Study the Factors Affecting Maturity Level in UAE Information Technology Organizations

دراسة العوامل المؤثرة في مستوى النضج في شركات نظم المعلومات في الإمارات العربية المتحدة

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List of Abbreviations

ARC: Appraisal Requirements for CMMI

CMM: Capability Maturity Model

CMMI: Capability Maturity Model Integration

CBA-IPI: CMM-Based Appraisal for Internal Process Improvement

HP: Hewlett-Packard

IGC: Inter Group Coordination

IT: Information Technology

KPA: Key Process Areas

QMO: Quality Method of Operation

QSR: Quality System Review

SDP: Software Development Plan

SEI: Software Engineering Institute

SEPG: Software Engineering Process Group

SESD: Software Engineering Systems Division

SPI: Software Process Improvement

SPSC: Statistical Project Schedule Control

SQA: Software Quality Assurance

SQMT: Strategic Quality Management Team

TQMT: Tactical Quality Management Team

Abstract

UAE has invested immensely in IT and has become an acknowledged IT economy. Many initiatives undertaken by the government of UAE has made it renowned as a regional hub for IT services and manufacturing. However, there is need to establish internationally recognized industrial standards to provide both global recognition and a competitive edge to UAE IT organizations. CMMI is a well-established framework in the area of process maturity that details a list of prescribed process areas from levels 1-5. Some IT organizations in UAE are working towards CMMI implementation and achieving higher levels of maturity. A high score on CMMI maturity levels provides the required recognition and competitive advantages to organizations. However, CMMI awareness is low in UAE and only a handful of organizations have adopted it. CMMI implementation is also not well documented in the UAE and this field needs further research– to encourage and enhance CMMI adoption in UAE.

This research identified the factors that affect the CMMI maturity levels in UAE organizations through secondary research – an extensive literature review and case studies. This research has been limited in scope due to the inadequate CMMI awareness in the UAE. A total of seven case studies were undertaken of which on two were from the Arab region. A single case study of Mercator of the Emirates Group in the UAE was also conducted, but the results were inconclusive due to scarcity of relevant data.

Several factors were found to effect CMMI maturity levels in organization, of which two in particular were specific to the Arab region. These effective factors can be easily manipulated to the advantage of organizations implementing CMMI as has been demonstrated in the case studies examined by this research.

الملخص

استثمرت دولة الإمارات العربية المتحدة في مجال تكنولوجيا المعلومات بشكل كبير وأقرت باقتصاده.

و المبادرات التي قامت بها حكومة الامارات جعلتها تشتهر كمركز إقليمي لخدمات تكنولوجيا المعلومات والصناعات التحويلية.

ومع ذلك، هناك حاجة إلى وضع معايير الصناعية المعترف بها دولياً لتقديم كل من الاعتراف العالمي والقدرة التنافسية للمؤسسات تكنولوجيا المعلومات الإمارات العربية المتحدة. نموذج النضوج المتكامل

هو إطار راسخ في مجال عملية النضج التي تفاصيله في قائمة العمليات المقررة من مستويات 1-5.

وتعمل بعض المنظمات تكنولوجيا المعلومات في دولة الإمارات العربية المتحدة نحو نضج تنفيذ التكامل النموذجي وتحقيق مستويات أعلى من النضج.

توفر درجة عالية في مستويات النضج نموذج النضوج المتكامل الاعتراف المطلوب والمزايا التنافسية للمنظمات.

و مع ذلك، الوعي نموذج نموذج النضوج المتكامل منخفض في الإمارات العربية المتحدة و اعتمدته حفنة من المنظمات فقط. كما لم يتم توثيق نموذج النضوج المتكامل جيدًا في دولة الإمارات العربية المتحدة ويحتاج هذا المجال مزيدًا من البحوث لتشجيع وتعزيز اعتماد نموذج النضوج المتكامل في الإمارات العربية المتحدة.

و تتحدد هذه الدراسة العوامل التي تؤثر على مستويات نموذج النضوج المتكامل في المنظمات الإمارات العربية المتحدة من خلال بحث ثانوي لمراجعة الدراسات و الأبحاث في نطاق أوسع.

وكان هذا البحث محدودًا في نطاق نظرًا لعدم كفاية الوعي في نموذج التكامل في دولة الإمارات العربية المتحدة.

نفذت مجموعة من سبع دراسات على حالتين من المنطقة العربية.

و أجريت أيضاً دراسة حالة واحدة من (مركاتور) لمجموعة الإمارات في دولة الإمارات العربية المتحدة، ولكن كانت النتائج غير حاسمة نظراً لندرة البيانات ذات الصلة.

تم العثور على عدة عوامل لاحداث نضج على مستويات نموذج نضج التكامل في المؤسسة ، اثنان على وجه الخصوص محدد للمنطقة العربية.

هذه العوامل الفعالة يمكن التلاعب بها بسهولة لصالح المنظمات المنفذة لنموذج النضوج المتكامل كما ثبت في الدراسات

التي تم بحثها في هذا البحث.

1 Chapter One: Introduction

1.1 Overview

In 1987, the US Department of Defence assigned the Software Engineering Institute (SEI) the task of developing a model to evaluate its organization, and software process improvement (SPI) initiatives (SEI, 2010). SEI administered a questionnaire that allowed them to identify five levels of maturity, which became the basis of the Capability Maturity Model (CMM). According to Englund and Graham (1999) CMM was initially developed to combine several benchmark methods and theoretical frameworks in software development for the provision of a standardised framework that was internationally accepted. The central aim of CMM is to enable organizations to align all their business processes to optimize organizational success. Thus, CMMs can be described as industrial best practices adopted for optimizing organizations' efficacy (Chrissis, Levine, & Shrum, 2009). CMM provides a framework for the SPI. Capability Maturity Model Integration (CMMI) is a refinement of the CMM.

CMMI is structured such that it guides organizations to the achievement of greater levels of maturity; beginning with an assessment of the establishment's maturity and process proficiency, then recognising and delineating priorities for advancement, and lastly establishing SPI best practices to achieve those improvements (SEI, 2010).

According to Balasubramanian and Manivannan (2007), CMMI is used in military, governmental, and business organizations to; reduce risks in development projects, increase efficacy, and improve the general quality of products and processes.

Many public industries, including transport and communications, have made CMMI usage a prerequisite for submitting big tenders. Developing nations– such as India and China– are using it to market themselves as reliable, constant sources of global outsourcing services (Balasubramanian & Manivannan, 2007).

This research aims to identify the factors that affect the CMMI maturity levels in UAE organizations. The results will show how organizations can move to higher levels of CMMI. This will allow organizations to focus more effectively on factors affecting maturity level, thereby, enabling them to achieve desired CMMI maturity levels. Advanced levels of maturity will allow these institutions to be at par with global organizational standards of CMMI; thereby, increasing the status of these organizations in the global economy.

1.2 Background

UAE has emerged as the forerunner among Information Technology (IT) based societies in the Arab region. The nation has invested immensely in IT and has become an acknowledged IT economy. Currently, the UAE is foremost in the Middle East in putting IT to work, viz. it is in the process of digitalizing national bodies such as customs, telecommunication etc. towards an e-governance model, and is encouraging the digitization of the private sector industry also. With the rapid advent and adoption of IT processes, UAE has positioned itself as the Arab interface with the international economy. The many ground-breaking and ambitious initiatives undertaken by the government of UAE in both public and the private sectors has made it renowned as a regional hub for IT services and manufacturing.

But according to Niazi, Babar, and Verner (2010), IT organizations have been overwhelmed with by complications concerning the development of appropriate software and efficacious products and processes. These complications adversely affect the proposed benefits to organizations (time management, increased productivity, ROI, customer satisfaction) from new IT projects (Barclay, 2008). With this in mind, there has been concern about implementation and success of SPI has risen. SPI is a predefined process improvement scope for process improvement that ensures that software development processes are in place. These initiatives need to be regularly evaluated so as to gauge their efficacy and implementation. To this end capability and maturity models have established measurement

processes which compare organizational, efficiency, product and process development levels against set standards. These models then assign maturity and capability levels to process cycle of products and are used as both frameworks for improvement and evaluation of organizational maturity.

Software engineering literature reports numerous capability and maturity models for assessing and evaluating a specific process in order to produce a corresponding maturity level. SPI follows certain standards and models to assess the maturity level of organizations, one of which is Capability Maturity Model Integration (CMMI) to assess the maturity level of organizations. CMMI is a well-established framework in the area of process maturity that details a list of prescribed process areas from levels 1-5, against which a which can be used to assess a firm's process maturity can be assessed. The organizations observe the benefits of CMMI implementation, such as a positive impact on cost, schedule, productivity, quality, customer satisfaction, and return on investment.

1.3 Statement of the problem

In the current era of digitalization and automation, incorporation of IT is vital to the strategic requirements of organizations (Bokhari, 2005). Software (both process and product) has become a key component of business systems and provides a critical competitive advantage for many organizations. Many organizations undertake SPI to enhance their productivity. However, a large percentage of IT projects are plagued with problems such as budgeting, time management, and rejection by staff/management (Bulatovic, 2011; Li, Huang, Luftman, & Sha, 2012; Standish Group, 2009).

Many scholars posit that the main reasons for IT failures are not related to financial or human resources, but the poor quality of software product and processes (Brooks, 1987; Walia & Carver, 2009). Scholars such as Humphrey (1989) and Paulk et al (1995) believe that careful analysis and design of the software delivery process is the most important factor for

organizational success. This belief is largely responsible for the popularity of SPI initiatives. Most scholars ignore human factors such as training and emphasize process as, according to the SEI (2005) "everyone realizes the importance of having a motivated workforce, quality work force, and the latest technology, but even the finest people can't perform at their best when the process is not understood or operating at its best" (p. 9).

Other scholars (NSTD) agree that the main focus of CMMI is on processes, customers, and quality of deliverables, but they argue that human factors such as management, policy, and training are also important factors for success (QSR, 2008). Yamamura (1999) states that many factors must be considered in order to deliver quality software on time and within budget. These organizational factors include people, process, technology and management.

Thus, the success of SPI and product development initiatives is dependent on organizational management as well as the efficacy of SPI implementation. CMMI is the tool and guiding framework used to evaluate the maturity or the success level of an organization against pre-existing industrial standards. The study aims to examine the maturity level of IT organizations in UAE and the factors affecting them. It will identify, evaluate, and establish critical success factors to help organizations with IT products and processes to achieve optimum CMMI maturity levels.

1.4 The Significance of the Research

Although CMMI has been widely implemented and studied in the western world, there is a lack of research in CMMI in the Arab countries like the UAE. Typically the general research in this category is focused on western countries and the multinational organizational structures; however, the work culture in the western societies is very different from that of the Arab region. Specific factors such as conservative organizational hierarchies, a foreign workforce, and the cultural ethos in the UAE make it vital that effective factors of CMMI implementation be studied in context to its regional work environment. This study will help

organizations in UAE better improve their understanding and hence, implementation of SPI through the CMMI by enabling the attainment of higher maturity levels, these improvements will help UAE's organizations to attain higher maturity levels increasing their competitive edge in the global economy.

1.5 The Research Questions

Q1. What factors, as identified in the CMMI literature and case studies, have a positive impact on maturity levels?

Q2. What factors, as identified in the CMMI literature and case studies, inhibit maturity levels?

Q3. What factors have a positive impact on maturity levels in organizations in the UAE?

Q4. What factors inhibit maturity levels in organizations in the UAE?

1.6 Methodology

As the UAE is a relatively new entrant in the global IT market, it lacks the decades of established and mature organizations well versed in software processes and products, further the IT and organizational culture of the country is also behind the more developed nations. Thus, in order to identify industrial best practices it is necessary to examine in detail the success factors of organizations that have already achieved successful accreditation in the developed countries as well as those specifically in UAE and the surrounding Arab countries. This will provide a wide broad overview of maturity levels in firms and it will be possible to identify critical success factors and barriers to CMMI in organizations.

Research can be either quantitative that is based on gathering data from numerous sources or qualitative that gathers data from fewer sources. In the first case the data is usually obtained through conducting structured or unstructured interviews with individuals across the related area of research (Nkwi, Nyamongo, & Gery, 2001). In the second case data is gathered from

a case study for which the documents are gathered from the companies and other external sources besides interviews conducted with the managers of the companies that have been chosen for the study (Denzin & Lincoln, 1994). As stated above the UAE is yet to develop an open organizational and robust IT culture, in fact the organizational hierarchy is rigid and many managers lack expertise in CMMI field in terms of handling IT process and project management. Thus, a quantitative study requiring participation from industrial experts is not possible within the limited scope of this study.

