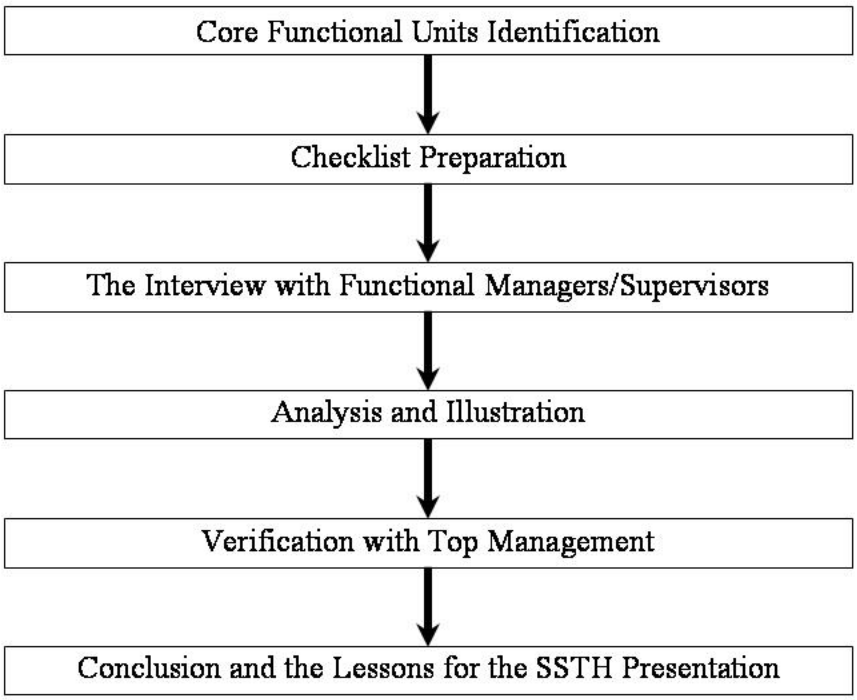


Figure 6 The six steps of research methodology

Core functional units identification

Core functional units are identified to be examined. This step is critical as all of the organization's units are recognized into ten functional units but some of organization's units may not be part of the ISO 9001:2000 scope such as the Accounting function (see Appendix C). The functional managers/supervisors, who are organization's ISO 9001:2000 committees, are interviewed to verify the recognized correctness of ten functional units. In addition, core functional units are identified by the same committees (see Appendix D for questionnaire). The interview results are qualitative results as "Yes" and "No" that are translated to quantitative results as "1" and "0" respectively. In this case, the Standard Deviation value (σ) is unknown and sampling size is small. Thus, the t-distribution (t-test) is suitably applied to judge examined results. The formulation of t-distribution can be expressed as follow.

$$t_{n-1} = \frac{\overline{X} - \mu_0}{S / \sqrt{n}} \quad (1)$$

Where

t_{n-1}	=	The t-distribution with n-1 degree of freedom
Probability level (1-α)	=	95%
$\overline{X}$	=	Average of sample
μ_0	=	1
S	=	Sample standard deviation
n	=	Number of sample

The examined results of each functional unit are accepted if their t-distribution values are in acceptable range.

Checklist preparation

The checklist is prepared to assess the strength of ISO 9001:2000 implementation in each core functional unit. The checklist adapts key features from the SE-CMM. Several brainstorming sessions with the organization's ISO 9001:2000 committees help finalize the checklist. Altogether, there are 43 items in the checklist (see Appendix E). Two items are for the SE-CMM level 1. Fourteen items are developed to help assess the SE-CMM level 2. Eight items help evaluate functional practices for the SE-CMM level 3. There are ten and nine items for the SE-CMM levels 4 and 5 respectively. This checklist is further evaluated by SSTH staffs. The initial examination on the checklist suitability is based on the results from its deployment at three organizations (see Appendix F). These organizations have had extensive business relationships with the SSTH. This examination focuses on whether the results from the SE-CMM checklist are consistent with the opinions from SSTH staffs who have closely worked with these three organizations. The checklist will be accepted if the findings show the consistency between staffs' perception (anticipated organizational behavior in accordance with the SE-CMM) and the actual SE-CMM level of these three organizations. Furthermore, Staffs from three organizations are interviewed to assure their right perception and checklist suitability.

The interview with functional managers/supervisors

The functional managers/supervisors are interviewed following to the accepted checklist. These managers/supervisors are ISO 9001:2000 committees who have participated in organization's certification process.

Analysis and illustration

The strength of ISO 9001:2000 implementation is based on the % checklist items performed that are also differentiated among core functional units. The good practices in each core functional unit and the excellent practices are observed during assessment.

Verification with top management

The findings are verified to complete in conjunction with the organization's top management who understands all of functional units in ISO 9001:2000 implementation (see Appendix H for questionnaire). It is important to note that the purpose of the study is repeatedly reiterated during this step. This action helps avoid a sense or a perception that the competency of functional managers/supervisors is under scrutiny.

Conclusion and the lessons for the SSTH presentation

The results are concluded and the lesson for the SSTH is presented. The practices are also identified. In addition, the excellent practices and their impacts are identified and outlined to discover benefits from the SE-CMM to knowledge management.

RESULTS AND DISCUSSION

Results

The functional units participated in the SSTH's ISO 9001:2000 implementation can be recognized into ten functional units. This recognition is accepted as 100% acceptance of interviewed results. The managers/supervisors are interviewed to identify core functional units from recognized functional units base (see Appendix D). The examination is resulted by the t-distribution value (see Table 1). There are a total of seven core functional units. These units deal directly with ISO 9001:2000 and can be viewed as both technical and support. They include:

(1) Delivery and Storage Control,
(2) Engineering,
(3) Product and Process Development,
(4) Production,
(5) Purchasing,
(6) Quality Control, and
(7) Quality System and Customer Support.

The Delivery and Storage Control functional unit takes care of product delivery as well as storages for materials, component parts, and final parts. The Engineering functional unit primarily handles technical support on production/operation. The Product and Process Development functional unit is responsible for product parts and processes relating to the Advanced Product Quality Planning (APQP) and the Production Part Approval Process (PPAP). The Production functional unit deals with planning and operation. The Purchasing functional unit is responsible for obtaining materials, component parts and subcontractor for production/operation as well as for inspecting these incoming entities. The Quality Control functional unit manages product inspection and standard conformity. Finally, the Quality System and Customer Support functional unit deals with suppliers and

customers such as quality management of suppliers, handling customer requests and claims, and presiding over corrective and preventive actions.

It is important to recognize that other relevant functional units (in addition to the Accounting functional unit) such as Human Resource Development, Management, and Management System are omitted. Their omission is due to an ongoing change in their organizational structure and chain of command.

Table 1 The examined results by t-distribution to identify core functional units

Functional units	t-distribution value	Judgment
Delivery and Storage Control	0.00	Accept
Engineering	-1.00	Accept
Human Resource Development	-4.58	Reject
Management	-4.58	Reject
Management System	-4.58	Reject
Product and Process Development	-1.96	Accept
Production	0.00	Accept
Purchasing	-1.00	Accept
Quality Control	0.00	Accept
Quality System and Customer Support	-1.50	Accept

Remark The t-distribution value can be accepted when $-2.262 < t_{n-1} < 2.262$

The next step is to access seven core functional units by checklist that is derived from the SE-CMM. The checklist is accepted by results of initial examination on the checklist suitability. The findings show the consistency between staff's perception and the actual SE-CMM level of three organizations (see Table 2). In addition, staffs of three organizations are also interviewed to assure their right perceptions and checklist suitability. All staffs clearly understand both their QMS and the SE-CMM to assure the right perception. The checklist suitability can be able to assess the right SE-CMM level and provide information for improvements. As a matter of checklist suitability, the checklist is accepted (see Appendix F).

