

FACTORS THAT AFFECT THE DURATION OF CMMI-BASED SOFTWARE  
PROCESS IMPROVEMENT INITIATIVES

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Approval of the Graduate School of Informatics

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# **ABSTRACT**

## **FACTORS THAT AFFECT THE DURATION OF CMMI-BASED SOFTWARE PROCESS IMPROVEMENT INITIATIVES**

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Reference models developed for software process improvement (SPI) provide guidelines about what to do while assessing and improving the processes, but they do not answer the questions of how. There have been a number of studies that try to find effective and strategic implementation models or to identify factors that affect the SPI success. However, these studies do not provide answers to questions about the effect of these factors on SPI program duration or accelerated SPI studies.

This study aims to investigate the factors that affect CMMI-based SPI duration. It consists of two phases: in the first phase, factors that influence SPI success are identified and hypotheses related to these factors are formulated based on the case studies published in the literature. In the second phase of the study, hypotheses are revised based on the results of the qualitative research conducted in seven companies, six of which have obtained CMMI-Level 3 certification as a consequence of their SPI effort. The study has shown that management commitment and involvement as well as process documentation have had a significant shortening effect on CMMI-based SPI duration, within the context of the studied cases.

Keywords: Software process improvement; CMMI; Success factors; Duration factors.

# ÖZ

## CMMI TABANLI YAZILIM SÜREÇ İYİLEŞTİRME GİRİŞİMLERİNİN SÜRESİNİ ETKİLEYEN ETMENLER

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Yazılım süreç iyileştirme (YSİ) için geliştirilen referans modelleri, süreçleri değerlendirirken ve iyileştirirken ne yapılacağına dair yardımcı olurken, nasıl sorusuna cevap vermez. YSİ başarısını etkileyen etmenleri saptamaya veya etkin ve stratejik uygulama modellerini bulmaya çalışan bir takım çalışmalar olmuştur. Ancak bu çalışmalar, bu etmenlerin, YSİ süresi ya da hızlandırılmış YSİ üzerine etkileri ile ilgili soruları yanıtlamamaktadır.

Bu çalışma, CMMI tabanlı YSİ süresini etkileyen etmenleri incelemeyi amaçlamaktadır ve iki aşamadan oluşmaktadır. İlk aşamada, literatürde

yayımlanmış örnek olay çalışmalarına dayalı olarak YSI başarısını etkileyen etmenler saptanmış ve bu etmenlerle ilişkili hipotezler oluşturulmuştur. Çalışmanın ikinci aşamasında, hipotezler, süreç iyileştirme çalışmalarının bir sonucu olarak altısı CMMI-Seviye 3 sertifikasyonu kazanmış yedi firmada yürütülen nitel araştırma sonuçlarına göre gözden geçirilmiştir. Çalışma, incelenen örnekler bağlamında, hem yönetim desteğinin ve katılımının hem de süreç belgelemenin, CMMI tabanlı YSI süresini kısaltmakta önemli etkisi olduğunu göstermiştir.

Anahtar Kelimeler: Yazılım süreç iyileştirme; CMMI; Başarı etmenleri; Süre etmenleri.

*To  
my beloved husband  
and  
my little princess*

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## LIST OF ABBREVIATIONS

AQAP	:Allied Quality Assurance Publication
C	:Consultant
CMM	:Capability Maturity Model
CMMI	:Capability Maturity Model Integration
CSF	:Critical Success Factors
E	:Experienced Staff
GM	:General Manager
H_C	:Hypothesis re-formulated after Case studies
H_L	:Hypothesis derived based on Literature review
IEEE	:Institute of Electrical and Electronics Engineers
ISF	:Initial Status Factors
ISO	:International Organization for Standardization
ITIL	:Information Technology Infrastructure Library
KPA	:Key Process Area
L1	:Level 1
L2	:Level 2
L3	:Level 3
Mth	:Months
NATO	:North Atlantic Treaty Organization
PC	:Project Consultants
PD	:Project Director
PF	:Progress Factors
Ph	:Phase
Q	:Quality Environment
SCAMPI	:Standard CMMI Appraisal Method for Process Improvement
SEI	:Software Engineering Institute of Carnegie Mellon University
SEPG	:Software Engineering Process Group
SPI	:Software Process Improvement
SQA	:Software Quality Assurance
SW-CMM	:Software Capability Maturity Model
TL	:Team Leader
UML	:Unified Modeling Language

# **CHAPTER 1**

## **INTRODUCTION**

The last decade has seen many organizations striving to achieve software development process maturity through certification within the Capability Maturity Model (CMM) framework. The resources required for such improvement have been studied extensively in the literature (see e.g. Herbsleb et al., 1994; Diaz and Sligo, 1997; Herbsleb et al., 1997) but the duration of process improvement and the factors that effect the time span for reaching the next level still seem to be a relatively less investigated subjects.