The study will be conducted via qualitative methods such as case studies and an extensive literature review. A thorough examination of the scientific literature and case studies regarding CMMI and maturity level in both global and UAE organizations will be conducted. The details of these strategies will be discussed in the methodology section later in the paper.

1.7 The Organization of the Research

This thesis is divided into five chapters. The first chapter outlines the problem at hand and develops the project's aims and objectives. It also offers an introduction to the thesis, and provides a brief outline of thesis construction.

The second chapter provides a comprehensive review of the existing literature on project management maturity levels and CMMI. It also explores the benefits of CMMI evaluation, the factors affecting the achievement of greater maturity levels and the barriers to the same.

The third chapter justifies the methodology on which this research paper relies. It will then further clarify the research methods utilized, including tools, ethical considerations, and limitations of the study.

The fourth chapter describes the case studies selected for the research. Four case studies were selected of which three are success stories and one is a failure of CMMI implementation. Furthermore, two more case studies were selected from the Arab region as they have specific

cultural and regional insight to the research parameters. A single case study of Mercator of the Emirates Group in the UAE was also conducted.

The fifth chapter examines and analyses these case studies and answers the research questions.

The sixth chapter discusses the results from the previous chapter. Finally, the paper draws conclusions from the study results and makes recommendations to improve CMMI levels in organization in UAE.

2 Chapter Two: Literature Review

This chapter will examine the CMMI maturity model in detail and explore the existing literature on the benefits of adopting CMMI. It will also explore the barriers and success factors affecting maturity levels of organization vis-à-vis CMMI.

2.1 What is CMMI?

In 2006, the Software Engineering Institute at Carnegie Mellon developed a process improvement maturity model for the improvement of products and services (SEI, 2010). This model, popularly known as CMMI, has become the internationally accepted standard for assessing and evaluating organizational maturity. Many organizations strive to achieve software development process maturity through certification within the CMMI framework. Maturity levels (0-5) are measured and assigned to firms depending on their organizational development such as management of processes, handling deviations, automation/organization of procedures and staff skills etc. The higher maturity levels indicate better managed organizations that have evolved SPI and are able to deliver quality products in time. Before reviewing CMMI in detail, it is first necessary to examine the meaning and purpose of 'maturity,' 'measuring maturity,' and 'maturity models'.

2.2 Maturity models

According to Rosemann and de Bruin (2005), 'maturity' can be defined as a measure allowing organizations to assess their proficiencies with regard to specific problem areas. The concept of maturity relates to diverse organizational resources such as process, deliverables, and human resources. Mettler (2011) posits that organizational maturity can be divided on the basis of:

- maturity of processes
- maturity of objects or technologies
- the maturity of the people's capabilities

Most scholars agree that maturity models define characteristic patterns in the growth and improvement of the processes, object, and capabilities (Kazanjian and Drazin, 1989; Solli-Sæther and Gottschalk, 2010). Each model attributes different levels or stages of maturity to developed processes/objects/capabilities, with each level being higher than the former (Rao et al., 2003). Maturity models provide the framework (in the form of descriptors and variables characterising different stages) within which organizations rate their level of development (Gottschalk, 2009; Holland and Light, 2001; Rao et al., 2003). Thus maturity models provide a hierarchical progression (not easily reversed) for organizations seeking higher levels of development/maturity (Solli-Sæther & Gottschalk, 2010).

Kamhawi (2007) stresses the importance of understanding the key determinants of process maturity in order to improve deliverables and achieve higher levels of maturity. Srinivasan and Murthy (2010) posit that process maturity indicates the maturity/developmental level of a current process, as well as its capacity to continuously improve via appraisals and feedback. Srinivasan and Murthy (2010) argue that this view of process maturity provides firms with a competitive edge. Further, attaining higher levels of process maturity boosts the prospects of generating well-developed and efficacious products and helps to reduce development costs, improve staff productivity, and increase customer satisfaction (Krishnan & Keller, 1999; SEI, 2010).

According to Mingay (2002), the Gartner Maturity Model refers to a staged structure of maturity levels. It defines the extent to which specific processes are demarcated, achieved, assessed, controlled and operative. The organization implementing these models improves and implements new practices from which it acquires, enhances and transfers to a higher level, till the preferred level is reached. Accordingly, maturity models encompass the following objectives:

- Measure the maturity of the process
- Compare the maturity of the organization to industry standards and best practices
- Provide a mechanism for improving organizational maturity levels (Mingay, 2002)

Among the current crop of process maturity models, CMMI has become the global standard due to its high acceptance rate in the industry (Jones and Soule, 2002).

2.3 Development of CMMI

Carnegie Mellon University's focus on the emerging discipline of software engineering was sponsored by the US Department of Defence (DOD) in the 1980s (SEI, 2010). Carnegie Mellon developed the Capability Maturity Model (CMM) which assists in the standard assessment of organizational performance.

Englund and Graham (1999) indicated that the CMM model was initially developed to create several different benchmark methods and theoretical frameworks in the field of software development. Its goal was to provide a consistent, internationally accepted framework within the industry. The central aim of CMM is to help organizations align all business processes to so that general organizational objectives are attained and sustained successfully. Consequently, CMMs can be defined as models of best practices used to improve an organizations' performance (Chrissis, Levine & Shrum 2009).

According to Gardiner (2005), CMM has been superseded by the Capability Maturity Model Integration (CMMI). CMMI looks at best practices when assimilating and executing new business practices on a cross-organizational level, such as the use of structures to transfer data on a real-time basis for increasing organizational efficacy. Meskendahl (2010) argues that CMMI has come to be considered as the standard benchmark tool for evaluating organizational maturity.

2.4 The CMMI Models

CMMI models are compilations of efficient practices and process improvement objectives that organizations utilise to assess and enhance their processes (CMMI, 2014). These objectives and practices are tabulated into intuited categories called 'Process Areas'. The 22 Process Areas are the main elements of the model; they are structured so that they guide organizations to improve process performances. CMMI models are interrelated and augment each other (CMMI, 2014). Most organizations are involved in the development, acquisition, and delivery of products and services, any of the models given below can be adopted:

(1) **CMMI for Acquisition** (CMMI-ACQ) model provides guidance to organizations that manage the supply chain to acquire and integrate products and services to meet the needs of the customer.

(2) **CMMI for Development** (CMMI-DEV) model is used for process improvement in organizations that develop products. CMMI-DEV provides guidance to improve the effectiveness, efficiency, and quality of their product development work.

(3) **CMMI for Services** (CMMI-SVC) model provides guidance to organizations that establish, manage, and deliver services that meet the needs of customers and end users.

(4) **People CMM** provides guidance to organizations for managing and developing their workforce. Many organizations have made improvements in their services or software and systems processes and practices using CMMI have discovered that their continued improvement requires significant changes in the way they manage people.

(5) **Data Management Maturity (DMM) ™** model's overall goal is to help organizations become more proficient in their management of critical data and to provide a consistent and comparable benchmark for regulatory authorities in their efforts to control operational risk (CMMI, 2014).

CMMI encompasses industrial best practices in the above disciplines by addressing developmental and maintenance issues throughout the product lifecycle – from formation to delivery and service. Starting with an evaluation of the organization's maturity level and process ability, CMMI establishes priorities for development and a strategy for achieving higher maturity levels

2.5 CMMI Representation

CMMI operates in three fundamental areas that form the overall business process: (a) acquisition, (b) services, and (c) development. Organizational maturity level is evaluated and each process is awarded a score. Such an evaluation benchmarks organizational efficacy. The appraisal helps organizations understand and improve their process maturity, which leads to greater efficiency (Williams, Klakegg, Walker, Andersen, & Magnussen, 2012). CMMI has two forms of operation (Trieu & Joze, 2010).

1. Continuous CMMI - Continuous application refers to the development and maintenance of the status quo. Each process area in the continuous CMMI has definite goals that are executed by well-defined practices wherein the summary components are process areas; organizations are free to choose which particular process area to emphasise (Shrum, 1999).
2. Staged CMMI – Staged or incremental CMMI refers to on-going development and process improvement to deliver organizational efficiency. With incremental CMMI, the organization improves their processes in a staggered manner, concentrating on one stage at a time. Here the summary component is the maturity model. Thus, each maturity level comprises a predetermined number of process areas that must be up to standard for attaining the desired level of maturity (Shrum, 1999).

The difference between staged and continuous CMMI models lies in their structure; viz. each model focuses on different processes, and organizational practices are assessed

differently. Continuous CMMI traces process improvement through six capability levels, while staged CMMI traces maturity through five levels (Chrissis, Levine & Shrum, 2009)

2.6 CMMI Appraisals

According to SEI (2006), CMMI appraisals of organizations must adhere to the prerequisites delineated in the 'Appraisal Requirements for CMMI' (ARC) document. Appraisals are classified into three categories called appraisal method classes. Requirements are then assigned to characteristics based on the appraisal class. Accordingly, a specific appraisal technique may be an ARC Class A, B, or C appraisal technique. Class A appraisal is the most stringent, and officially only a Class A appraisal can confer organizational maturity level rating (SEI, 2006). The following table, which is derived from the SEI CMMI website, illustrates the key features of the appraisal classes:

Table 1: CMMI Appraisal

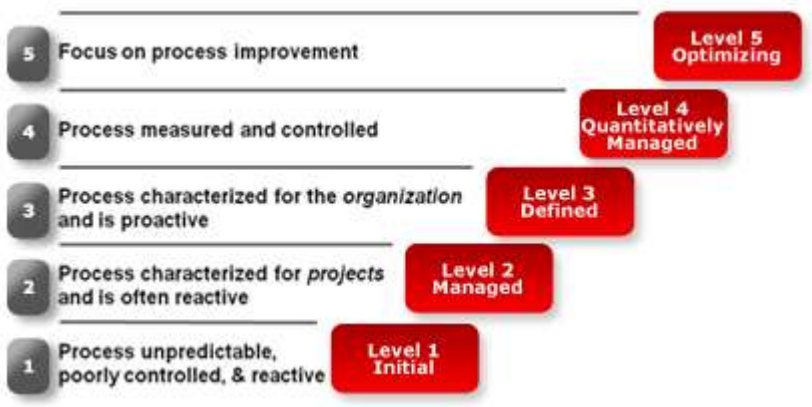
Characteristic	Class A	Class B	Class C
Amount of objective evidence	High	Medium	Low
Ratings generated	Yes	No	No
Resource needs	High	Medium	Low
Team size	Large	Medium	Small

Organizations can choose the type of appraisal to be conducted based on the circumstances and requirements of the project. Occasionally, self-assessments, preliminary appraisals, mini-appraisals, or external appraisals are appropriate; at other times, a formal benchmarking appraisal is appropriate.

The CMMI maturity model ranks organizations at five predetermined levels. The

organizations can progress from the lowest (level 1) to the highest (level 5) maturity levels by efficiently applying SPI and by meeting the goals of the level's process areas.

Figure 1: Levels of Maturity in CMMI



Source: (Netways, 2008)

2.7 CMMI Maturity Levels

CMMI Level 1: Initial

At level 1, organizational processes are typically ad-hoc and chaotic. In general, the organizational environment is unstable and cannot support the SPI. Organizational success is largely dependent on staff proficiency and individual capabilities, rather than the use of verified processes. However, despite the chaos of disorderly processes, CMMI level 1 organizations frequently produce efficacious products and services. Yet, despite the products and services produced, the organizations are unable to maintain predetermined budgetary and schedule limits. Hence, CMMI level 1 organizations have a propensity to overcommit resources, abandon processes in emergencies, and fail to duplicate their initial successes (SEI, 2010).

CMMI Level 2: Managed

CMII level 2 requires that products and services have an observable in-process status (at key milestones and when major work is accomplished) visible to management. Obligations and

goals are divided among appropriate stakeholders and are reviewed from time to time. Production processes are suitably organized, and work products and services fulfil their stated process descriptions, criteria, and practices (SEI, 2010).

CMMI level 2 is granted to organizations that:

- have confirmed that business processes are premeditated and implemented in accord with predetermined policy
- employ expert staff that have sufficient means to produce measured outputs
- involve important stakeholders
- are supervised, controlled, and appraised
- are assessed for observance of process descriptions

Thus, process discipline established at level 2 ensures that prevailing practices are engaged during times of crisis. When predetermined practices are in place, organizational performance is managed in accordance to accepted plans, and organizations are able to repeat initial success.

CMMI Level 3: Defined

At CMMI level 3, organizational processes are well considered and understood. The processes have predetermined criteria, procedures, tools, and systems. Organizational processes are standardised, and these processes are improved over time. Standardised processes help to create stability throughout the organization. Individual organizational projects adapt their processes from the organization's predetermined and successful processes, according to pre-set guidelines (SEI, 2010).