Table 2 Examination into checklist applicability and suitability

Organization	Predicted SE-CMM Level (based on past familiarity)	Actual Results from the SE-CMM Checklist	Conclusion
1	Should be at level 4 but probably a long way from reaching level 5	30% completed at level 4	Consistency
2	Should be at level 4 but probably a long way from reaching level 5	20% completed at level 4	Consistency
3	Should be at level 5	66.67% completed at level 5	Consistency

Later, SSTH's functional managers/supervisors evaluate this accepted checklist to assess the strength of ISO 9001:2000 implementation (see Appendix G). The overall findings on the SSTH's ISO 9001:2000 implementation is shown in Table 3. These overall findings can be differentiated the strength of ISO 9001:2000 implementation according to the SE-CMM (see Figure 7).

Table 3 Overall findings on the SSTH' s ISO 9001:2000 implementation

Functional unit	Level 1 (out of 2 items)	Level 2 (out of 14 items)	Level 3 (out of 8 items)	Level 4 (out of 10 items)	Level 5 (out of 9 items)
	Yes (%)	Yes (%)	Yes (%)	Yes (%)	Yes (%)
Delivery and Storage Control	2 (100)	14 (100)	8 (100)	4 (40)	N/A
Engineering	2 (100)	14 (100)	8 (100)	4 (40)	N/A
Product and Process Development	2 (100)	14 (100)	8 (100)	1 (10)	N/A
Production	2 (100)	14 (100)	8 (100)	10 (100)	6 (66.67)
Purchasing	2 (100)	14 (100)	8 (100)	8 (80)	N/A
Quality Control	2 (100)	14 (100)	8 (100)	7 (70)	N/A
Quality System and Customer Support	2 (100)	14 (100)	8 (100)	9 (90)	N/A

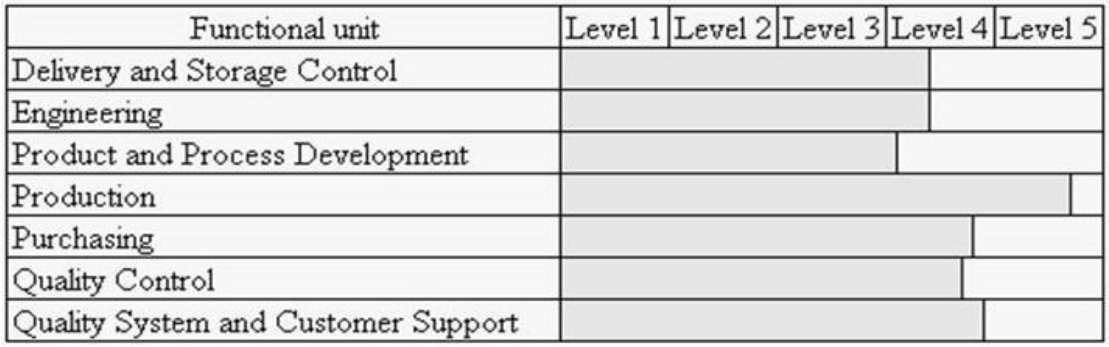


Figure 7 Strength of ISO 9001:2000 implementation according to the SE-CMM

These results are completed in conjunction with SSTH's top management to repeatedly reiterate the purpose of the study (see Appendix H). The consensus on each core functional unit's result between functional managers/supervisors and top management is reached before finalizing the findings. It appears that the Production functional unit has the strongest ISO 9001:2000 implementation. In fact, it is the only functional unit that exceeds the SE-CMM level 4. In general, this finding is consistent with top management's perception since the Production functional unit was initially chosen when the organization first focused on ISO 9000 series in the early 1990s. The Production functional unit is perceived as the SSTH's core functional unit and has been constantly encouraged to enhance its process management.

The follow-up discussion with the SSTH's top management appears to support the notion that ISO 9001:2000 implementation is the strongest at the Production functional unit. The reason is that several initiatives, projects, and programs relating to performance management (e.g., quality, productivity, quality of work life, energy, etc.) have started with this functional unit. In fact, the focus on a QMS began with the Production functional unit. The strength of ISO 9001:2000 implementation at the Quality System and Customer Support, Purchasing, and Quality Control functional units are also realistic and sensible. These three functional units have also received a great deal of attention during internal quality audit (first party audit) as well as external audit by certification body (third party audit). Recently, top management has emphasized ISO 9001:2000 implementation at the Delivery and Storage Control and

Engineering functional units. Nevertheless, the strength in these two functional units is behind others. Interestingly, the findings reveal the lack of work integration among core functional units within the SSTH. Some of managers are particular concerned at the strength level in the Product and Process Development functional unit. The reason is: this functional unit is expected to work closely with the Production functional unit - implying the expectation for higher strength. The lack of sharing and communication across the organization's functional units on activities and practices (except for data and quality records) is highlighted by the strength gap.

The overall results appear to be consistent with top management's perception. Interviews with functional managers/supervisors who have participated in the study generally agree with the findings. Furthermore, the application of the SE-CMM helps provide better and clearer visibility of ISO 9001:2000 implementation among core functional units. In other words, the application of the SE-CMM helps maintain and strengthen ISO 9001:2000 implementation. This is because it demonstrates an easy-to-understand roadmap for continuous improvement. More importantly, the SE-CMM framework helps top management and functional committees at the SSTH identify excellent quality- related practices in regard to process management. In other words, knowledge management at the SSTH is viewed as being stronger as a result of this experiment. The reason is that the knowledge of these practices can be shared and transferred in the simpler manner. To underline this point, some of the Production functional unit's excellent practices are identified and outlined (see Table 4).

Table 4 Benefits from the SE-CMM to Knowledge Management

Excellent Practices	Impacts
Shop-floor staffs and functional managers are directly and actively engaged in planning, information review, performance analysis, and corrective/preventive plans - creating process ownership.	Enhancing quantitatively-controlled processes (due to staffs are viewed as an asset or human capital) with a strong possibility to gradually and continuously improve process performance.
Both statistical thinking (i.e., not overreacting to problems) and techniques are strongly embedded within the Production functional unit. Extensive and intensive knowledge have been provided. Regular invitations to experts in statistical applications are extended.	Enhancing the utilization of quantitative information while minimizing fears from the threats of human errors (due to fact- and trend-based analysis) as well as reducing meeting time.
Promoting visibility of performance information through regular morning meetings, face-to-face meeting, e-mails, bulletin board, newsletters, and formal weekly meetings.	Enhancing staffs' acceptance of policy, plans and measurable targets (i.e., an effective handling on change management).
Establishing measurable targets and a specific timeframe to help create synergy within the Production functional unit (as well as sharing gaps and challenges ahead with functional staffs).	Continuing the robustness of a management process (i.e., measurement, analysis, and improvement).

Discussion

The research yields an interesting observation from the SSTH top management. Top management notices that the Production functional unit has begun to pay more attention on how the issues regarding knowledge and changes are handled (instead of focusing on procedures, standards, work instructions, and requirements in the previous years). Maintaining quality environment in the workplace appears to be far more important in the Production function than others. This shift may be attributed to continuous visits from external experts, improved skill competency among functional staffs, and functional cultures. Interesting, Prajogo (2006) also observed and summarized similar changes in the focus on quality management among Australian firms. It is important to note that it is not the SSTH's goal to reward a functional unit that achieves the SE-CMM level 5.

The benefits of the SE-CMM or the CMM in general are SSTH self-assessment study for helping the continuous improvement of whole organization and comparison of its activities and result with the excellent practices (Benavent *et al.*, 2005). This continuous improvement aims to secure long-term competitive advantage and it act as a method for measuring maturity of current status (Amaratunga, 2002a). It promotes a continuous improvement culture with organization. However, it is not limited to self-assessment study. The organization's top management foresees a strong application possibility on supply-chain management, especially on managing supplier risk. The higher level of the CMM implies the less likelihood of problems or risk stemmed from a supplier under examination (Blanchard 2004). Finally, this research provides a helpful introduction on what the SSTH top management can expect when the organization is to be accredited (on top of certification) that has transition zone at the intersection between the operational and management infrastructure (Hill *et al.*, 2001).