This study aims to study the factors that effect CMMI-based SPI duration. A number of authors have focused on the factors that affect SPI success, but they have not provided answers to questions about the effect of these factors on SPI program duration.

There are some successful cases that have managed to decrease the time to move up from one CMM level to another drastically (Akmenek and Tarhan, 2003; Zeid, 2004; Tufail, Kellum, and Olson, 2006). Analysis of these success stories may be helpful in identifying a relationship between the factors and SPI duration. This

may help managers while they are planning their SPI activities; strengths and weaknesses of the organization may be determined and resource allocation for the program can be enhanced.

## **1.1 Process Model, Software Process Improvement, and CMMI**

SEI (2007) defines a process model as “a structured collection of practices that describe the characteristics of effective processes.” An organization can define process improvement objectives and priorities and make its processes stable, capable, and mature by the help of a process model. Moreover, a process model provides guidelines for organization to understand its current state; to identify related improvement activities and to determine how to start these activities (SEI, 2007.)

### **1.1.1 CMMI**

CMMI can be described as a collection of best practices gathered from the experiences with SW-CMM, and other standards and models. How effective process should look like is defined in CMMI model. It provides a framework for practitioners so that improvement activities can be organized. Moreover, it enables the organization to coordinate multi-disciplined activities and to align process improvement objectives with organizational business objectives, easily (SEI, 2007.)

There are two representations of CMMI: continuous representation which focuses on process area capability; and staged representation which focuses on organizational maturity. This study is interested in CMMI staged representation, briefly discussed below.

There are five maturity levels, numbered through 1 to 5 in CMMI staged representation. Maturity levels are defined in terms of related specific and generic process areas whose requirements must be satisfied. Achievement of specific and generic goals related to a process area determines the maturity level of the organization. These levels and associated process areas are shown in Table 1 (SEI, 2006; Demirors, 2009).

**Table 1 Maturity Levels and Their Associated Process Areas**

<b>Maturity Level</b>	<b>Focus</b>	<b>Process Areas</b>
1 Initial		
2 Managed	Basic Project Management	Configuration Management Measurement and Analysis Process and Product Quality Assurance Project Monitoring and Control Project Planning Requirements Management Supplier Agreement Management
3 Defined	Process Standardization	Decision Analysis and Resolution Integrated Project Management Organizational Process Definition Organizational Process Focus Organizational Training Product Integration Requirements Development Risk Management Technical Solution Validation Verification
4 Quantitatively Managed	Quantitative Management	Organizational Process Performance Quantitative Project Management
5 Optimizing	Continuous Process Improvement	Causal Analysis and Resolution Organizational Innovation and Deployment

At maturity level 1, processes are unpredictable, poorly controlled and reactive. A stable environment to support the processes cannot be provided. At maturity level 2, processes are characterized by projects and are often reactive. The organization

develops projects that are compatible with their specified process descriptions, standards and procedures. At maturity level 3, processes are well characterized for the organization and proactive. Consistency across the organization is established by the improved standards, procedures, tools and methods used. There are two critical distinctions between maturity level 2 and 3. First of all, the standards, procedures, and process descriptions may differ from project to project at maturity level 2; whereas they are consistent at maturity level 3. Secondly, process descriptions at maturity level 3 are more rigorous than maturity level 2. At maturity level 4, the processes are measured and controlled using statistical and other quantitative techniques. The aim of maturity level 5 organizations is continuous process improvement (SEI, 2006; Demirors, 2009).

#### ***1.1.1.1 The benefits of CMMI***

The organizations observe the benefits of CMMI in terms of cost, schedule, productivity, quality, customer satisfaction, and return on investment. Performance measure of 30 different organizations is given in Table 2.

**Table 2 Performance results of CMMI (SEI, 2007)**

<b>Performance Category</b>	<b>Median Improvement</b>
Cost	34%
Schedule	50%
Productivity	61%
Quality	48%
Customer Satisfaction	14%
Return on Investment	4:1

#### **1.1.2 Why CMMI?**

Day by day, more people are interested in software process improvement, but especially CMMI. Among the software process improvement models, CMMI became a de facto standard with its high acceptance rate (Jones and Soule, 2002).

As a result, there has been an increase in the number of companies that applied for CMMI appraisal.