There are some major differences in the range of criteria, process descriptions, and practices of CMMI levels 2 and 3. At level 2, the criteria, process descriptions, and practices may

differ greatly in each particular occurrence of the process (on a specific project). However, at level 3, the criteria, process descriptions, and practices for specific projects are adapted from the organization's predetermined standard processes to match the requirements of that project or organizational unit. Therefore, at level 3, organizational processes are more consistent (except for the alterations permitted by the adaptation guidelines) than that at level 2.

Furthermore, at level 3 processes are usually defined more meticulously than level 2. A meticulously defined process visibly states the purpose, participations, entry norms, undertakings, roles, methods, certification steps, productions, and exit norms. Additionally, at level 3, processes are handled more proactively – with an understanding of the inter-connections of the practices and comprehensive procedures of processes, outputs, and services. Thus, to achieve CMMI level 3, organizations must further develop and improve the level 2 process areas. Those generic practices that accompany general goal 3 -- but which have not been addressed at level 2 -- are required to achieve CMMI level 3 (SEI, 2010).

CMMI level 4: Quantitatively Managed

CMMI level 4 requires that organizational projects create quantifiable goals for quality and 'process performance' and utilise them as benchmarks in the management processes (SEI, 2010). Quantifiable goals are based on customer requirements, end users' needs, organizational capacity, and process operators. Quality and process practices are contained in statistical standings and are reviewed throughout the processes lifecycle (SEI, 2010)

Comprehensive measures of process performances are gathered and statistically evaluated. Quality and 'process performance' measures are amalgamated into the organization's assessment resources to facilitate factual and accurate decision making (McGarry, et al.,

2001). In the case of any process variation, specific causes are identified and addressed. The specific causes of variations in the processes are rectified to avert future incidents.

The main difference between CMMI levels 3 and 4 is the predictability of 'process performance.' Organizational performance of processes at level 4 is ordered by statistical and other quantifiable systems and is quantitatively calculable. In contrast, at CMMI level 3 process performance is usually only qualitatively knowable (SEI, 2010).

CMMI Level 5: Optimizing

CMMI level 5 is the highest level of the framework. At this level the organization constantly strives to improve its processes based on a quantifiable understanding of the typical causes of deviation within the business processes.

CMMI level 5 organizations focus on continuous improvement of process performance via increased and pioneering process and technical developments. Once the quantifiable process up-grade goals for the organization are recognised, they are repeatedly reviewed for alignment with organizations specific business goals and used as benchmarks for the management of process up-grades. Further, the influence of installed process enhancements is assessed and calculated in comparison to the quantifiable process enhancement goals. Both the demarcated processes and the organization's benchmark processes are objects of calculable upgrade activities (SEI, 2010).

The main difference between CMMI levels 4 and 5 is the nature of the process variation that is measured and corrected. Organizations at level 4 are concerned with rectifying specific causes of process discrepancy and delivering statistical surety of the outcomes. Though processes may yield foreseeable outcomes, these outcomes may be inadequate for achieving the stipulated organizational goals. However, organizations at level 5 are concerned with rectifying typical causes of process discrepancies and with altering the process itself (thus

shifting the centre of the process performance or reducing the intrinsic process discrepancy experienced) to restore process performance and to attain predetermined, quantifiable process improvement goals (SEI, 2010).

Table 2 SEI's software process-maturity framework

Level	Focus	Characteristics	Key process Areas	Result
5. Optimizing	Continuous process improvement	• Improvement feedback into process • Data gathering is automated and used to identify weakest process elements • Numerical evidence used to justify application of technology to critical task • Rigorous defect – cause analyses and detect prevention	• Defect Prevention • Technology Change Management • Process Change Management	Productivity & Quality
4. Managed	Product and process quality	• Measured process • Minimum set of quality and productivity measurements established • Process database established with resources to analyze its data and maintain it	• Quantitative Process Management • Software Quality Management	
3. Defined	Engineering process and organizational support	• Process defined and institutionalized • Software Engineering Process Group established to lead process improvement	• Organization Process Focus • Organization Process Definition • Training Program • Integrated Software Management • Software Product Engineering • Intergroup Coordination • Peer Reviews	
2. Repeatable	Project management process	• Process dependent on individuals • Established basic project controls • Strength in doing similar work, but face major risk when presented with new challenges • Lacks orderly framework for improvement	Requirements Management • Software Project Planning • Software Project Tracking & Oversight • Software Subcontract Management • Software Quality Assurance • Software Configuration Management	

1. Initial		No formal procedures, cost estimates, project plans • No management mechanism to ensure procedures are followed, tools not well integrated, and change control is lax • Senior management does not understand key issues		Risk

Source: (Humphrey, Snyder, & Willis, 1991; Paulk, Weber, Garcia, Chirssis, & Bush, 1993)

2.8 Process Areas

CMMI consists of 22 Process Areas, each defining a business process with specific and measurable goals. Organizations desiring to be ranked must achieve certain levels of success in designated Process Areas. The level of maturity at which they are ranked is dependent on the number of and the successful implementation of predetermined Process Areas.

Following is the full list of 22 Process Areas (SEI, 2010):

1. Causal Analysis and Resolution (CAR)
2. Configuration Management (CM)
3. Decision Analysis and Resolution (DAR)
4. Integrated Project Management +IPPD (IPM+IPPD)
5. Measurement and Analysis (MA)
6. Organizational Innovation and Deployment (OID)
7. Organizational Process Definition +IPPD (OPD+IPPD)
8. Organizational Process Focus (OPF)
9. Organizational Process Performance (OPP)
10. Organizational Training (OT)
11. Product Integration (PI)
12. Project Monitoring and Control (PMC)
13. Project Planning (PP)
14. Process and Product Quality Assurance (PPQA)
15. Quantitative Project Management (QPM)

16. Requirements Development (RD)
17. Requirements Management (REQM)
18. Risk Management (RSKM)
19. Supplier Agreement Management (SAM)
20. Technical Solution (TS)
21. Validation (VAL)
22. Verification (VER)

The attainment of explicit and general goals linked to set Process Areas establishes the CMMI level of organizations. Maturity levels and related Process Areas are shown in the table below

Table 3 Maturity Levels and Process Areas

Maturity Level	Focus	Process Area
1. Initial		
2. Managed	Basic Project Management	Configuration Management (CM) Measurement and Analysis (MA) Process and Product Quality Assurance (PPQA) Project Monitoring and Control (PMC) Project Planning (PP) Requirements Management (REQM) Supplier Agreement Management (SAM)
3. Defined	Process Standardization	Decision Analysis and Resolution (DAR) Integrated Project Management (IPM) Organizational Process Definition (OPD) Organizational Process Focus (OPF) Organizational Training (OT) Product Integration (PI) Requirements Development (RD) Risk Management (RSKM) Technical Solution (TS) Validation (VAL) Verification (VER)
4. Quantitatively Managed	Quantitative Management	Organizational Process Performance

		Quantitative Project Management
5. Optimized	Continuous Process Improvement	Causal Analysis and Resolution (CAR) Organizational Innovation and Deployment (OID)

Source: (Demirors, 2009; SEI, 2006)

2.9 CMMI Benefits

Effort invested in following these models and standards can help produce high quality software, reduce costs and time, and increase productivity (Pitterman, 2000; Yamamura, 1999). Goldenson & Gibson (2003) examined the benefits accruing to organizations that had adopted the CMMI model. They found the following benefits of CMMI implementation:

1. **Reduced Costs**
    - 33% decrease in the average cost to fix a defect (Boeing)
    - 20% reduction in unit software costs (Lockheed Martin)
    - 15% reduction in cost of poor quality from over 45% to under 30 % over a three year period (Siemens)
    - 10% decrease in overall cost per maturity level (Northrop Grumman)
2. **Faster Schedules**
    - 50% reduction in release turnaround time (Boeing)
    - 60% reduction in re-work following tests (Boeing)
    - 45% Increase the number of milestones met from 50% to 95% (General Motors)
3. **Greater Productivity and Higher Quality**
    - 25-30% increase in productivity within 3 years (Lockheed Martin, Harris, Siemens)
    - 50% reduction of software defects (Lockheed Martin)

4. **Customer Satisfaction**
    - 55% increase in award fees (Lockheed Martin)
5. **Return on Investment (ROI)**
    - 15% reduction in the cost associated with poor quality
    - 2:1 ROI over 3 years (Siemens Information Systems Ltd, India)

2.10 Barriers to CMMI

In order to successfully deploy the CMMI model, it is necessary to first identify the factors that determine the success or failure of CMMI implementation. According to Niazi et al. (2005), the problem of process improvement lies in the lack of a strategy for implementing improvement models (such as the CMMI). Nazi et al. posit that ignoring the social facets of process deployment strategies damages the institutionalization of implemented improvement processes. Mc. Dermid and Bennet (1999) also argue that human factors for SPI (such as CMMI) are usually disregarded, leading to negative impacts on process improvement. Several scholars posit that the main challenges of CMMI relate to its inflexible attitude to process control, which can at times be excessively oppressive, particularly small-scale organizations and agile processes (Benamati & Lederer, 2000; Basu, Hartono, Lederer, & Sethi, 2003).

Bayona et.al. (2014, p. 21) summarize the barriers to process improvement models as:

(1) Misaligned SPI goals and objectives- Improvement efforts that are not aligned with business goals

(2) Lack of Management commitment- Lack of leadership and visible commitment to improvement efforts

(3) Insufficient planning- A process that does not respond to business needs

(4) Disregard of Organizational culture and politics- Implementation of technical aspects of implementing CMMI while ignoring strategies to manage social aspects.

Niazi (2009) notes that many factors can generate organization politics including – reordering of organizational resources, opportunities for staff's advancement, low level of trust, deadlines, and role obscurity.

Furthermore, Alshammari and Ahmad (2011) conducted a study of Saudi Arabian software companies wherein, they noted that several barriers were specific to the Arab region:

(5) Turnover of staff- staff in Arab organizations are often sourced from foreign countries and even when employees are natives of the state, staff turnover due to resignations, transfers or alternative employment negatively affect achievement of objectives. New teams or employees are slow to integrate and cause delay in attaining desired maturity levels.

(6) Imposed partner - this is also identified as a factor having a negative influence on attaining higher maturity levels. An imposed partner is typically added to the organization due to a high social status. The partners are seen as affecting staff's productivity and delaying accreditation processing.

2.11 Success factors of CMMI

The literature includes many studies that identify the factors necessary to successfully implement SPI programs (Goldenson and Herbslebs, 1995; Stelzer and Melis, 1999; Rainer and Hall, 2001; El-Emam, Goldenson, McCurley, & Herbsleb, 2001; Niazi et al, 2006; Dyba, 2005)

Therefore, success factors for implementing process SPI (such as CMMI) can be summarised as: (1) Management Commitment, (2) Defining SPI goals and objectives, (3) Organizational Culture and politics, (4) Staff Involvement, (5) Training, (6) Experienced Staff, (7) Implementation Plan, and (8) Quality environment

(1) Management Commitment

While mid-level managers constantly participate in SPI activities in numerous areas, the commitment and personal involvement of high level managers is not consistent. However higher level management involvement in SPI initiative is necessary because:

- if top level commitment isn't obvious to staff, then the SP will not be truly applied throughout the organization
- workers at all levels of an organization will not dedicate themselves to a structure when their commitment is not motivated, reinforced, and supported by higher level management (Xanxo, 2012)

SPI initiatives should be proactively supported by the higher-level management, so that all personnel understand the significance of SPI. Furthermore, managers should be aware of the complex nature of SPI and provide resources and assistance as needed (Diaz & Sligo, 1997). El-Emam et al. (2001) note that management commitment can be assessed by the extent to resources for SPI are made available.

(2) Defining SPI goals and objectives

According to (Xanxo, 2012) setting authentic and applicable goals for SPI is crucial to its successful implementation. The project goals need to be absolutely clear and, SPI supervisors must ensure that all staff clearly understand and are aware of these goals. Stelzer and Mellis (1998) note that:

> Setting relevant objectives means that the improvement efforts attempt to contribute to the success of the organization. Setting realistic objectives means that the goals may be achieved in the foreseeable future and with a reasonable amount of resources. It is essential that staff members understand the relationship between the objectives of software process improvement and revenues,

> cash flow, or other business results. The real test of the improvement objectives is the degree to which everyone can make the translation from top management goals to the goals that each person is being asked to achieve (Stelzer & Mellis, 1998).