The reason is that the SE-CMM or the CMM helps visualize and diagnose process management in core functional units. It can clearly differentiate the strength of process management. It also integrates deals with the ways an organization has to follow, in order to maintain well mapped practices, having well defined stages that enable to control process improvement in organization by tracking maturity level (Dayan and Evans, 2006). As Calingo (1996) stated that continuous quality improvement appeared to be a better strategy than stable quality norms. Strategic quality goes beyond competitive advantage through functional unit excellence. If quality initiatives are going to succeed, they must be implemented organization-wide because all functional units are interrelated. A consequence of the need for a organization-wide quality initiative is that the formulation of such a strategy must involve all management levels.

In addition, this research results in more managerial attention on knowledge sharing and transfer. Knowledge sharing can assist in accelerating organizational performance improvement (Wickramansinghe and Sharma, 2005). This knowledge sharing is necessary for knowledge management of organization that is linked to cooperate maintenance and promotes continuous improvement, facilitates innovation in processes (Robinson *et al.*, 2006), and provides approaches to achievement of competitive advantage (Dayan and Evans, 2006). Organization should define a discipline for enhancing the concept of learning from experience and maintain the infusion and reinforcement of the best practices (Frank and Bill, 2002).

The application of the SE-CMM apparently helps integrate knowledge and quality management. This application also considers knowledge factor and significant relationship between people and quality. Perceptions of improvement are related to understanding about people orientation of quality management. It can be expected that quality management increased, employee evaluation of organizational outcomes should also increase (Patti *et al.,* 2001).

Furthermore, this study results support organizational knowledge management that can be further applied with Process Classification Framework (PCF) to reflect excellent practices model of ISO 9001:2000 implementation to whole organization. The framework for process improvement of PCF provides the guideline to manage knowledge, improvement, and change. The guideline is required to: (1) create and manage organizational performance strategy, (2) benchmark performance, (30 develop enterprise-wide knowledge management capability, and (4) manage change (American Productivity & Quality Center [APQC], 2006). The SE-CMM concept can be applied for assessment tools in benchmarking process. These study results especially best practices findings can be demonstrated to identify excellent ISO 9001:2000 implementation approach into whole organization that can be further created knowledge management project.

By the way, the SE-CMM can help improvement in quality assurance. Organizational procedures are collectively grouped into a quality system model for quality assurance in implementation. These procedures can be customized to the needs by simply adding or deleting sections, as appropriate (Opiyo *et al.*, 2002). The SE-CMM can be applied for assessment tool to assess needs and procedures implementation maturity and guide to expand capability maturity to be desired maturity for quality assurance improvement.

In summary, this research benefits to provide guideline for improvement of ISO 9001:2000 implementation in academic field. The research results demonstrate that the SE-CMM can be applied as the self-assessment tools to assess the maturity of ISO 9001:2000 implementation. The best practices findings from its assessment are lesson learns as intelligent properties of organization that provide knowledge as guided approach to improve whole organization.

For SSTH, there are important benefits from this research. The SE-CMM is applied to assess the maturity of ISO 9001:2000 implementation among seven core functional units. The results inform the maturity status, weakness, and strength in each core functional unit. The best practices of the strengthen core functional unit (the Production functional unit) guide the improvement approach to improve whole SSTH's QMS.

For further use of the SE-CMM, self-assessment of ISO 9001:2000 for internal benchmarking process should be applied from the SE-CMM framework. Then, knowledge management project should be established to identify and implement improved approach by using assessment results. After improvement approach is implemented, the self-assessment by applying the SE-CMM should be conducted again to check the improvement status and changes. The cycle of improvement and the SE-CMM assessment should be applied concept of PDCA cycle to promote continuous improvement.

CONCLUSION AND RECOMMENDATION

Conclusion

The research highlights the need to find an alternative to help maintain and continuously improve QMS of ISO 9001:2000 implementation. By the reason, the requirements of ISO 9001:2000 are general and certified organization as the SSTH has to establish own specific procedures, work instructions, and standards for its QMS. The SSTH also necessitates maintaining and continuous improving its QMS for certification. ISO 9001:2000 certification focuses on requirements' conformity but does not indicate the strength of ISO 9001:2000 implementation that is important to maintain and improve QMS.

Therefore, the SSTH has adapted the SE-CMM for assessing and evaluating the strengths and weaknesses of the ISO 9001:2000 implementation among its seven core functional units. There are two reasons for a selection of the SE-CMM adaptation. The first reason is it is important that an organization needs to be able to assess how well its QMS has been implemented. The organization-wide implementation is more crucial than that of one successful function. In addition, the SE-CMM can strengthen knowledge management within an organization. By identifying which function is outstanding for its QMS, lessons as well as experiences can be learned, shared, and transferred.

The SE-CMM checklist is established to assess SSTH's ISO 9001:2000 implementation. This checklist is examined on checklist suitability from its deployment at three organizations. The checklist suitability is accepted by the examined results. After that, SSTH's functional managers/supervisors evaluated the SE-CMM checklist to assess the strength of ISO 9001:2000 implementation among seven core functional units. Furthermore, the overall findings of these assessments are also verified with SSTH's top management.

The results show that the Production functional unit has the strongest ISO 9001:2000 implementation. This functional unit is the only one of the core functional unit that exceeds the SE-CMM level 4. The excellent practices from its functional unit are identified and outlined. In addition, SSTH top management's perception is consistent with these findings.

As the results, the use of the SE-CMM appears to facilitate the linkage between quality and knowledge management. This linkage shares the knowledge of excellent practices that are important for maintaining and continuous improving ISO 9001:2000 implementation. Finally, the assessment of this research is proven, from the SSTH top management's viewpoint, to be helpful before a formal effort can be made to continuously improve the ISO 9001:2000 implementation of organization.

Recommendation

The application of SE-CMM to assess the effectiveness of ISO 9001:2000 implementation is helpful introduction on maintaining and continuous improving the SSTH's QMS. In this research, the SSTH top management has awareness to share the knowledge of research findings into whole organization. Nevertheless, there are limitations in this research that should be concerned before using the SE-CMM checklist. The limitations result from the limitations of examination on the SE-CMM checklist suitability, skill and knowledge of SSTH's committees who evaluate SE-CMM checklist, and timeless from these committees. For examination on the SE-CMM checklist suitability, personal knowledge of the SE-CMM is necessary for this examination. The lack of sample organization is limited from SE-CMM knowledge and confidential information security. For the SSTH's committees, skill and knowledge of ISO 9001:2000 must be assured before study and number of question in SE-CMM checklist must be limited to solve the timeless condition from committees in the balance of the checklist suitability.

Furthermore, the SE-CMM is an alternative to maintain and continuously improve ISO 9001:2000 implementation. It can be applied to assess the strength of QMS. The excellent practices are identified during assessment that can be shared knowledge into whole organization. Organization must establish its knowledge management system to support sharing of lesson learns from assessment. Staffs awareness is also necessary to facilitate the linkage of knowledge among functional units.

For further study, this study can be furthered in several directions in order to encompass a wider vicinity of the organization management system. The following are the alternative considerations to made in order to further this study.

1. Obviously, this study is aimed at only internal QMS that can be expand to organization's supply chain and its partnerships, for example, suppliers for supplier development and supplier audit as the second party audit.

2. As this study focuses on manufacturing organization that can be expand to service organization e.g. hotel and hospital.

3. Moreover, this study concerns only the management system of ISO 9001:2000. Similar study can be conducted to unravel in other management systems such as ISO 14001, OHSAS 18001 and integrated management system.

LITERATURE CITED

Aldowaisa, T.A. and A.S.Youssef. 2006. An ISO 9001:2000-based framework for quality in small businesses. **The International Journal of Management Science.** 34: 231 – 235.

Aken, E.M.V., G. Letens, G.D. Coleman,. J. Farris and D.V. Goubergen. 2005. Assessing maturity and effectiveness of enterprise performance measurement systems. **International Journal of Productivity and Performance Management.** 54(506): 400-418.

Amaratunga, D., M. Sarshar and D. Baldry. 2002. Process improvement in facilities management: the SPICE approach. **Business Process Management Journal.** 8(4): 318-337.