A similar trend is observed in the companies in Turkey. Especially, after the unofficial declaration saying that the prerequisite for the companies who want to develop project for the Undersecretariat for Defense Industries would be being CMMI certified, the interest in CMMI in Turkey has been increased. However, CMMI certification process is a long term project which may be accepted as a barrier for some of the companies. Those companies, as well as the others, may seek for ways of accelerated CMMI programs. Therefore, with the result of this study, it is aimed to provide a road map for the CMMI candidate organizations.

Table 3 shows the median time to move up values for organizations that completed the SW-CMM appraisals between 1992 and June 2005, and early CMMI results is said to be comparable (SEI, 2006).

**Table 3 Median time to move up values for SW-CMM (SEI, 2006)**

<b>Maturity Level</b>	<b>Median # months</b>
Level 1 to 2	19
Level 2 to 3	20
Level 3 to 4	25
Level 4 to 5	13

## **1.2 Objectives and scope of the study**

This study aims to formulate hypotheses that explain the effects that various factors have on the duration of software process improvement projects. First, from an extended review of relevant literature, hypotheses that explain the outcomes in published cases will be formulated. Then, case studies will be performed to evaluate and possibly reformulate the hypotheses based on literature review.

It is not the aim of this study to establish a firm theoretical foundation for prediction and control of the duration of software process improvement initiatives. Such an undertaking would definitely require much more extensive work, greatly surpassing the resources available within the framework of a single doctoral dissertation study. Rather, qualitative research will be undertaken with the purpose of studying the factors and the nature of their effects on SPI duration in the context of the cases published in the literature as well as cases that are directly studied by the present researcher. It is expected that the understanding of relevant factors and their effects to be elaborated through this research, will provide decision makers with knowledge, not explicitly investigated and established so far, to allocate resources and make choices in a rational fashion.

### **1.3 Motivation for the thesis**

In the literature there are numerous studies about critical success factors for a successful SPI implementation. What is observed during the literature review is that even though the results of these studies list the factors, they usually do not explain how these factors should be employed throughout the SPI studies. However, beside an investigation of the existence of a number of factors, it is necessary to observe the details of the SPI processes based on the factors and find out the causes behind the outcomes throughout the SPI lifecycle. Only after such an investigation would the results of the study be beneficial to the SPI candidate organizations in providing them with a road map.

It is believed that CMMI, with its high acceptance rate as an SPI framework, requires a special investigation about the critical success factors.

It is known that originally, in the USA, CMMI studies were sponsored by the Ministry of Defense to improve the processes of public organizations that developed projects for them, but today 74.1 % of the organizations that are

appraised are commercial/in-house organizations (SEI, 2009). In Turkey, after the Defense Industry Undersecretariat's decision in 2007 to require CMMI certification from potential bidders in all of its procurements of software intensive systems, it must be expected that the number of private as well as public organizations that will apply for the appraisal in Turkey will increase. Hence, controllability of CMMI-based SPI initiatives is currently quite critical in the country. This acts as another motivator for this thesis.

CMMI-based SPI programs are usually longitudinal studies. Petterson et al. (2007) state that this is a barrier to SPI success. Moreover, having problems in the separation of product development and process improvement activities is another barrier for successful SPI. For most of the organizations which employ process improvement, it is stated that the first thing they give up when they have to deliver any project is process improvement activities. When these drawbacks are considered, accelerated CMMI-based SPI can be an alternative for the ones who want to improve their processes and increase the capability-maturity level of the organization.

In addition to motivators mentioned above, to the best of our knowledge, studies that focus on accelerated CMMI-based SPI are missing in the literature. Therefore, with the hypotheses proposed, we aim to construct a baseline for further studies.

Finally, there may be other factors that may have an effect on SPI duration. Possible candidates are organization size, organization age, the reason for attempting CMMI certification, e.g. to do a better job, to gain market recognition, to be able to bid in the defense project. However, the aim of this thesis is to focus on controllable variables like *Management Commitment*, *Staff Involvement*, *Experienced Staff*, *Quality Environment*, *Training*, and *Metrics and Measurement*. By the help of the results of the study, it is believed that it would be possible for

the staff to elaborate the necessary actions to perform for an accelerated CMMI certification both before the commencement of CMMI program and throughout the progress of the improvement activities.