(3) Organizational Culture and Politics

The social influence of SPI on organizational culture should always be considered. Organizational culture depends on many factors such as industry type, level of automation and regional practices. An organization can have an open and flexible culture (where employees have freedom to make relevant decisions) or be strictly hierarchical (where every decision comes from the top) (Xanxo, 2012). Guerrero and Eterovic (2004) note that it is better not to implement ideas that contradict organizational culture as this create opposition to change. If properly implemented, SPI activities can actually improve the organizational culture and minimize any opposition to change.

Nevertheless, even young organizations with no established culture typically face some resistance to change. In order to avoid such a resistance and accomplish the requirements of the SPI program in a short time, adopting the activities (such as assigning particular tasks and responsibilities to employees) parallel to the organizational culture may be an effective solution (Karagul, 2009).

(4) Staff Involvement

Dyba (2005) described staff involvement as the amount to which personnel used their experience and skills to adopt, implement, and take accountability for SPI; and indicates that such involvement is positively allied to SPI achievement. Successful SPI initiatives require staff that is enthusiastic and dedicated to SPI endeavours. Organizations should boost staff involvement and participation. As people are the main drivers of SPI improvement, division

of resources and team activities should be structured such that the organizations acquire the maximum advantage from personnel (Basri & O'Connor, 2011).

(5) Training

The success of an SPI program depends on the people implementing it. Therefore, it is vital that personnel involved in SPI initiatives be trained with essential skills and competencies. Paulk et al (cited in Rainer and Hall, 2001) noted that SPI initiatives were more successful when knowledgeable and motivated staff was assigned to processes. Guerrero and Eterovic (2004) state that all personnel involved in process maturity improvement should be provided with adequate training in accordance with their jobs. If expense prevents the detailed and targeted training of staff, organizations can train handpicked individuals for specific processes.

(6) Experienced Staff

Staff in all positions should be cognizant of the advantages of SPI and their responsibilities to the SPI program. Staff with prior SPI experience should be given preference in the allocation of resources. Each team should have an experienced member. Employing consultant companies for assessments is also advantageous (Xanxo, 2012).

(7) Implementation Plan

Successful SPI administration is plausible with a proactive implementation plan and an official policy that is established on the basis of prior experiences. Implementation in several staged milestones may speed SPI success. Further, repeated appraisals (either formal or casual) may be useful. These appraisals quantify the results of the SPI, making it easily observed and measured. Karagul (2009) advises regular preparation of process

implementation reports. Process monitoring via regular reviews is also helpful in keeping the SPI on track.

(8) Quality Environment

According to Karagul (2009), when the organization has produced software to established in-house standards or has fulfilled the requirements of official accreditations (for e.g. CMMI), then they possess a greater probability of succeeding in SPI implementation. The most important environmental factors for success are:

- SPI goals that parallel business goals. The more alignment exists, the higher the perception of success.
- Compatibility of the organizations' quality procedures with the requirements of the applied maturity model
- The collection and utilization of quality data to guide and assess the effects of SPI activities (Karagul, 2009, p. 26)

2.12 Summary

CMMI is no doubt a very successful and complex SPI framework that is uniquely suited to software development needs. However, despite its complexity, CMMI implementation is simple due to well delineated process area, clear and consistent goals, and an adaptable appraisal process. Organizations that have implemented CMMI have reported benefits (Goldenson & Gibson, 2003) including reduced costs, better quality products, and higher productivity. This certainly makes a strong case for organizations to implement the CMMI framework. This review has outlined several factors that inhibit successful implementation, as well as factors that have a positive effect on SPI. The success factors (management commitment, organizational culture, staff involvement, etc.) can be easily adapted to CMMI frameworks being implemented in UAE organizations to increase the maturity levels.

3 Chapter Three: Methodology

Research methodology refers to the method or methods of collecting, analysing and presenting/reporting data (Warsame, 2012). This section shall exclusively discuss the framework within which data was collected, analysed, and presented. The methodology was chosen to ensure maximum focus and precision.

This section is grounded on the requirement to build an account of the entire research process– which ought to be true, reliable, complete, orderly, and easy to grasp and understand. It follows that the methods of collecting, analysing and reporting data should facilitate the foregoing (Barzun & Graff, 2003).

3.1 Research Methods

Research involves an investigation about a phenomenon to discover why it takes place and how it impacts society or environment. Quantitative and qualitative researches are the two most used methods, but a third mixed methods research (combining quantitative and qualitative) is also popular. The quantitative method endeavours to endorse the hypothesis about events. However it uses a rigid style approaching the event from a fixed viewpoint. It therefore uses tools such as structured questionnaires pursuing corroborations of its premise (Nkwi, Nyamongo, & Gery, 2001). Qualitative methods, on the contrary, are flexible being more investigative; seeking the rationale for events. They utilise tools like open ended interviews to draw opinions and understandings through comprehensive investigations (Denzin & Lincoln, 1994).

Qualitative research aims to produce fuller understandings on the basis of rich, contextual, and detailed data (Mason, 1996). This type of research converts material from observations, compilations, and records into data in the structure of written reports. Detailed descriptions of proceedings or individuals are essential in qualitative analysis. Since the researchers examine the particular issues in great minutiae, this research typically deals with limited sample sizes

(Denscombe, 2007; Patton, 1990). Qualitative research offers evidence from secondary or documentary sources (Tripp-Reimer, 1985) and produces findings without using statistical procedures or other means of quantification (Corbin & Strauss, 1990). Rather, qualitative methods involve a planned investigation that relies on narrative data in the form of documents. Such research serves as qualitative evaluation of an organisation by way of studying its effectiveness or efficiency in context of the research topic (Faherty, 2009). A qualitative research is therefore diagnostic as it seeks to discover behaviours. Qualitative methods are applied when superficial examination will not suffice to identify the underlying causes of multiple variances in complex situations requiring more than simplistic opinions

Kaplan and Maxwell (1994) advise that the researcher should apply qualitative research techniques if it is needed:

1. To find answers to questions of not only what but also why and how;
2. To analyse the relationship between the area of study and social, organizational, and cultural context;
3. To investigate the details of the processes;
4. To observe the process life cycle rather than its outcomes or impacts.

But it has also been said that use of a qualitative or quantitative approach alone may produce prejudiced results. Hence, a sensible use of both approaches is normally recommended for thorough analysis (Eisenhardt, 1989; Locke, 2001).

Nevertheless, the approach has to be decided on issue basis. This study requires inquiry into the phenomenon of effective factors on attaining higher maturity levels in UAE organizations as detailed in the research problem. Normally a quantitative research through structured questionnaires would result in diverse data due to personal perceptions of different

stakeholders. Therefore, it is more objective to establish the ground realities by examining documents and reports published in literature.

Consequently, this study will be utilizing a case study methodology using secondary research (Kaplan & Duchon, 2004). This may include both qualitative and quantitative information as appropriate (Marschan-Piekkari & Welsh, 2004). Case study results are samples from reality. They show how things work in a specific place, time, and circumstance. The case study has therefore developed into a standard practice as a scientific method of research (Yin, 2003). Case studies may be explorative or descriptive wherein the research aims to closely investigate phenomena. .

3.2 Research strategy

Research strategy refers to general approaches used in achieving the goals of a research study. Warren (2006) classifies research strategies into: (i) descriptive research strategy, (ii) exploratory research strategy, (iii) diagnostic research strategy, (iv) non-experimental strategy, (v) correlation strategy, (vi) experimental strategy, and (vii) quasi-experimental strategy. The research questions and the objectives of the research study should guide the researcher when making a decision on the strategy to apply in the research.

Jackson (2009) points out that descriptive research is normally intended for describing situations. There are three main types of descriptive research methods: observational methods, survey methods and, case study methods. However, such studies lack the power to make predictions and are unable to determine cause and affect relationships. According to Eldredge (2004) descriptive research strategy does not establish relationships between variables, but gives an in-depth description of the variable under investigation. Thus, a descriptive strategy, while helping us identify several factors that help organizational success, will not help in establishing factors that specifically affect maturity levels in UAE organizations. In contrast, diagnostic research is concerned with establishing associations

between variables. Accordingly, diagnostic research, in combination with descriptive research, will guide this study in attaining desired objectives.

Based on the research questions, aims, and objectives of the research, the study will utilize three strategies: specifically, (a) non-experimental research strategy, (b) descriptive research strategy, and (c) diagnostic research strategy. Non-experimental research strategy was selected because there is no manipulation of factors in the study. Descriptive research strategy will be used to describe the factors previously noted by numerous scholars on success factors for CMMI. Lastly, diagnostic research strategy was utilized with the primary aim of establishing specific requirements for increasing maturity levels (CMMI) of the IT industry in UAE vis-a-vis the general success factors in various SPI programs across the globe.

3.3 Research Questions

The main research question asks what factors affect maturity levels in UAE. To answer this question, it is necessary to investigate the details of the SPI processes of the organizations; to discover the causes behind the outcomes throughout the SPI lifecycle; and to identify the relationship between the success factors and organizational and cultural contexts. Under subjective quantitative studies, the sample data is an average of opinions. In contrast, a case study approach enables examination of different aspects of the event. UAE is yet to develop an open organizational and robust IT culture; in fact the organizational hierarchy is rigid and many managers lack expertise in the CMMI field in terms of handling IT process and project management. Thus, a quantitative study requiring participation from industrial experts is not possible within the limited scope of this study.

This paper therefore proposes to conduct research by selection of suitable case studies in the field of CMMI implementation to answer the following research questions:

Q1. What factors, as identified in the CMMI literature and case studies, have a positive impact on maturity levels?

Q2. What factors, as identified in the CMMI literature and case studies, inhibit maturity levels?

Q3. What factors have a positive impact on maturity levels in organizations in the UAE?

Q4. What factors inhibit maturity levels in organizations in the UAE?

3.4 Data collection

Saunders, Lewis and Thornhill (2012) argue that in order to justify its inclusion, it is essential to explain where data is collected from. Data for this research was gathered from trustworthy and reliable sources comprising academic and professional journals and literature, conference presentations, and the websites of appropriate professional bodies such as the Software Engineering Institute (SEI, 2013). Preference was given to empirical research studies which established the effectiveness or otherwise of CMMI using case studies and primary evidence (Saunders, Lewis, & Thornhill, 2012). The literature was accessed with the help of the online search engines like Google Scholar and online databases like EBSCo Host, Elsevier Science Direct, JSTOR, and SpringerLink by using a combination of the following keywords: "software process improvement," "CMMI," "maturity levels," "critical success factors," and "CMMI in UAE."

The search results produced a number of case studies in CMMI implementation in the developed countries; however cases of CMMI in the Arab region were limited. It was also found that organizations in UAE in particular were more liable to adopt ISO, ITIL, Prince 2 certifications. Only a handful of UAE organizations had applied for CMMI appraisals as illustrated in Fig.2. Furthermore, no peer reviewed literature is available on the details of

management commitment, staff involvement and quality environment etc. of these organizations.

Figure 2: CMMI Organizations in UAE

Organization Organizational Unit	Team Leader Sponsor	Appraisal End Date	Model (Representation): Maturity Level
Abu Dhabi Company for Onshore Oil Operations (ADCO) CITD-Solutions Development	HansRaj Takemal Abdul Salam Alzubaidi	01/30/2014	CMMI-DEV v1.3(Staged):Maturity Level 2
Abu Dhabi Tourism & Culture Authority (TCA-Abu Dhabi) Development Projects, IT Division	Anandkumar K Shelat Mohammed Al Dhaheri	07/05/2012	CMMI-DEV v1.3(Staged):Maturity Level 3
C4 Advanced Solutions Applications Group - AFAD Account	Ramamurthy Rangarajan Ahmed El-Quosey	02/29/2012	CMMI-DEV v1.3(Staged):Maturity Level 3
DP World UAE Region, IT Department - managed projects	Rajiv Nag Ahmad Alhaddad	12/19/2011	CMMI-DEV v1.3(Staged):Maturity Level 3
GET Group IT & Passport ID Software Solutions	Madiha Hassan Maysoon Jamal	02/07/2013	CMMI-DEV v1.3(Staged):Maturity Level 3
The Emirates Group Emirates Group IT / Mercator	Sankararaman Dhandapani Neetan Chopra	05/10/2012	CMMI-DEV v1.3(Staged):Maturity Level 3

Source: (CMMI Institute, 2014)

Four case studies were selected for analysis, of which three are success stories and one is a failure of CMMI implementation. Furthermore, two more case studies were selected from the Arab region as they lend specific cultural and regional insight to the research parameters. A single case study of Mercator of the Emirates Group in the UAE was also conducted, but the results were inconclusive due to scarcity of relevant data.