Amaratunga, D., R. Haigh, M. Sarshar and D. Baldry. 2002. Assessment of facilities management process capability: a NHS facilities case study. **International Journal of Health Care Quality Assurance.** 15(6): 277-288.

American Productivity & Quality Center [APQC]. 2006. **Process classification framework.** APQC PCF. Available Source: http://www.apqc.org/portal/apqc/site/?path=/research/pcf/index.html, April 3, 2008.

Azuma, M. 1996. Software products evaluation system: quality models, metrics and processes-international standards and Japanese practice. **Information and Software Technology.** 38: 145-154.

Benavent, F.B., S.C. Ros and M. Moreno-Luzon. 2005. A model of quality management self-assessment: an exploratory research. **International Journal of Quality & Reliability Management.** 22(5): 432-451.

Bicego, A. and P. Kuvaja. 1996. Software process maturity and certification. **Journal of Systems Architecture.** 42: 611-620.

Blanchard, B. and W. Fabrycky. 1998. **Systems Engineering and Analysis.** John Wiley & Sons: NY.

Blanchard, B. 2004. **System Engineering and Management.** Wiley-Interscience: Singapore.

Calingo, L.M.R. 1996. The evolution of strategic quality management. **International Journal of Quality & Reliability Management.** 13(9): 19-37.

Chung, W.K. 2001. Benchmarking Singapore's high-TQM maturity organization. **Benchmarking: An International Journal.** 8(1): 8-34.

Cusick, K. 1997. The systems engineering capability maturity model: where to start?. **IEEE.** 36015: 410-416.

Dahlberg, T. and J. Jarvinen. 1997. Challenges to IS quality. **Information and Software technology.** 39: 809-818.

Dayan, R. and S. Evans. 2006. KM your way to CMMI. **Journal of Knowledge Management.** 10(1): 69- 80.

Duffy, J. 2001. Maturity models Blueprints for e-volution. **Strategy & Leadership.** 29(6): 19-26.

Frank, M. and D. Bill. 2002. Attaining level 5 in CMM process maturity. **IEEE Software.** 19: 87-96.

Hill, F.M., S.A. Hazlett and S. Meegan. 2001. A study of the transition from ISO 9000 to TQM in the context of organizational learning. **International Journal of Quality & Reliability Management.** 18(2): 142-168.

Hillson, D. 2003. Assessing organizational project management capability. **Journal of Facilities Management.** 2(3):289- 311.

Ivanovic, M. and V. Majstorovic. 2006. Model developed for the assessment of quality management level in manufacturing systems. **The TQM Magazine.** 18(4): 410- 423.

Kaner, M. and R. Karni. 2004. A capability maturity model for knowledge-based decision making. **Information Knowledge Systems Management.** 4: 225-252.

Karapetrovic, S. and W. Willborn. 2001. Audit and self-assessment in quality management: comparison and compatibility. **Managial Auditing Journal.** 16(6): 366-377.

Kartha, C.P. 2004. A comparison of ISO 9000:2000 quality system standards, QS9000, ISO/TS 16949 and Baldrige criteria. **The TQM Magazine.** 16: 331-340.

Kenny, J. 2006. Strategy and the learning organization: a maturity model for th formation of strategy. **The Learning Organization.** 13(4): 353-368.

Khalfan M.M.A, C.J. Anumba and P.M. Carrillo. 2001. Development of a readiness assessment model for concurrent engineering in construction. **Benchmarking: An International Journal.** 8(3): 223-239.

Kuilboer, J.P. and N. Ashrafi. 2000. Software process and product improvement: an empirical assessment. **Information and Software Technology.** 42: 27-34.

Kumar, S. and D. Lie. 2005. Impact of globalization on entrepreneurial enterprises in the world markets. **International Journal of Management and Enterprise Development.** 2(1): 46-64.

Leung H.K.N., L. Liao, and Y. Qu. 2007. Automated support of software quality yimprovement. **International Journal of Quality & Reliability Management.** 24(3): 230-243.

Lewis, W.G., K.F. Pun and T.R.M. Lalla. 2006. Empirical investigation of the hard and soft criteria of TQM in ISO 9001 certified small and medium-sized enterprises. **International Journal of Quality & Reliability Management.** 23(8): 964-985.

Lockamy III, A. and K. McCormark. 2004. The development of a supply chain management process maturity model using the concepts of business process orientation. **The Supply Chain Management: An International Journal.** 9(4): 272-278.

Manasserian, T. 2005. **New realities in global markets and Thailand's economy today**, Available Source: http://webh01.ua.ac.be/cas/PDF/CAS48.pdf, December 1, 2007.

McGuire, E.G. and K.A. Mckeown. 2001. 5 critical steps for adopting CMM in ISO environment. **Management of Engineering and Technology.** 1: 430-431.

Melton, C., J. Chen and B. Lin. 2006. Organisational knowledge and learning: leveraging it to accelerate the creation of competitive advantages. **International Journal of Innovation and Learning.** 3(3): 254- 266.

Opiyo, E.Z., I. Horvath and J.S.M. Vergeest. 2002. Quality assurance of design support software: review and analysis of the state of the art**. Computers in Industry.** 49: 195–215.

Patti, A., S. Hartman and L. Fok. 2001. Investigating organizational quality management maturity: an instrumental validation study. **International Journal of Quality & Reliability Management.** 18(9):882- 899.

Pearn, W. and S. Kotz. 2006. **Encyclopedia and Handbook of Process Capability Indices.** World Scientific: Singapore.

Phusavat, K., R. Kanchana and P. Helo. 2007. Supplier management: past, present and anticipated future perspectives. **International Journal of Management and Enterprise Development.** 4(5): 502- 519.

Piskar, F and S. Dolinsek. 2006. Implementation of the ISO 9001: from QMS to business model. **Industrial Management & Data System.** 106(9): 1333- 1343.

Prajogo, D. 2006. Progress of quality management practices in Australian manufacturing firms. **The TQM Magazine.** 18(5): 501- 513.

Prajogo, D. 2007. The relationship between competitive strategies and product quality. **Industrial Management and Data Systems.** 107(1): 69- 83.

Robinson, H., C. Anumba, P. Carrillo and A. Al-Ghassani. 2006. STEPS - a knowledge management maturity roadmap for corporate sustainability. **Business Process Management Journal.** 12(6): 793- 808.

Saiedian, H. and K. Chennupati. 1999. Towards and evaluative framework for software process improvement models. **The Journal of Systems and Software.** 47:139-148.

Samson, D. and D. Challis. 2002. Patterns of business excellence. **Measuring Business Excellence.** 6(2): 15-21.

Sandholm, L. 1999. Trendy versus effective quality strategies. **The TQM Magazine.** 11(6): 437-444.

Thai Industrial Standards Institute [TISI]. 2007. **List of certified companies in Thailand: ISO 9000.** Systems Certification. Available Source: http://www.tisi.go.th/syscer/9000.html, January 18, 2008.

The International Organization for Standardization. 2000. **Quality Management Systems – Requirements.** ISO 9001:2000.

The International Organization for Standardization. 2000. **Quality Management Systems – Guidelines for Performance Improvements.** ISO 9004:2000.

The International Organization for Standardization. 2002. **Guidelines for Quality and/or Environmental Management System Auditing.** ISO 19011:2002.

The International Organization for Standardization. 2005. **Quality Management Systems – Fundamentals and Vocabulary.** ISO 9000:2005.

Tiku, S., M. Azarian and M. Pecht. 2007. Using a reliability capability and maturity model to benchmark electronics companies. **International Journal of Quality and Reliability Management.** 24(5): 547- 563.

Traver, I. and A. Wilcock. 2006. Identification of overseas vendor selection criteria used by Canadian apparel buyers: Is ISO9000 relevant?. **Journal of Fashion Marketing and Management.** 10(1): 56-70.

Trienekens, J.J.M., R.J. Kusters, B. Rendering and K. Stokla. 2005. Business-oriented process improvement: practices and experiences at Thales Naval The Netherlands (TNNL). **Information and Software Technology.** 47: 67-79.

Wadsworth, H.M., K.S. Stephens and A.B. Godfey. 2002. **Modern Methods for Quality Control and Improvement.** 2nd ed. John Wiley and Sons, Inc., New York.

Wickramansinghe, N. and S. Sharma. 2005. Key factors that hinder SMEs in succeeding in today's knowledge-based economy. **International Journal of Management and Enterprise Development.** 2(2): 141- 158.

Wiele, T.V.D., A.R.T. Williams and B.G. Dale. 2000. ISO 9000 series registration to business excellence: the migratory path. **Business Process Management.** 6(5): 417-427.

Wiele, T.V.D., A. Brown and B.G. Dale. 2001. The ISO 9000 series as a tool for organizational change: Is there a case?. **Business Process Management Journal.** 7(4): 323-331.

Wiele, T.V.D. and A. Brown. 2002. Quality management over a decade: a longitudinal study. **International Journal of Quality & Reliability Management.** 5: 508-523.

Yang, Y.H. 2001. Software quality management and ISO 9000 implementation. **Industrial Management & Data Systems.** 101(7): 329-338.

APPENDICES

Appendix A

The SSTH's profile and background

Organization background

The organization background of the SSTH is shown in Appendix Table A1.

Appendix Table A1 Organization background of the SSTH

Subject	Description
Name	Sanyo Semiconductor (Thailand) Co., Ltd. (SSTH)
Location	1/7 Moo 5, Rojana Industrial Park, T. Khanharm, A. U-thai, Ayutthaya 13210, Thailand
Establishment	November 6, 1990
Registered capital	823,000,000 Baht
Area	108,364 m^2
Production space	16,960 m^2
Products	Transistor (TR), Large Scale Integrated Circuit (LSI), and Charge Couple Device (CCD)
Working time	Office: 8 hours, 2 shifts: 24 hours
Employees	1,698 persons (as of December 2007)

Key milestones in process management

The SSTH is certified many the international standards by certification bodies to promote its management systems as a world class organization. These certifications are shown in Appendix Table A2. In addition, the SSTH is also awarded and recognized to promote its organization as one of the leading organization in Thailand. The details on the SSTH's past important awards and recognitions are shown in Appendix Table A3.

Appendix Table A2 The international certification of the SSTH

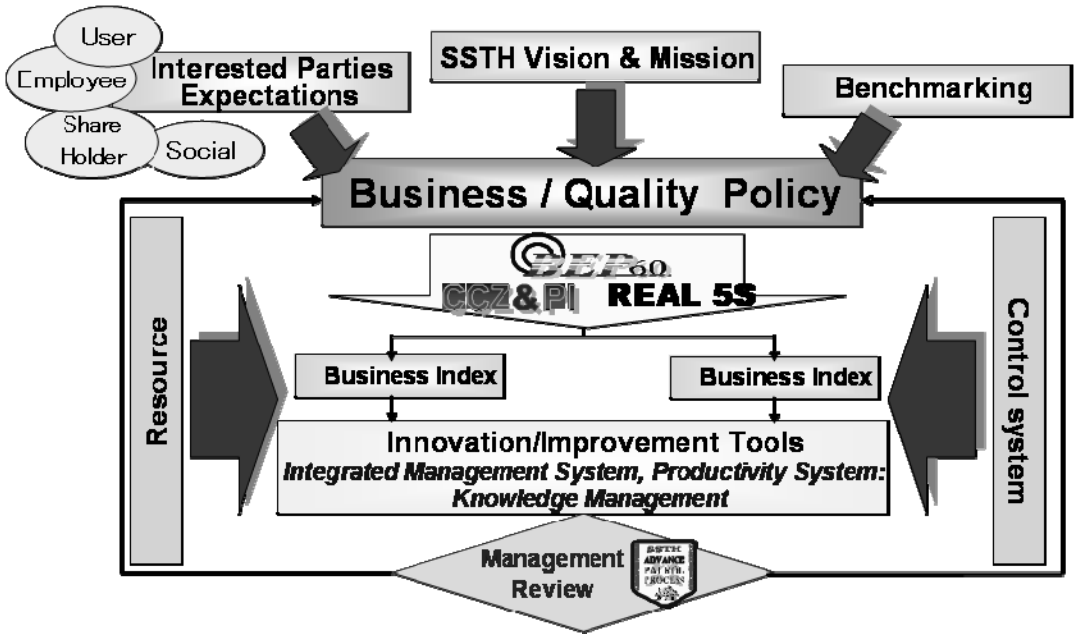
Standards	Focus are	Certification body
ISO 9000:2000	Quality management system	SGS (Thailand)
ISO/TS 16949:2002	Quality management system for automotive parts	SGS (Thailand)
ISO 14001:2004	Environmental management system	SGS (Thailand)
OHSAS 18001:1999	Occupational health and safety management system	SGS (Thailand)
TLS 8001:2003	Thai corporate social responsibility	Ministry of Labour
ISO/IEC 17025:2005	General requirements for the competence of testing and calibration laboratories	Management System Certification Institute (Thailand)

Appendix Table A3 The SSTH's past important awards and recognition

Performance Areas	Awards/ recognition during 2004-2007
Quality and management	(1) The Prime Minister's Best Industry Award (2) The Prime Minister's Industry Award on Quality Management (3) QC Prize (4) TPA Thailand 5S Award
Productivity	(1) The Prime Minister's Industry Award on Productivity (2) TPA Robot Innovation Award (3) TPA Automation Kaizen Award
Energy	(1) The Prime Minister's Industry Award on Energy Management (2) Thailand Energy Award
Quality of Work Life	(1) The Prime Minister's Industry Award on Safety Management (2) The Best Workplace in Celebration of His Majesty the King's Project (3) The Safety Company of Thailand (4) Food Sanitation Standard (5) White Factory (6) Healthy Workplace (7) ASO Thailand: AIDS – Response Standard Organization

The management system of the SSTH

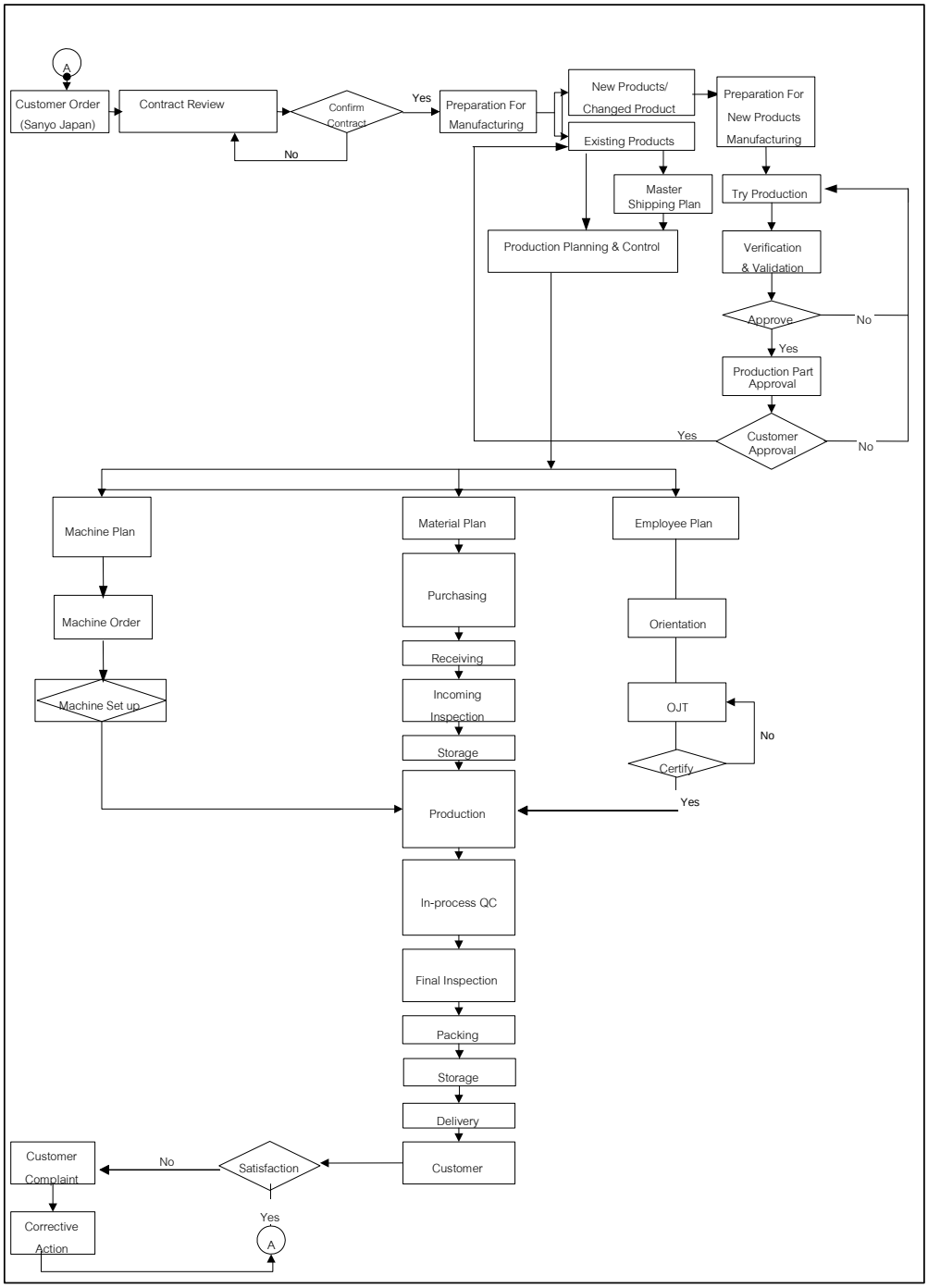
The SSTH creates own specific management system by applying many management tools and systems into its organization that can be illustrated in Appendix Figure A1.