3.5 Ethical Considerations

This is research is based on case studies and all available documents will be in the public domain. Only published data will be used. The question of ethical conflict is not expected to arise.

3.6 Limitations

This research is limited as it based on existing, published documentation; a more accurate picture would necessitate extensive primary research requiring financial support and additional time. Furthermore, UAE still lacks an open organizational culture, CMMI expertise, and a robust IT industry. As a result, gathering primary data is not possible within the limited scope and resources of this project. However, the secondary case studies together with the literature review should provide general insight into the factors affecting maturity levels in UAE. It will also identify the gaps where the data is inconsistent with the literature review and will thereby help direct future research efforts.

4 Chapter Four: Case studies

4.1 Success Story #1: Hewlett-Packard (HP)

Lowe and Cox (1996) documented a CMM implementation study of HP's Software Engineering Systems Division (SESD). The SESD reached a Maturity Level 2 within a few months of initiating the project. The project began with investigations and goal setting in September and was implemented in November 1994. By August 1995, the SESD was functioning at 100% Maturity Level 2.

Management Commitment

Management was totally committed to this programmed task and three people were exclusively assigned to the project. Furthermore, expert external assistance was sought and provided throughout the project duration and management was amenable to suggestions and input.

Defining Organizational Goals

The key organizational issues were timely delivery of product to market and quality improvement. Product delivery issues were identified from previous performances of product teams in an 18-to-24-month window, as were problems in providing products that addressed key customer satisfaction concerns. Countering these issues was identified as the main objective and goal on which the entire organization could focus. The SoftBench2 product team had a business goal of releasing an update in a 12-month cycle, (viz. a 6 - 12 month decrease in cycle time). Additional aims included reduction in the quantity of lines of code in software, providing three key consumer satisfaction improvements and three competitive improvements, and fixing all significant problems reported by clients.

External Assistance

The SESD enlisted external assistance from HP's Corporate Engineering SPI team (which had expertise in software process areas fundamental to SPI) in the primary stages of the project. The SPI team worked with several levels of SESD to improve its development ability, fast-tracking the creation of permanent tactical improvements and decreasing the risk of change. Furthermore, three process consultants (formerly from SEI) met daily over a period of several weeks to evaluate the CMMI specifications, develop SESD's interpretation of the model, and render it into language that was applicable and comprehensible throughout the organization.

Assessing Current Practices

To evaluate current practices, SESD used a 'software process profile.' The process profile can be defined as "an assessment of the state of an organization's software development process, identifying strengths and weaknesses, highlighting the process improvements the organization values most, and recommending areas for change" (Lowe & Cox, 1996, p. 4). CMM is used as the benchmark for assessing software processes in the SESD process profile.

Engineers and managers in organizations are first required to fill a survey intended for evaluation of the organization's software process maturity alongside the CMM requirements. The outcomes of the surveys are assembled into a software process profile for the organization being evaluated. Thirty engineers and managers participated in the process profile evaluation for SESD. The results indicated that:

- Only four Maturity Level 2 process areas were partially satisfied – (1) Configuration Management, (2) Quality Assurance, (3) Project Tracking, and (4) Project Planning.

- Two areas were not satisfied at all – (1) Requirements Management and (2) Subcontract Management.
- Out of the seven Level 3 processes, only one area was partially satisfied – (1) Peer Reviews.

Implementation Plan

In order to get the company to accept changes necessary for Maturity Level 2, the authors first clearly defined the new policies and procedures. Secondly, training was provided in these new policies and procedures. Finally, the organizational culture was also addressed as it was an essential factor in getting everybody positively involved in the change process. Accordingly, implementation of SPI involved a succession of short stages including definition, revision, and approval of policies, processes, and outlines. Only after passing through this necessary structuring were SPI policies etc. passed on to the software development teams. It was decided that this change would be positively managed by accomplishing the following:

- Demonstrate success with a phased approach
- Leverage existing processes and minimize some areas of change
- Make everyone's contributions very visible (Lowe & Cox, 1996).

Staff Involvement

The management was aware that communicating the new changes in a positive manner to the staff was vital to the successful implementation of the new SPI plan. Therefore, the organization clearly defined and described changes from the old manner of doing things and provided either group or solo training in new approaches as required. The change managers

clearly understood the need to connect with the staff and keep them involved in the process. Hence, they ensured that all staff understood changes to processes and were clear on their duties and responsibilities in the new structure.

Continuous Assessments

The quality assurance team executed an inspection – after each software development checkpoint – by interviewing the involved staff according to specifications for Maturity Level 2. The external consultants were from SEI itself; and brought experience and knowledge to the appraisal process in questioning, reporting, and additional consultation with personnel. These reviews had numerous benefits. Firstly, the project team knew processes being used in each stage would be demonstrably appraised by an autonomous team. This elevated the significance of each stage and encouraged the use of defined processes. Secondly, the appraisal interviews revealed grave issues and hazards for the software's development; these were mostly an outcome of deviation from defined plans or procedures.

Achieving Maturity Level 2

With the achievement of Maturity Level-2, Lowe and Cox (1996, p. 10) documented several benefits:

- Condensed cycle time for the SoftBench release from 18-24 months to 14 months. This prompted a noteworthy decrease in engineering time, leading to savings in the product's developmental costs.
- Anticipated 12-month release cycle required more time. However, the commitment period at the time of design completion was met with no schedule slip and no reduction in product reliability standards.

- Reduced defects (across all of SESD's products) from an average of 4.6 open serious defects at manufacturing release in 1994 to 1.6 open serious defects per product in 1995.
- Fixed all outstanding major customer service requests during this period.
- Reduced the overall code size by 12%.
- Reduced documentation size by 35%.
- Delivered three major customer satisfaction improvements and three major competitive improvements.

4.2 Success Story #2: Link

Guererro and Eterovic (2004) discuss the implementation of SW-CMM Level 2 in Link (a Chilean organization). Link is a software development and maintenance firm providing IT services for an indigenous retail dealer, their only customer. By default, the organization was at an operational Maturity Level 1. Its software ventures in the previous four years had pursued the waterfall software life process and used premeditated devices for software manufacturing. The SPI initiative was led by one of the authors.

Defining Organizational Goals

Prior to beginning the SPI initiative, the organization had generated a software quality assurance area and a software configuration management area each staffed with one operative. It had somewhat-established software improvement processes and had created a requirements and project administration system (Oracle Forms and Java Server Pages). Implementing the SW-CMM aligned with Link's tactical goal – to retail their software services in the international marketplace.

Management Commitment

Link's senior manager was unequivocally committed to the initiative's importance from the start. The managements unwavering commitment and backing facilitated the implementation by providing means and assisting in obtaining buy-ins from developers.

Implementation Plan

The plan to upgrade Link to Maturity Level 2 was formally initiated in May 2002. The senior manager allocated a dedicated project manager, and administration projected a timetable and budget, defining two five-month process improvement phases (Guerrero & Eterovic, 2004, p. 31):

Phase 1 (Initial Research)

This phase was directed at:

- Determining which process standard to use
- Deciding how to guide the SPI self-assessment—rough process appraisal
- Planning—detailed plan for the SPI initiative
- Establishing documentation and first improvements—process documentation, rollout of first improvements
- Executing informal assessments—external consultant's assessment, similar to the CMM-Based Appraisal for Internal Process Improvement (CBA-IPI)

Phase 2 (Implementing)

- Planning—detailed plan for noncompliance issues
- Training and communications—personnel process-related training

- Documentation—finish process documentation
- Self-assessment—internal process appraisal
- Levelling—aggressive CMM-related training
- Pilots—deployment of improvements
- Formal assessment—CBA-IPI

Achieving Maturity Level 2

Guerrero and Eterovic (2004) closely monitored project status during the 10 months of implementation. The first strategic goal for the general SPI initiative was to be evaluated Maturity Level 2 by the beginning of 2003. A self-appraisal was conducted against the selected process model, and a five-person Software Engineering Process Group (SEPG) was created to accomplish process improvement plans. The staff formed technical work-teams, each responsible for a particular key process area. These teams controlled the design and production of SPI. In 2002, an external consultant was brought in to execute a mini-appraisal. Several non-compliance issues were found; Link tackled these issues via a robust action plan. In the closing four months, the entire software division was given process-related training, and all necessary software improvements were implemented throughout Link. Finally, in January 2003, the company was officially evaluated at Maturity Level 2.

4.3 Success story #3 Telcordia

Telcordia is a software development organization combining eight business units responsible for a portfolio of over 120 refined, high-tech software artifacts and almost 130 million lines of code. Pitterman (2000) examines how this organization achieved a CMM Level 5 rating. This was a two-step process beginning in 1996 when Telcordia decided to focus on the CMM for certification in quality.

Defining Organizational Goal #1

An organization-wide Quality Method of Operation (QMO) had already been established. It was determined that the quality system needed only minimal additions and modifications to be assessed at Maturity Level 3.

Management #1

The organization established a two-tier managing structure to supervise the QMO's efficacy and suitability and to ensure that senior management's commitment to the task was unquestionably apparent to all developers and staff. A governing body, the Strategic Quality Management Team (SQMT), was established to manage the quality system. The SQMT comprised of "Telcordia's president and chief operating officer, corporate vice presidents from the strategic business units, and the software organizations' general managers" (Pitterman, 2000, p. 90). The main aims of the SQMT were to create annual business quality objectives and enterprises and guarantee the sustained suitability and efficacy of the general QMO.

Furthermore, a Tactical Quality Management Team (TQMT) was also established. This consisted of the organizations' executive and directors in addition to delegates from vital organizations supporting software development. TQMT's main aims were to (Pitterman, 2000, p. 91):

- implement the quality goals and initiatives established by the SQMT,
- review and approve all proposed changes to the QMO,
- act as the primary communication conduit to the software units for quality-related issues,

- identify best-in-class local procedures that might become part of the QMO

Staff Involvement #1

According to Pitterman (2000) implementation of the QMO from the top to middle management was a crucial factor to its institution and the response of all relevant staff. By keeping intra-organization communications open, Telcordia instilled a widespread, wholehearted backing for the QMO. The organization made the QMO and all auxiliary documents accessible to all staff through the Telcordia intranet. Consequently, a spirit of collective purpose was prevalent throughout the organization.

Training #1

The quality managers constantly instructed all staff in the QMO and their attendant tasks via half-day training classes, product team classes, and even individualized classes.

Quality Assessment #1

The Software Quality Assurance (SQA) organizations execute all the autonomous testing at the artifact- and solution-level and evaluate and act on in-process measures throughout the software development life cycle. The SQA organizations use a succession of quantitative metrics to assess the test phase.

Furthermore, as part of the assessment, project managers oversee the QMO from requirements development through coding – qualitatively. The assessment process guarantees that all acknowledged errors are corroborated and rectified before exit benchmarks are fulfilled and the project can transfer to the next level.

Organizational Culture #1

A feeling of proprietorship of the quality system was rapidly infused in all staff. Everybody knew that the quality managers were available and receptive to new ideas; and staff at all ranks of the organization was encouraged to recommend alterations to the quality system. Hence, making recommendations to advance the process was soon accepted as part of the organizational culture at Telcordia.

Achieving Maturity Level 3

In December 1996, Telcordia was assessed as a CMM Level 3 organization. Additionally, the organization also fulfilled two Key Process Areas (KPA)– defect prevention and process change management at Level 5 – its next objective.

Goal #2

The next step in the Telcordia's development was the change to quantitatively managing software development to achieve Maturity Level 5.

Management #2

Managers were accustomed to running their projects on the basis of knowledge and insight instead of hard data. The change from reporting to evaluating and acting on hard data, as well as the addition of quantitative metrics, was a major leap forward for organizational management. However, managers were convinced by initial triumphs with quantitative management, leading to recognition and acceptance of the advantages of quantitative measurement.

Quantitative Measurement #2

The organization developed a mixed method to control software development quantitatively. This included the use of defect-and-test-execution metrics and establishing control bounds based on project capability. A Statistical Project Schedule Control (SPSC) process was also established to enable project managers to control early development stages quantitatively. Statistical procedures were also applied to the Quality System Review **(**QSR program) which was part of the organization's internal audit process. The quality system's components were dissolved, weighted, and broken down into four QSR classifications: "project control, technical implementation, documentation, and continuous quality improvement" (Pitterman, 2000, p. 95).

Telcordia's use of quantitative management not only provides control over product quality but also helps to capture cost and time-to-deliver data. Managers can concentrate on processes that digress from the projected standard and control necessary process changes as and when required. Quantifying the review process is most effective and impartial in calculating the projects' conformity to the established processes.