Appendix Figure A1 The management system of the SSTH

Business flowchart

The business flowchart of the SSTH can be illustrated in Appendix Figure A2.



Appendix Figure A2 The business flowchart of the SST

Appendix B

The SE-CMM description

Appendix Table B1 The SE-CMM description within the context of the SSTH

(adapted from Blanchard, 2004)

Level	Description or process behavior within the context of the SSTH
1 (Initial)	Work process or operation is performed informally. It is performed without a documented process or standard. The planning process is completed without clear and measurable. There is also a lack of communication during target deployment. It depends on individuals who manage the tasks. Nevertheless, this process transforms from input to outputs. At this moment, process performance is not known and available. The ability to set performance targets does not exist. Process capability is not predictable.
2 (Repeatable)	Work process or operation is planned, documented, and executed in accordance with organizational policy and objectives. There are standards and process descriptions. Clarity in task responsibility and authority is made. Adequate resources to help strive for improvement are consistently provided, especially on training and skill development. Planning on data and information needed for process management is made. At this moment, process performance is not known. Nevertheless, performance targets can be imprecisely identified. They are likely based on feelings and judgment. Process capability is somewhat predictable, given that extensive experiences in the workplace are required.

Appendix Table B1 (Continued)

Level	Description or process behavior within the context of the SSTH
3 (Defined)	Work process or operation is consistently maintained in accordance with standards, instructions, and procedures. Information and records on process performance are available. Data collection and storage are part of a management process. At this moment, process performance and targets are somewhat predictable (i.e., less certain on the targets or less confidence in an ability to achieve process targets). Process capability can be predicted with a great deal of uncertainty.
4 (Managed)	Work process or operation is controlled by extensively using statistical analysis, based on available quantitative information. Quantitative targets and objectives are established in accordance with process capability. People who perform quantitative analysis are process owners. Special and common causes are identified and classified. At this moment, process performance and targets are predictable and stable (e.g., reduced variation). Process capability can be predicted with certainty.
5 (Optimized)	Work process or operation is continuously improved through rational decisions in accordance with statistical analysis and quantitative information. A continuous improvement cycle is embedded into operational processes. Explicitly efforts are made to address root cause, based on statistical and relevant analysis techniques (e.g., 5-why technique). At this moment, process performance is always gradually shifted towards improvement. Process capability can be predicted with high certainty.

Appendix C

The functional units of the SSTH's ISO 9001:2000 implementation

Appendix Table C1 The functional units of the SSTH's ISO 9001:2000 Implementation

Functional unit	Definition
Delivery and Storage Control	The functional unit takes care of product delivery as well as storages for materials, component parts, and final parts.
Engineering	The functional unit primarily handles technical support on production/operation.
Human Resource Development	The functional unit qualifies and improves the competency of employee.
Management	The functional unit responds management and business strategic processes, including the determination of policy and objectives, the management review, and the consideration of necessary resources.
Management System	The functional unit coordinates the QMS implementation and its improvement, including the internal quality audit and the document control.
Product and Process Development	The functional unit is responsible for product parts and processes relating to the Advanced Product Quality Planning (APQP) and the Production Part Approval Process (PPAP).
Production	The functional unit deals with planning and operation.
Purchasing	The functional unit is responsible for obtaining materials, component parts and subcontractor for production/operation as well as for inspecting these incoming entities.
Quality Control	The functional unit manages product inspection and standard conformity.
Quality System and Customer Support	The functional unit deals with suppliers and customers such as quality management of suppliers, handling customer requests and claims, and presiding over corrective and preventive actions.

Appendix D

Core functional unit identification

The questionnaire for core functional unit identification

The questionnaire for core functional unit identification is divided into two parts that is shown in Appendix Table D1. The question in part 1 is to verify the recognized correctness of ten functional units in SSTH's ISO 9001:2000 implementation and the questions in part 2 are to identify core functional unit.

Appendix Table D1 The questionnaire for core functional unit identification

No.	Question	Yes	No
Part 1: To verify the recognized correctness of the SSTH's functional units			
1	Do you agree that all of functional units in SSTH's ISO 9001:2000 implementation can be recognized into ten functional units (as Appendix C)?		
Part 2: To identify core functional unit			
1	Do you agree that the Delivery and Storage Control functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
2	Do you agree that the Engineering functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
3	Do you agree that the Human Resource Development functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
4	Do you agree that the Management functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
5	Do you agree that the Management System functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
6	Do you agree that the Product and Process Development functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
7	Do you agree that the Production functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		

Appendix Table D1 (Continued)

No.	Question	Yes	No
8	Do you agree that the Purchasing functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
9	Do you agree that the Quality Control functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		
10	Do you agree that the Quality System and Customer Support functional unit is core functional unit in SSTH's ISO 9001:2000 implementation?		

The results for core functional unit identification

The results for core functional unit identification can be divided into two parts according to questionnaire. Part 1 is the result for verifying the recognized correctness of ten functional units in SSTH's ISO 9001:2000 implementation and part 2 is the result for identifying core functional unit.

Part 1: The result for verifying the recognized correctness of ten functional units in SSTH's ISO 9001:2000 implementation

The committees of ISO 9001:2000 implementation are interviewed to verify the recognized correctness of ten functional units in SSTH's ISO 9001:2000 implementation. All of committees accept the recognition of ten functional units that is shown in Appendix Table D2.

Appendix Table D2 The interviewed result for verifying the recognized correctness of ten functional units

Committee	The acceptation of recognized functional unit
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

Part 2: The result for identifying core functional unit.

The same committees, who are interviewed in part 1, are also interviewed for identifying core functional unit. The results of this interview are shown in Appendix Table D3.

Appendix Table D3 The interviewed result for identifying core functional unit

Functional unit	The acceptation from committees									
	1	2	3	4	5	6	7	8	9	10
Delivery and Storage Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Engineering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Human Resource Development	No	Yes	No	No	No	No	Yes	Yes	No	No
Management	No	Yes	No	No	No	Yes	No	Yes	No	No
Management System	No	Yes	No	Yes	No	No	No	Yes	No	No
Product and Process Development	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
Production	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Purchasing	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Quality Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quality System and Customer Support	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes

The interviewed results in Appendix Table D3 are qualitative results as “Yes” and “No” that are translated to quantitative results as “1” and “0” respectively. After that, the t-distribution value is calculated for future judgment of examined results. The t-distribution values of all functional units are shown in Appendix Table D4.