Achieving Maturity Level 5

In May 1999, eight business units and more than 3,500 software engineers were appraised over the course of three weeks. Finally, Telcordia was appraised at the highest Maturity Level 5.

4.4 Accreditation Failure #4 Danske Data

The case study by Iversen & Ngwenyama (2006) was conducted in a CMMI Level 1 software development firm – Danske Data. It was a part of a greater longitudinal (from 1996 to 2001) research project to further improve the advanced software departments in four software-developing companies in Denmark (Mathiassen, Pries-Heje, & Ngwenyama, 2002). Danske

Data was a subsidiary of Den Danske Bank Group, and their chief business purpose was developing business management software for Den Danske Bank Group. Danske Data had proficiency in developing applications for banking, mortgage, insurance, and finance. They had almost 850 employees positioned at four diverse development centres around the country. Projects were varied in size, with smaller short-term developments having a team of 3–5 people for the duration of half a year or more. But some major undertakings had tactical implication for the whole organization, including the Y2K project and a plan to empower the central structures to run in overseas branches. Danske Data primarily developed software for the principal mainframe platform. Security and consistency were key essentials of the systems, since data was represented in real time amid the two setups in Arhus and Copenhagen.

Defining Organizational Goals

The firm's SPI project had two goals – 10% improvement in productivity and fulfilment of the requirements for CMMI Maturity Level 2. All staff at Danske Data was made conscious of these objectives and of the senior executive vice president's commitment to the SPI mission. However, even though the primary goal of the program was well defined, the management did not consult any professional entity (for assessing project viability or help in guiding the initiative to its conclusion) before establishing these objectives and precipitately established a 10% improvement goal. Data was collected over a period of four years (1996 – 2000) but Maturity Level 2 certification was not achieved.

Management Commitment

Resolutions regarding the SPI initiative required a good deal of in-house politicking and negotiation. To make decisions and have them implemented, the SPI project team required backing from key organizational actors. This occasioned lengthy deliberations; however,

when settlement was attained, there was typically solid administrative commitment to the resolution.

Staffing Issues

The SPI projects were manned with expert and experienced staff. Although the SPI initiative had a priority status in the firm, management assistance was not always available. There were a number of hurdles to getting appropriate staff assigned in time, and in some cases requested staff was not assigned at all.

Problems of Measurement

A major part of improvement efforts was concentrated on reliably demonstrating the achievement of 10% improvement. The SPI team decided to carry out a program to assess productivity, together with several other factors (such as, quality, timeliness, customer satisfaction) associated with the software development process. As the addition of an assessment program was considered a best practice into the business, its introduction became a development area in itself. The SPI team had several difficulties in assessing project size and the accuracy of the function point quantities due to technical systems issues. Furthermore, the assessment was never intended to provide substantial assistance to the project managers who were laden with delivering the data. With the first assessment reports, some pains were made to deliver responses that would allow project managers to contrast their projects with the Danske Data median. While the SPI implementation team regarded such responses as critical to the attainment of the program, numerous factors made appropriate and well-timed feedback problematic.

Organizational Culture

Data was collected for completed projects only and the publishing of reports was a major problem. As per the firm's policy, results were made public only in quarterly reports. This led to a delay of several months from the conclusion of a project to the time managers could see and match their project's performance to others in the company. Further, only condensed information (averages etc.) was available in the reports. Accordingly, it was problematic for project managers to carry out a detailed comparative analysis.

Failure to Achieve Maturity Level 2

The Danske Data case faced several problems in achieving Maturity Level 2. The company did succeed in fulfilling two requirements of Level 2 – at establishing business processes that are premeditated and implemented in accordance with predetermined policy and at employing expert staff that have sufficient means to produce measured outputs. However, the company failed to achieve an observable in-process status (at key milestones and when major work is accomplished) visible to management (SEI, 2010). At Danske Data, the SPI program was beset by technical issues of assessment and accuracy; the program also faced issues of organizational culture and policy in the publication of assessment reports. Thus, the key requirement of observable in-process status was not completed, and the company failed to achieve Maturity Level 2 certification.

4.5 Regional Success Story #5 ITSoft

Zeid (2002) studied the case of ITSoft from CMM Maturity Level 2 to Level 3. ITSoft is a corporation that comprises many developmental groups representing core banking, delivery channel, trade finance, higher education management, etc. Each group offers software development and personalization services around a central product provided by a market

leader in the industry. ITSoft has achieved Maturity Level 3 making a successful upgrade from Level 2.

Defining Organizational Goals

When evaluated at Maturity Level 2, the organization had already assimilated many of the KPAs associated with Level 3 CMM. The effort to achieve Maturity Level 3 was carried on simultaneous to the final stages of the Level 2 project. Such concurrent efforts for both Levels 2 and 3 were possible because many of KPAs at Level 3 address organizational concerns instead of project-related concerns. Consequently, it was decided to make another round of formal assessment for Maturity Level 3 in mid-June 2004.

Management Commitment

When the SPI initiative began in 2003, the charter included the establishment of a SEPG that focused on achieving SPI goals. SEPG was directed by permanent corporate members and some casual members. Furthermore, the entire organization was involved at a functional level in the process implementation engaged by the SPEG.

Staff Involvement

Many participants remained doubtful of the achievability of the project agenda and goals. The foremost challenge was to preserve the same excitement for Maturity Level 3 and to avert the expected predisposition of involved employees to slow down after acquiring Maturity Level 2 in May 2004. To this end, project goals and necessities were specified and implemented in a phased manner through different processes.

Inter Group Coordination (IGC)

Inter Group Coordination (IGC) is a vital strategy adopted by the corporation, enabling consensus among all stakeholders and associated groups within ITSoft on commitments made in the name of the parent organization. A kick-off meeting is compulsory for any project, wherein all allied groups gather to review the Software Development Plan (SDP) and decide accountabilities for the planned project. The Project Tracking phase ensures that any alteration in the project requisites are tracked and communicated to all allied participating groups throughout the project duration. Teams were formed for many vital tasks which required the involvement of several groups, such as (Zeid, 2004, p. 7):

- Proposal Preparation Team
- Contract Preparation Team
- SDP Preparation Team

Furthermore certain meetings were enforced as control mechanisms:

- Project Kick-off Meeting
- Project Status Meeting
- Contract Follow-up Meeting

Training

ITSoft had set processes for directing training suites to leverage the abilities of its employees. These included course registration, course attendance, course assessment procedures, and preparation for training. Furthermore, records of each employee's existing skills, required skills, and skills acquired by training were maintained. Course Post Assessment served to

calculate training scores and metrics for the assessment of training, as well as for updating the skills records of staff.

Achieving Maturity Level 3

Even though Organizational Process Focus (OPF) is a Level 3 KPA, ITSoft had already implemented it during Maturity Level 2 project fulfilment. This imparted a strong base to the SPI initiative from the start, easing and making possible the countless modifications necessary to enhance improvement. The SEPG procedures and periodical plans produced strategic SPI efforts which had management support.

ITSoft was formally assessed at Maturity Level 3 within 2 months of acquiring Level 2. This is primarily attributed to considering Level 3 KPAs while implementing Level 2.

4.6 Regional Factors Study #6 Saudi Arabia

Alshammari and Ahmad (2011) conducted a study in Saudi Arabia wherein they sent out questionnaires to a total of 117 participants. They also conducted 10 interviews in 7 different Saudi software companies to identify the factors applicable to achieving higher CMMI maturity levels. The investigation was restricted to organizations which had previously reached CMMI Level 3 or those which had a CMMI Level 2 and were working on reaching CMMI Level 3.

Out of the 117 participants surveyed, only 46 replied from 12 companies. The authors asked the respondents to “rank each factor on a five-point scale (high, medium, low, zero and not sure) to determine the effect of each factor” (Alshammari & Ahmad, 2011, p. 7342).

Effective Factors

Saudi practitioners' identified the 21 effective factors as:

> Training, turnover of staff, review, allocation of resources, resistance to change, separation of process and product concerns, CMMI experienced staff, defined SPI implementation methodology, visibility into the SPI process planning, imposed partner, management of change, unscheduled events, investments of a company, management and staff involvement, awareness, process documentation frequency of process assessment, metrics and measurement, and consultation (Alshammari & Ahmad, 2011, p. 7344)

As noted in the literature review these factors can be both positive and negative, but Saudi practitioners have identified the highest frequency effective factors (more than 80%) as:

1. Training
2. Management commitment
3. Gap analysis
4. Turnover of staff
5. Review
6. Allocation of resources
7. Resistance to change
8. Separation of process and product concerns
9. CMMI-experienced staff
10. Defined SPI implementation methodology

Factors having a medium frequency (60% - 75%) were identified as:

1. Visibility into the SPI process planning
2. Imposed partner
3. Management of change
4. Unscheduled events

5. Investments of a company
6. Management and staff involvement
7. Awareness
8. Process documentation

Factors having a moderate frequency (50% - 60%) were identified as:

1. Frequency of process assessment
2. Metrics and Measurement
3. Consultation

The authors found that Saudi organizations seriously needed to improve SPI planning and that their staff required additional training. Management commitment was also a sensitive issue, as higher levels of management were not totally committed to CMMI – failing to realise that continuous and active engagement with the project was vital to its success. New factors not discussed in previous literature or studies were also identified, viz. staff turnover and an imposed partner.

- **Staff turnover –** Staff may resign, transfer or change employment. This has a negative effect as trained staff is a vital resource to any project.
- **Imposed partner-** An imposed partner is identified as a factor with a negative impact. The partner usually added to organizations due to a high social status. An imposed partner affects staff productivity and stalls documentation processing.

The authors recommend that Saudi software organizations should emphasise these 'effective factors' to achieve higher levels of maturity.

4.7 Emirates Group UAE Study#7 Mercator

Mercator is the IT unit of Emirates Group (UAE) meeting and satisfying the all the IT requirements of the Emirates Group. It also supplies IT solutions to the international air travel business. Mercator works with international airlines carriers including: British Airways, Emirates, Gulf Air, Malaysia Airlines, Qantas, Singapore Airlines and OzJet.

Mercator received a CMMI Level 3 certification in 2009. Patrick Naef (President of Mercator) established CMMI Level 3 as the minimum acceptable benchmark for Mercator and set the organizational objective at the highest rating - CMMI Level 5 (QAI, 2009)

QAI led the appraisal team at Mercator as part of this engagement. During the assessment period, over 184 Mercator projects for both the Emirates Group and external customers such as British Airways, Malaysian Airlines, Tunis Air and Air Algerie were assessed against the CMMI Level 3 framework. Additionally, more than 85 Mercator staff members participated in formal interviews during the course of the assessment. (QAI, 2009)

However, no peer reviewed literature is available on the details of management commitment, staff involvement and quality environment etc. Furthermore, another appraisal published in 2012 (CMMI, 2012) found that Mercator has not moved above Level 3.

5 Chapter Five: Findings and Analysis

This first part of this chapter describes in tabulated form the findings from selected case studies vis-à-vis the factors defined in the literature review. The effective factors shall be listed and degree of fulfilment by the organizations to these factors will be described and evaluated as high, moderate, and low. Four case studies were selected for analysis, of which three are success stories and one is a failure of CMMI implementation. Furthermore, three more case studies were selected from the Arab region as they lend specific cultural and regional insight to the research parameters.

1. HP
2. Link,
3. Telcordia
4. Danske Data
5. ITSoft,
6. Saudi Arabia
7. Mercator

This chapter will also analyse the findings from these cases vis-à-vis the factors needed for achievement of CMMI Maturity Levels. The chapter will close by answering the research questions raised earlier.

5.1 Hewlett-Packard (HP)

Table 4: HP

Effective Factors	Hewlett-Packard (HP)	Degree of Fulfilment
Management Commitment	• Totally committed • Staff exclusively assigned to SPI	High
Defining SPI Goals and Objectives	• Goals were clearly defined--releasing an update in a 12-month cycle, reducing lines of code in software, customer satisfaction, competitive edge	High
Organizational Culture	• Management was positive and ready to heed expert advice • Change managers clearly understood	High

	the need to connect with the staff and kept them involved in the process	
Staff Involvement	• Communicating the new changes in a positive manner	High
Training	• Training was provided in new policies and procedures, both individually and in groups	High
Experienced Staff	• All staff understood changes to process, and were clear on their duties and responsibilities in the new structure	High
Implementation Plan	• Inspections were made after each software development checkpoint	High
Quality Environment	• External assistance from HP's Corporate Engineering's SPI team • Clearly defined and described changes from the old manner of doing things, and provided staff with either group or solo training in new approaches as required	High

Proactive involvement of management is one of the most vital factors of successful CMMI ((Niazi, D. Wilson, & Zowghi, 2006). The top management at HP's SESD had recognised the need for expert guidance and had taken steps to ensure the same was available to them at all levels of production and development. Management was amenable to the changes suggested by the consultants and provided the necessary funding and support.

Furthermore, senior managers kept communications open with all staff. According to Xanxo (2012) open communication is a critical point in the ability of top-level commitment to motivate similar involvement at all ranks in the organization. This communication led to a positive organizational culture where the need for change was understood at all levels. Experienced staff was actively involved in the project and received appropriate training.

Thus, HP fulfilled the staff involvement and experience factors extrapolated by scholars (Dyba, 2005; Guerrero & Eterovic, 2004). As posited by Kargul (2009), the clear definition of goals and processes helped in implementing the SPI, as did the creation of an environment in which changes were supported at all levels and business goals were aligned with the SPI.

The organization positively fulfilled all effective factors and, as such, succeeded in attaining Level 2 (Managed) with visible in-process status of products and processes.

5.2 Link

Table 5: Link

Effective Factors	LINK	Degree of Fulfilment
Management Commitment	• Unequivocally committed to the SPI • Assisting in obtaining buy-ins from developers	High
Defining SPI Goals and Objectives	• Implementing the SW-CMM is in line with Link's tactical goal– to retail their software services in the international marketplace.	High
Organizational Culture and Politics	• Not Available	Not Available
Staff Involvement	• A five-person SEPG was created to accomplish process improvement plans. • Staff formed technical work-teams, each responsible for a particular key process area. • Teams controlled the design and production of SPI.	High
Training	• Personnel process-related training • Aggressive CMM-related training	High
Experienced Staff	• A software quality assurance area and a software configuration management area each staffed with one operative	Moderate
Implementation Plan	• A dedicated SPI project manager was appointed • Administration projected a timetable and budget– defining two five-month process improvement phases	High
Quality Environment	• Marginally formed software improvement processes with established a requirements and project administration system (Oracle Forms and Java Server Pages)	Moderate

Link had a high level of management commitment. As El-Emam (2001) notes management commitment can be assessed by the extent to which resources for SPI are made available; Link management helped obtain buy-in from developers and provided dedicated experienced personnel for the project. A mini-assessment and external consultation also confirm senior

management's high level of commitment and involvement, which could be seen throughout the implementation process. The SPI objectives were clearly defined and aligned with the business goals of worldwide retailing. However, staff experience (Xanxo, 2012) and quality environment (Karagul, 2009) scored only moderately as there was only a single employee for SQA and SCM and only marginal SPI. Nevertheless, aggressive training programmes and a dedicated SPEG team (Niazi, D. Wilson, & Zowghi, 2006) were helpful in overcoming these drawbacks. Link successfully achieved a Maturity Level 2.

5.3 Telcordia

Table 6: Telcordia

Effective Factors	Telcordia	Degree of Fulfilment
Management Commitment	• Highly committed to upgrading the organization • A two-tier management structure to supervise the QMO's efficacy and suitability of SQMT and TQMT	High
Defining SPI Goals and Objectives	• Clear establishment of internal QMO as the standard • Quantitatively managed software development to achieve Maturity Level 5.	High
Organizational Culture and Politics	• A feeling of proprietorship of the quality system was rapidly infused in all staff • Staff at all ranks in the organization were encouraged to recommend alterations to the quality system	High
Staff Involvement	• Organization made the QMO and all auxiliary documents accessible to all staff through the Telcordia intranet • A spirit of collective purpose was prevalent throughout the organization.	High
Training	• Staff had half-day training classes, product team classes, and even individualized classes	High
Experienced Staff	• Managers were accustomed to running their projects on the basis of knowledge and insight instead of hard data.	Moderate
Implementation Plan	• The organization developed a mixed method to control software development quantitatively. • The quality system's components	High

	were dissolved, weighted, and broken down into four QSR classifications: project control, technical implementation, documentation, and continuous quality improvement	
Quality Environment	• Telcordia was assessed as a CMM Level 3 organization. Additionally, the organization also fulfilled two Key Process Areas (defect prevention and process change management)	High

Telcordia is an ideal company in terms of CMM application. It transformed itself form a null level organization to a Maturity Level 5 holder in a span of a few years. This transformation was achieved by a focus on quality, SPI, and--most significantly--social aspects (staff, involvement and organizational culture). Telcordia is the first organization in this study that so fully emphasised staff involvement and organizational culture. The organizational culture was open, and all staff could access all documents on the organizational intranet. This encouraged trust from the grassroots level to the top and fostered a collective organizational identity and motivation. This, according to Xanxo (2012), is vital to SPI success. Training, experienced staff, and quality environment were all high, as expected from such dedicated management and staff.

Telcordia also took comprehensive measures of process performances for statistical evaluation. The quality system's components were dissolved, weighted, and broken down into four QSR classifications: project control, technical implementation, documentation, and continuous quality improvement. Furthermore, mixed methods of measurement were adopted, assimilating quality and 'process performance' into the organization's assessment resources. McGarry, et al. (2001) posit that these are necessary steps towards optimizing maturity levels as they assist in factual and accurate decision making. In May 1999 Telcordia was appraised at Maturity Level 5, the highest level in the CMM assessment.

5.4 Danske Data

Table 7: Danske Data

Effective Factors	Danske Data	Degree of Fulfilment
Management Commitment	• Conflicted management • Resolutions regarding the SPI initiative subject to organizational politicking	• Low
Defining SPI Goals and Objectives	• To effect 10% improvement in productivity and to fulfil the requirements for CMMI Maturity Level 2. • Management did not consult any professional entity before establishing these objectives and precipitately established a 10% improvement goal	• Moderate
Organizational Culture	• Apathetic organizational culture. • Results were made public only in quarterly reports	• Low
Staff Involvement	• Project assessment did not provide any assistance to the project managers who were tasked with delivering the data	• Low
Training	• Problems faced in getting appropriate staff assigned in time	• Low
Experienced Staff	• The SPI projects were manned with expert and experienced staff	• Moderate
Implementation Plan	• The SPI team had several difficulties in assessing project size and the accuracy of the function point quantities due to the technical systems issues • Data was collected for completed projects only and the publishing of reports was a major problem.	• Moderate
Quality environment	• No previous experience with SPI and no professional help employed	• Low

Danske Data had the right objectives, but the organization faced problems from the start. Management commitment was low, with organizational politicking taking precedence over SPI implementation. There were complaints of experienced staff being assigned only as a result of office politics and, in some cases, not being assigned at all. This created a low level of trust. Niazi (2009) has noted that reordering of organizational resources, opportunities for

staff's advancement, low level of trust, deadlines, and role obscurity are all factors of organizational politics that negatively impact SPI efforts.

Danske's organizational politicking was further aggravated by the policy of not publishing relevant documents in time, making progress slow. This again led to difficulties in assessment. Management apathy also translated into a lack of training, motivation, and staff involvement. SPI and business goals were clearly misaligned, a factor that has been noted as a major barrier to CMMI success (Bayona, Calvo-Manzano, Cuevas, & Feliu, 2014). Despite the generation of reams of data over four years, Danske Data was unable to reach Maturity Level 2.

5.5 ITSoft

Table 8: ITSoft

Effective Factors	ITSoft	Degree of Fulfilment
Management Commitment	• A Software Engineering Process Group (SEPG) with members from the different units of the corporatation that focused on achieving SPI goals was established	• High
Defining SPI Goals and Objectives	• Achieving Level 3	• High
Organizational Culture	• Entire organization was involved at a functional level in the process implementation engaged by the SPEG • The concept of teams was introduced for many vital tasks	• High
Staff Involvement	• Managers worked hard to preserve the same excitement for Level 3 as was previously exhibited • Inter Group Coordination (IGC) strategies such as kick-off meetings were adopted	• High
Training	• Set processes for directing training suites to leverage the abilities of its employees	• High
Experienced Staff	• Records of each employee's existing skills, required skills, and skills acquired by training were maintained	• High
Implementation Plan	• OPF, a Level 3 KPA, already established in Level 2 • The effort to achieve Maturity Level 3 was carried on	• High

	simultaneous to the final stages of the Level 2 project	
Quality Environment	• Has already assimilated many of the Key Process Areas (KPA) of associated with Level 3 of CMM	• High

ITSoft was specifically chosen to demonstrate the achievability of higher maturity levels in the Arab region. This organization demonstrated a high level of management commitment that ensured its CMMI success. Traditionally, organizational culture in this region is hierarchal and not very flexible. ITSoft too, had a somewhat rigid organizational culture; but, this rigidity was positively used to infuse top-down involvement in the SPI. The entire organization was involved at a functional level in the process implementation engaged by the SPEG. The mangers worked hard to motivate and involve the staff, and training was managed by well-established and successful practices. The staff, having already worked on achieving Level 2, was experienced with the process, and the quality environment was high. Overall, the organization fulfilled all the requirements outlined by scholars (Bayona, Calvo-Manzano, Cuevas, & Feliu, 2014; Dyba, 2005; Karagul, 2009; Niazi, D. Wilson, & Zowghi, 2006) for a successful SPI implementation, while applying them in hierarchical manner suited to regional sensibilities. ITSoft was successfully assessed at Maturity Level 3 in 2003.

5.6 Saudi Arabia (Alshammari & Ahmad, 2011)

Effective Factors	Saudi Arabia	Degree of Fulfilment
Management Commitment	• Senior managers are not directly involved	• Medium
Defining SPI Goals and Objectives	• Goals are well defined in most cases	• High
Organizational Culture	• Conservative. Imposed partners create delays	• Low
Staff Involvement	• Employees need to follow a rigid hierarchical structure and line of	• Low

	communications are traditional	
Training	• Training needs are high and not always fulfilled	• Medium
Experienced Staff	• High staff turnover	• Low
Implementation Plan	• SPI plans are usually not well defined and lack expert guidance	• Low-medium
Quality Environment	• Most companies have no experience in CMMI	• Low

This study covered several organizations in Saudi Arabia and documented the effective factors of CMMI implementation. The study identified 21 factors, of which the most important were:

- Training
- Management commitment
- Gap analysis
- Turnover of staff
- Review
- Allocation of resources
- Resistance to change
- Separation of process and product concerns
- CMMI experienced staff
- Defined SPI implementation methodology

These factors have been well documented in literature and most have also been discussed in this paper. Two new factors specific to the region have been identified as turnover of staff and imposed partner (Alshammari & Ahmad, 2011). These issues are specific to Arab

country. The first results from the dependency of Arab countries on foreign nationals to man its industries, and the second from a cultural ethos necessitating such partnerships.

5.7 Mercator

Effective Factors	Mercator	Degree of Fulfilment
Management Commitment	• No data available	•
Defining SPI Goals and Objectives	• Achieving Level 5	• High
Organizational Culture	• No data available	•
Staff Involvement	• No data available	•
Training	• No data available	•
Experienced Staff	• No data available	•
Implementation Plan	• No data available	•
Quality Environment	• Already achieved a CMMI level 3 rating	• High

Mercator had achieved a Level 3 status in CMMI in 2009, but has failed to improve its rating. The appraisal results of 2012 clearly show that the company is still stuck at Level 3 and has been unable to achieve its goal of Level 5. The unavailability of data restricts us from knowing or deliberating on the causes of Mercator's failure to improve maturity level.

5.8 Summary

This research was aimed at finding the factors that affect maturity levels in organizations in the UAE. Therefore, a detailed review of literature was conducted, followed by a detailed examination of seven case studies. The four successful SPI implementation studies were HP, Link and Telcordia and ITSoft. The foremost positive factor in all three success stories was a high level of senior management commitment. This factor has been given top priority by

scholars as it is undeniably clear that sustained commitment all through the implementation is necessary for success. Senior management not only sets the tone for organizational culture and politics, but it is also responsible for facilitating change. Undoubtedly, implementing SPI to attain higher levels of maturity requires change: In the lower levels of maturity, changes are both social and procedural, while in the upper levels, the required changes are those of quantifiable evaluation and continuous improvement.

The most successful case is that of Telcordia which has achieved the highest maturity level (5--Optimized). The organization started with definite commitment from management, who immediately established an SQMT and TQMT. This enabled managers to establish achievable goals in line with business objectives and keep tabs on progress being made. The organization worked according to a motto of quality control and ensured that each and every employee was committed to the task of raising the quality of software. The staff was fully devoted to achieving organizational goals; this crucial factor in its success can be attributed to Telecordia's organizational culture, wherein all employees could freely approach their managers and were encouraged to recommend new ideas and alterations to the quality system. Training was continuous, allowing employees to develop their full potential and keep up with the increasing standards of the organization.