Appendix Table D4 The t-distribution values of all functional units

Functional unit	Total of acceptation from committees	Average	Sample standard deviation	The t-distribution value
Delivery and Storage Control	10	1.00	0.00	0.00
Engineering	9	0.90	0.32	-1.00
Human Resource Development	3	0.30	0.48	-4.58
Management	3	0.30	0.48	-4.58
Management System	3	0.30	0.48	-4.58
Product and Process Development	7	0.30	0.48	-1.96
Production	10	1.00	0.00	0.00
Purchasing	9	0.90	0.32	-1.00
Quality Control	10	1.00	0.00	0.00
Quality System and Customer Support	8	0.80	0.42	-1.50

Remark The t-distribution value can be accepted when $-2.262 < t_{n-1} < 2.262$

Appendix E

The SE-CMM checklist for assessment of ISO 9001:2000 implementation

The SE-CMM checklist for the assessment of the strength of SSTH's ISO 9001:2000 implementation can be demonstrated that is shown in Appendix Table E1.

Appendix Table E1 The SE-CMM checklist for assessment of ISO 9001:2000 implementation

Item	Checklist
SE-CMM level 1: Initial	
1	Does functional unit perform work product and transform input to output?
2	Are specific goals and expectation of work achieved?
SE-CMM level 2: Repeatable	
1	Are requirements of work determined?
2	Is the integrity of work established and maintained?
3	Is the work planned, documented, and executed in accordance with organizational policy?
4	Are objectives established?
5	Is the action plan established and implemented to achieve objectives?
6	Are resource adequately provided to perform work?
7	Are responsibilities and authorities assigned to perform work and communicated through functional unit?
8	Is appropriated training provided to functional staffs?
9	Is overview training such as OJT (on-the-job training) provided to functional staffs?
10	Are actual results monitored and measured against the work plan?
11	Are actual actions and status of objectives reviewed and evaluated against the action plan?
12	Is problem identified if result derives from plan?
13	Is correction taken if result derives from plan?
14	Is management review taken to review activities, status, and results?

Appendix Table E1 (Continued)

Item	Checklist
SE-CMM level 3: Defined	
1	Is work description of functional unit established and maintained in accordance with organization chart?
2	Are work standards, procedures and instructions established, implemented and maintained?
3	Are work standards, procedures and instructions documented and updated?
4	Are records on process performance established and maintained?
5	Is information on process performance collected?
6	Is information maintained to support future use and improvement?
7	Is lesson learning from work documented and maintained?
8	Is improvement proposed to organization property?
SE-CMM level 4: Managed	
1	Are quantitative objectives established for managing and evaluating the functional unit's performance level?
2	Are these objectives visible to functional staffs?
3	Do these objectives communicate clearly and regularly to functional staffs?
4	Are statistical and other relevant techniques extensively and regularly applied to help analyze quantitative information on the functional unit's performance level?
5	Do these applications result in identifying special and common causes to process variations, and a gap between actual performance and performance targets?
6	Are these causes forwarded to top management regularly with a plan for correction and prevention?
7	Are functional staffs aware of these causes and possible action plans to solve the problems?
8	Do functional staffs actively and directly involve in preparing and analyzing a management report?

Appendix Table E1 (Continued)

Item	Checklist
9	Does a management report contain relevant statistical trends of the functional unit's performance level?
10	Is this management report visible and accessible to functional staffs?
SE-CMM level 5: Optimized	
1	Do a management review session result in corrective actions?
2	Do a management review session result in preventive actions?
3	Do these corrective and preventive actions translate to measurable impacts on process performance?
4	Are corrective and preventive actions constantly communicate and clearly explained to functional staffs?
5	Do these corrective and preventive actions respond to root cause of process variation?
6	Does the function perform internal and/or external benchmarking in both formal and/or informal manners?
7	Is knowledge on performance analysis and improvement interventions shared among functional staffs on the continuous basis?
8	Are experiences on past mistakes, including human and system errors, shared among functional staffs on the continuous basis?
9	Do skill development programs and subjects revise and correspond to continuous changes in problems during process management?

Appendix F

The supporting information for SE-CMM checklist verification

The checklist suitability is assessed by three organizations. The examination is based on the consistency between staffs' perception and the actual SE-CMM level of these three organizations. The staffs from three organizations are also interviewed to assure their right perception and checklist suitability. The details of the examination and interview are shown as follow.

The organization background of three organizations

Appendix Table F1 The organization background of three organizations

Organization	Functional unit	Certification	Supporting tools
1. Auto Interior Product Co., Ltd.	Quality Control	ISO 9001 ISO/TS 16949 ISO 14001	5S Just-In-Time
2. Mitsubishi Motors (Thailand) Co., Ltd.	Warranty	ISO 9001 ISO 14001 ISO/IEC 17025	5S MiPS (Mistubishi Production System)
3. Moresco (Thailand) Co., Ltd.	Production	ISO 9001 ISO 14001 OHSAS18001	5S KAIZEN

The examined results of checklist suitability

The examination of checklist suitability focuses on the results from the SE-CMM checklist is consistent with the staffs' perception. The perceptions of predicted SE-CMM level are level 4 for organization 1 and organization 2, and level 5 for organization 3. These perceptions are shown in Appendix Table F2.

Appendix Table F2 The predicted SE-CMM level of three organization

Organization	Predicted SE-CMM Level (based on past familiarity)
1	Should be at level 4 but probably a long way from reaching level 5
2	Should be at level 4 but probably a long way from reaching level 5
3	Should be at level 5

The actual results from the SE-CMM checklist of three organizations are shown in Appendix Table F3 and Appendix Table F4.

Appendix Table F3 The evaluated results from the SE-CMM checklist of three organization

Item	The evaluated results of each core functional unit		
	Organization 1	Organization 2	Organization 3
SE-CMM level 1: Initial			
1	Yes	Yes	Yes
2	Yes	Yes	Yes

Appendix Table F3 (Continued)

Item	The evaluated results of each core functional unit		
	Organization 1	Organization 2	Organization 3
SE-CMM level 2: Repeatable			
1	Yes	Yes	Yes
2	Yes	Yes	Yes
3	Yes	Yes	Yes
4	Yes	Yes	Yes
5	Yes	Yes	Yes
6	Yes	Yes	Yes
7	Yes	Yes	Yes
8	Yes	Yes	Yes
9	Yes	Yes	Yes
10	Yes	Yes	Yes
11	Yes	Yes	Yes
12	Yes	Yes	Yes
13	Yes	Yes	Yes
14	Yes	Yes	Yes
SE-CMM level 3: Defined			
1	Yes	Yes	Yes
2	Yes	Yes	Yes
3	Yes	Yes	Yes
4	Yes	Yes	Yes
5	Yes	Yes	Yes
6	Yes	Yes	Yes
7	Yes	Yes	Yes
8	Yes	Yes	Yes

Appendix Table F3 (Continued)

Item	The evaluated results of each core functional unit		
	Organization 1	Organization 2	Organization 3
SE-CMM level 4: Managed			
1	Yes	Yes	Yes
2	No	No	Yes
3	No	No	Yes
4	No	No	Yes
5	No	No	Yes
6	Yes	No	Yes
7	Yes	No	Yes
8	No	No	Yes
9	No	Yes	Yes
10	No	No	Yes
SE-CMM level 5: Optimized			
1	No	No	Yes
2	No	No	Yes
3	No	No	Yes
4	No	No	Yes
5	No	No	Yes
6	No	No	No
7	No	No	No
8	No	No	Yes
9	No	No	No

Appendix Table F4 The summary results from the SE-CMM checklist of three organizations

Organization	Level 1 (out of 2 items)	Level 2 (out of 14 items)	Level 3 (out of 8 items)	Level 4 (out of 10 items)	Level 5 (out of 9 items)
	Yes (%)	Yes (%)	Yes (%)	Yes (%)	Yes (%)
1	2 (100)	14 (100)	8 (100)	3 (30)	N/A
2	2 (100)	14 (100)	8 (100)	2 (20)	N/A
3	2 (100)	14 (100)	8 (100)	10 (100)	6 (66.67)

The interview to assure the right perception and checklist suitability

Staffs from three organizations are interviewed to assure the right perception and checklist suitability. The questions for interview are shown as Appendix Table F5.

Appendix Table F5 The interviewed question to assure the right perception and checklist suitability

No.	Question
1	Do you understand the SE-CMM concept and have its basic knowledge?
2	Do you strongly understand your role and aim of the SE-CMM checklist suitability verification?
3	Are you the key person of your functional unit?

Appendix Table F5 (Continued)

No.	Question
4	Do you understand management system and its actual details of your functional unit?
5	Are you able to provide the right answers and its information supports for all questions in the SE-CMM checklist?
6	Do you agree that all questions in the SE-CMM checklist are suitable to identify the SE-CMM level?
7	Do you agree that all questions in the SE-CMM checklist are cleared to provide the right answer?
8	Do you agree that language and wording in the SE-CMM checklist are easy to understand, cleared and non-perplexed?
9	Do you agree that the SE-CMM checklist is able to rightly identify the SE-CMM level?
10	Do you agree that the SE-CMM checklist is proper to assess capability of ISO 9001:2000 implementation?
11	Do you agree that the SE-CMM checklist can provide operational status and capability of functional unit?
12	Do you agree that the SE-CMM checklist can provide strong and/or weak point of functional unit?
13	Do you agree that the SE-CMM checklist can provide adequate information for improvement?
14	Do you agree that the SE-CMM checklist is able to identify improvement?
15	Do you agree that the SE-CMM checklist can direct improvement approach?
16	Do you have any comment to improve this SE-CMM checklist (if yes, please identify)?

For interviewed results, all of staffs from three organizations confirm their right perception in questions 1-5 and agree on all questions of 6-15. Furthermore, none of staffs comment the SE-CMM checklist for improvement. The interviewed results are shown in Appendix Table F6.

Appendix Table F6 The interviewed results to assure the right perception and checklist suitability

Question no.	Organization 1	Organization 2	Organization 3
1	Yes	Yes	Yes
2	Yes	Yes	Yes
3	Yes	Yes	Yes
4	Yes	Yes	Yes
5	Yes	Yes	Yes
6	Yes	Yes	Yes
7	Yes	Yes	Yes
8	Yes	Yes	Yes
9	Yes	Yes	Yes
10	Yes	Yes	Yes
11	Yes	Yes	Yes
12	Yes	Yes	Yes
13	Yes	Yes	Yes
14	Yes	Yes	Yes
15	Yes	Yes	Yes
16	No	No	No

Appendix G

The evaluated results of the SE-CMM checklist

SSTH's core functional units are assessed the strength of ISO 9001:2000 implementation. SSTH's functional managers/supervisors evaluated the SE-CMM checklist and the evaluated results are shown in Appendix Table G1.

Appendix Table G1 The evaluated results of the SE-CMM checklist

Item	The evaluated results of each core functional unit						
	Function 1	Function 2	Function 3	Function 4	Function 5	Function 6	Function 7
SE-CMM level 1: Initial							
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE-CMM level 2: Repeatable							
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix Table G1 (Continued)

Item	The evaluated results of each core functional unit						
	Function 1	Function 2	Function 3	Function 4	Function 5	Function 6	Function 7
SE-CMM level 3: Defined							
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE-CMM level 4: Managed							
1	Yes	Yes	No	Yes	Yes	Yes	Yes
2	Yes	No	No	Yes	Yes	Yes	Yes
3	Yes	No	No	Yes	Yes	Yes	Yes
4	No	Yes	No	Yes	No	Yes	Yes
5	No	Yes	No	Yes	Yes	No	Yes
6	No	No	No	Yes	Yes	No	Yes
7	Yes	No	Yes	Yes	Yes	No	Yes
8	No	No	No	Yes	Yes	Yes	Yes
9	No	Yes	No	Yes	No	Yes	No
10	No	No	No	Yes	Yes	Yes	Yes

Appendix Table G1 (Continued)

Item	The evaluated results of each core functional unit						
	Function 1	Function 2	Function 3	Function 4	Function 5	Function 6	Function 7
SE-CMM level 5: Optimized							
1	No	No	No	Yes	No	No	No
2	No	No	No	Yes	No	No	No
3	No	No	No	No	No	No	No
4	No	No	No	Yes	No	No	No
5	No	No	No	Yes	No	No	No
6	No	No	No	No	No	No	No
7	No	No	No	Yes	No	No	No
8	No	No	No	Yes	No	No	No
9	No	No	No	No	No	No	No

Remark Function 1 = Delivery and Storage Control functional unit

Function 2 = Engineering functional unit

Function 3 = Product and Process Development functional unit

Function 4 = Production functional unit

Function 5 = Purchasing functional unit

Function 6 = Quality Control functional unit

Function 7 = Quality System and Customer Support functional unit

Appendix H

The findings verification with top management

The questionnaire for the findings verification with top management

Appendix Table H1 The questionnaire for the findings verification with top management

No.	Question	Yes	No	Additional details
1	Are you SSTH's top management who understands all of functional units in SSTH's ISO 9001:2000 implementation?			
2	Do you agree that all of functional units in SSTH's ISO 9001:2000 implementation can be recognized into ten functional units as results?			
3	Do you agree that core functional units in SSTH's ISO 9001:2000 implementation can be identified into seven functional units as results?			
4	Do you agree that all of overall findings on the SSTH's ISO 9001:2000 implementation are conformable with your opinion as the assessment results?			
5	Do you agree that these overall findings can be differentiated the strength of ISO 9001:2000 implementation according to the SE-CMM as results?			

Appendix Table H1 (Continued)

No.	Question	Yes	No	Additional details
6	Do you agree that the Production functional unit has strongest ISO 9001:2000 implementation?			
7	Do you agree that the strength and lack of ISO 9001:2000 implementation are conformable with your opinion?			
8	Do you agree that the excellent practices and their benefits can be identified as result?			
9	Will you apply the excellent practices whole SSTH's QMS?			
10	Do you agree that the application of the SE-CMM helps provide better and clearer visibility of ISO 9001:2000 implementation?			

The results for the findings verification with top management

Appendix Table H2 The results for the findings verification with top management

Question no.	Results from top management	Additional details from top management
1	Yes	I am a director who is SSTH's top management. I also responsible for the quality management representative of QMS. Thus, I understand all functional units in SSTH's QMS.
2	Yes	-
3	Yes	-
4	Yes	-
5	Yes	For QMS, the SSTH documents and updates procedures, work instruction, and other supporting information. In addition, quantitative measurement is applied in QMS as more as possible practice.
6	Yes	The Production functional unit is SSTH's main functional unit. The SSTH design good practices and strongly control actual implementation and its results to assure products conforming to customer and relevant requirements.
7	Yes	-
8	Yes	-
9	Yes	-

Appendix Table H2 (Continued)

Question no.	Results from top management	Additional details form top management
10	Yes	The excellent practices are useful practical guidance to learn and share their implementation into SSTH's QMS. The initial implementation should be applied into all functional units in SSTH's QMS as organization standards.

CIRRICULUM VITAE

NAME	**:**	Ms. Sakulrat Songnisai
BIRTH DATE	**:**	April 20, 1979
BIRTH PLACE	**:**	Bangkok, Thailand
EDUCATION	**:**	**YEAR** **INSTITUTE** **DEGREE/DIPLOMA**
		1999 Khonkhen Univ. B.Sc. (Biotechnology)
POSITION/TITLE	**:**	Trainer
WORK PLACE	**:**	TÜV Rheinland Thailand Ltd.