Thus, the quality environment at Telcordia ranked very high in all significant factors, such as management commitment, staff involvement, training, etc. Telcordia soon achieved Level 3. Experienced employees who were first trained at Level 3 were further instructed to achieve Level 5; as a result, the new project was staffed with expert and loyal employees. The use of mixed methods to control software development quantitatively led to early triumphs with managing projects. Statistical procedures were also applied to the organization's internal audits process. This application of the required quantitative management techniques and process controls enabled Telcordia to achieve a Maturity Level 5.

According to the SEI (2010) the Defined (2) and Managed (3) levels of maturity require a focus on basic project management and process standardization respectively. HP and Link both achieved defined levels, indicating basic project management capabilities that enabled them to repeat production processes successfully. ITSoft was assessed at Level 3. HP scored high on all effective factors, while Link had some difficulties in terms of inexperienced staff and a low quality environment. However, a dedicated and determined management overcame these problems by dint of aggressive staff training programmes and bringing in external consultants to conduct mini-appraisals. This definitely motivated Link's staff to do better and guided them in the right direction despite their relative inexperience.

As discussed before ITSoft is a traditional organization with a rigid hierarchy; however, even within that hierarchy, the company managed to infuse a top-down enthusiasm for the CMMI project. Meetings were held at various levels and phases of the project ensure that all stakeholders understood the aims of the project as well as their individual responsibilities. Training and assistance was also provided as required. All of this happened through pre-set channels and agendas. ITSoft's success demonstrates that, if understood properly, traditional organizational culture need not be an inhibiting factor in high maturity level attainment.

In contrast, Danske Data is a case of failed implementation, despite being a well-established organization with a well-developed social structure. But the company faced two major drawbacks. First, Dankse precipitately established a 10% improvement goal without any expert consultation. CMMI is a specialised SPI requiring expertise for implementation, and arbitrarily establishing SPI goals without proper consideration of business goals and requirements, organizational culture, and available staff, etc. is not a guarantee of success. Assessment and measurements require expertise for which Danske should have employed outside experts, as their in-house team was unable to make proper assessments. The senior management of Danske Data made no effort to manage the social aspects of implementation

viz. required changes in staff training and involvement. Project managers were burdened with compiling data without being able to access data from their peers for comparative analysis. In summation, the project was mired in logistics and politics. Thus the organization failed to achieve Maturity Level 2.

In the case of Saudi Arabia, Alshammari and Ahmad (2011) found that low management commitment, turnover of staff, lack of training, and imposed partners had the most negative effects on achieving maturity goals. However, as previously noted, ITSoft within the same region was able to successfully overcome the usual and specific regional barriers to achieving Level. They used organizational structures to motivate and train staff and adapted to the local culture by organizing permanent and casual members into a SPEG which then further established IGC with various control mechanism. Therefore, ITSoft's case makes clear that, although there are some specific cultural and organizational barriers to successful CMMI, these same factors (with the benefit of planning) can have a positive impact on attaining maturity levels in Arab countries and specifically UAE. The single case study of Mercator in the UAE has established two facts (1) that it is possible for UAE organizations to successfully implement CMMI and achieve high maturity levels, and (2) simply achieving a high maturity level does not guarantee that the organization can further this success automatically. Consistent efforts and attention to effective efforts is necessary to achieve higher CMMI Maturity Levels.

This study has been able to gather vital information towards the objective of answering the research questions as enumerated below:

Q1. What factors, as identified in the CMMI literature and case studies, have a positive impact on maturity levels?

Several factors have been identified as having a positive impact on maturity levels. They are high level of management commitment, positive staff involvement, intensive and on-time training, experienced staff, well defined SPI objectives and a sustainable implementation plan, the alignment of organizational culture and business goals with SPI goals, and a good quality environment.

Q2. What factors, as identified in the CMMI literature and case studies, inhibit maturity levels?

Several factors have been identified as inhibiting maturity levels. They are misaligned SPI goals and objectives, lack of management commitment, insufficient planning, and disregard of organizational culture.

Q3. What factors have a positive impact on maturity levels in organizations in the UAE?

In addition to the factors described in research question 1, several factors that positively impact maturity levels in UAE are: gap analysis, allocation of resources, separation of process and product concerns, and CMMI experienced staff and reviews.

Q4. What factors inhibit maturity levels in organizations in the UAE?

In addition to factors detailed in research question 2, two major factors inhibiting maturity levels in UAE are staff turnover and imposed partners.

6 Chapter Six: Conclusion

6.1 Introduction

CMMs can be defined as models of best practices used to improve an organizations' performance (Chrissis, Levine & Shrum 2009). As the central aim of CMM/CMMI is to help organizations align all business processes so that general organizational objectives are attained and sustained successfully. Therefore, it is highly desirable that organization in UAE adopt CMM/CMMI. Currently, only a handful of organizations in UAE have adopted the CMMI standards.

The benefits of CMMI adoption have been well documented. Goldenson & Gibson (2003) list the benefits of CMMI implementation as reductions in costs, faster schedules, increased ROIs, increased customer satisfaction, greater productivity and improved quality of products/processes.

This research has identified the factors that affect the CMMI maturity levels positively in UAE organizations as: (1) management commitment, (2) defining SPI goals and objectives, (3) organizational culture and politics, (4) staff involvement, (5) training, (6) experienced staff, (7) implementation plan, and (8) quality environment.

Factors affecting UAE organizations CMMI maturity levels negatively have been identified as: (1) misaligned SPI goals and objectives, (2)lack of management commitment, (3) insufficient planning (4) disregard for organizational culture and politics, (5) turnover of staff, and (6) imposed partners.

Knowledge of effective factors will enable organizations to achieve desired CMMI maturity levels. Companies should focus on adopting factors that positively affect maturity level and addressing negative issues. Advanced levels of maturity will allow these institutions to be on

par with global organizational standards of CMMI, thereby increasing the status of these organizations in the global economy.

6.2 Discussion

A review of CMMI literature finds that many scholars posit that the main reasons for IT failures are not related to financial or human resources, but rather the poor quality of software product and processes (Brooks, 1987; Walia & Carver, 2009). The SEI (2005) too endorses this view arguing that "everyone realizes the importance of having a motivated workforce, quality work force, and the latest technology, but even the finest people can't perform at their best when the process is not understood or operating at its best" (p. 9). In contrast, some scholars –while agreeing that the main focus of CMMI should be on processes, customers, and quality of deliverables– argue that human factors such as management, policy, and training are also important factors for success (QSR, 2008; Yamamura, Software process satisfied employees, 1999).

This study found that social and human factors had a high impact (either negative or positive) on SPI implementation and attaining levels of maturity--despite the belief that process is more important, as posited by Brooks, (1987) and, Walia and Carver (2009). The general social effective factors as enumerated by scholars (Alshammari & Ahmad, 2011; Bayona, Calvo-Manzano, Cuevas, & Feliu, 2014; Dyba, 2005; Karagul, 2009; Niazi & Babar, 2009; Stelzer & Mellis, 1998; Xanxo, 2012) and backed by this research are: management commitment, organizational culture and politics, staff involvement, training, and experienced staff.

The case of organizations such as Telcordia and HP amply demonstrate the efficacy and high positive impact of social factors. Telcordia emphasised staff involvement and had a high degree of management commitment, as well as an extremely open and receptive organizational culture. HP too emphasized training and staff motivation. Both companies

successfully achieved their CMMI objectives. The same social factors of management commitment and organizational culture were found to be the major reasons for the failure of CMMI in Danske Data. The organization was mired in in-house politicking and had a very restrictive organizational culture, wherein project managers were unable to access report on the progress of their peers and thus could not benefit from the data generated for CMMI purposes. Hence, the importance of social factors is reinforced: Positive interactions and open intra-organizational communications/commitment certainly enhance success, while negative politics and closed, restricted communications/commitment lead to eventual failure of CMMI objectives.

Unfortunately, the UAE case study of Mercator could not shed any light on any specific contextual reasons for the past success (achieving level 3) and recent failure in achieving CMMI Maturity Level 5. Thus, this study cannot point out any specific effective factors in the context of UAE in particular.

However, this research found two social and human factors specific to the Arab region in general– viz. staff turnover and imposed partner. Alshammari and Ahmad (2011) argue that employees in Arab organizations are often sourced from foreign countries. This translates into low levels of loyalty towards organizations and a prevalence of job hopping. Even when employees are natives of the state, staff turnover due to resignations, transfers or alternative employment negatively affects achievement of objectives.

An imposed partner is a business arrangement specific to the Middle East. Typically a business partner is added to the organization due to their high social /political status or influence. These partners have been shown to affect staff productivity and delay accreditation processing as they may insist on procedures that have negative impacts on the SPI goals of the organization (Alshammari & Ahmad, 2011).

However, the importance of social factors does not negate the impact of factors such as quality of software product and processes. In fact, this study found that clearly defined SPI goals and objectives, implementation plans, gap analysis, allocation of resources, quality of environment (viz. congruence of SPI and business goals) and established in-house quality procedures were major effective factors in achieving higher levels of maturity. All the successful case studies (Telcordia, HP, Link, ITSoft) described in this study scored highly on all factors mentioned above. Thus, the success of CMMI initiatives is dependent on a combination of factors, including social, human, financial, and process knowledge and understanding.

6.3 Conclusions

CMMI is unquestionably a globally accepted standard for assessing and evaluating organizational maturity. Adopting CMMI standards will benefit organizations in UAE by increasing their standing in the international market. Furthermore, CMMI implementation will be advantageous in terms of both quality and efficacy of production, increased returns and reduction in costs.

This study has identified many areas which should be addressed for successful implementation of CMMI in UAE. Some, such as staff turnover and imposed partner are specific to Arab regions. However, others such as management commitment, clear definition of goals, training, staff involvement and organizational culture are applicable in all industry types and across all regions.

The top three effective factors identified by Xanxo (2014) are management commitment, staff involvement, and mentoring and training. Senior management must adopt a positive attitude towards CMMI and remain involved throughout the process. This is a major issue in Arab organizations where management is often enthusiastic about initiating projects, but fails to provide the necessary support for properly implementation. Simply initiating the program

is not enough. Financial, training and motivational support are also necessary at all levels and at all times. Provision of adequate training is a vital factor, especially in the case of UAE, where employees lack expertise in SPI.

Furthermore, case studies amply demonstrate that successful CMMI does not require a radical change in the culture or social ethos of an organization. A simple implementation plan, keeping in mind the hierarchal preferences of organizations in UAE, will suffice to nurture the social and in-house political support required for success. Kick-off meetings, inclusion of casual members and imposed partners in the SPEG teams, and continuous reviews can all help the involved stakeholders to understand the requirements for successful CMMI implementation. These activities will also foster a sense of proprietorship and collective purpose. This will address the most crucial social factors affecting maturity levels in UAE organizations and help them to attain their desired goals.

6.4 Limitations

As stated above, the UAE is yet to develop an open organizational and robust IT culture. In fact, the organizational hierarchy is rigid and many managers lack expertise in the CMMI field in terms of handling IT process and project management. Furthermore, there is a scarcity of peer reviewed literature on CMMI in UAE. In such circumstances a detailed research would require collection of data from multiple sources including surveys, interviews from experts and staff, and longitudinal case studies to present an accurate picture of CMMI adoption in UAE. However, either a quantitative study requiring participation from industrial experts or a longitudinal case study is not possible within the limited scope of this study. Thus, this study was restricted to case studies found in previous literature.

6.5 Recommendations

This study has found that CMMI implementation provides substantial business benefits to organizations. This research has also established the effective factors of attaining desired maturity levels for organizations in UAE. However, it was found that only a handful of organizations were aware of these benefits and effective factors. CMMI standardisation, though acknowledged globally as an industrial standard, is not prevalent in UAE. It is recommended that:

(1) Further quantitative/mixed studies should be conducted to establish the extent of CMMI adoption and its effective factors in the UAE.

(2) As CMMI awareness is very low in the UAE, steps should be taken to popularise it through business conferences and seminars.

(3) Furthermore (in the case of organizations already implementing CMMI), organizations should take steps to ensure employee engagement and loyalty. This may be achieved through reward programs, company-sponsored peer interactions (both professional and social), and the inculcation of an organizational culture in whihc all employees are able to communicate freely – at the least with their immediate superiors and peers.

(4) Training should also be emphasized and provided continuously to ensure that staff is not overwhelmed by new concepts and duties.

(5) Senior management should also ensure that both employees and imposed partners understand the benefits of CMMI and are well informed about the necessity of each and every step in the implementation plan. This will improve attitudes and involvement with the project, consequently increasing motivation to achieve set objectives in a timely manner.

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