#### **1.4 Structure of the thesis**

This document is organized as follows. The relevant literature is reviewed in Chapter 2. The hypotheses derived from the literature on the relationship between relevant factors and SPI duration are presented in Chapter 3. Details of the case study design like sample profile, data collection and data analysis methods are explained in Chapter 4. Case studies are discussed in Chapter 5. Findings of the case studies carried out to verify the hypotheses derived from the literature are presented in Chapter 6, together with the revised hypotheses. Chapter 7 concludes the dissertation, with an evaluation of the work done and results obtained, together with suggestions for future work in the area.

## **CHAPTER 2**

### **THE RELEVANT LITERATURE**

In this chapter, the literature on key success factors in software process improvement programs, the effect of various factors on their duration, and success and failure stories about CMM programs, will be briefly reviewed.

The available literature can be classified under two categories: Those that report empirical studies and those that interpret previous results or derive key factors of SPI implementation. (e.g. Guerero and Eterovic (2004), Cares, Franch, Mayol, and Alvarez (2006) , Peterson et al.( 2007).)

Ranking of significance of factors by different authors of the first group of studies has been retained, to provide a common basis for comparison.

Table 4 summarizes the factors on SPI success, studied by various authors. The notation for Table 4 is as follows: “✓” means the factor has been studied. “0” means that in that particular study, the factor has not been attributed a significant effect. “+” means that in that study, the factor has been found to have a positive significant effect and a “-” indicates that the factor has been observed to have a significant negative effect. Numbers in the parenthesis show the ranking of importance of the factor from top to bottom. The definitions of factors in Table 4

that are investigated in more than one research paper and how the factors with different names but similar meaning have been grouped are presented in APPENDIX A. Section 2.1 below discusses the contents of Table 4.

## **2.1 Research on key success factors**

Wilson, Hall and Baddoo (2001) propose a framework for the evaluation of SPI success. The authors adapt and apply a framework which was previously developed for evaluation of metrics programs, to SPI. They also mention that the proposed framework can be used by companies prior to SPI implementation. By this way, the companies not only analyze the readiness of the organization to SPI program, but also identify areas of weakness. Success factors are identified as management commitment, respect, initial process definition and explanations.

Wilson et al. also state that “adequate training” and “SPI awareness” do not have an effect on the success of SPI programs which is contrary to the results of some later studies (Rainer & Hall, 2002; Rainer & Hall, 2003). In the case of “adequate training”, the rationale behind the statement is that both successful and unsuccessful companies in the sample have training programs. That is why the authors cannot conclude that training is a motivator. However, the content, quality, and quantity of training may have to be analyzed in detail. If these dimensions vary within the companies than a single question may not be enough to assess the importance of training as a factor. In the case of the factor “SPI awareness”, it is stated that it was the unsuccessful companies whose employees were aware of the processes. On the other hand, the employees of successful companies were said to have been unaware of the processes being improved. Thus, Wilson et al. suggest that “SPI awareness” has no significant effect on SPI success.

**Table 4 Factors related to SPI success**

Researchers	Group 1: Empirical studies				Group 2: Interpret previous results		
	Wilson et al (2001)	Berander & Wohlin (2003)	Dyba (2005)	Niazi et al. 2005a Niazi et al. 2005b <sup>1</sup>	Guerrero & Eterovic (2004) <sup>2</sup>	Cares et al. 2006	Peterson et al. 2007
(Adequate)training	✓, 0						
Awareness	✓			✓,+, (-/2)	✓, +		
Change mechanism	✓	✓,+, ( 5)		✓,+, (3/1)		✓,+, (2)	
Clear and relevant SPI goals	✓		✓ (2)	✓,+, (7/-)			
Communication					✓, +	✓, +, (9)	
Concern for measurement			✓,+, (3)				
Creating process action teams				✓,+, (5/8)		✓, +, (10)	
Experienced staff				✓, +, (6/4)	✓, +	✓, +, (7)	
Explanations	✓, +, (1)						
Facilitation							
Frequency of assessments					✓, +		
Implementation plan	✓			✓,+, (-/4)	✓, +	✓,+, (10)	
Inexperienced staff				✓, -, (2/6)			
Initial process definition	✓, +, (1)						

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<sup>1</sup> The first number in parenthesis is the ranking in literature review section of Niazi et al. 2005a & b; the second number is the ranking result from interview section of Niazi et al. 2005a & b.

<sup>2</sup> No ranking info is available in Guerrero and Eterovic (2004)

**Table 4 Factors related to SPI success (cont'd.)**

Researchers \ Factors	Group 1: Empirical Studies				Group 2: Interpret previous results		
	Wilson et al (2001)	Berander & Wohlin (2003)	Dyba (2005)	Niazi et al. 2005a Niazi et al. 2005b	Guerrero & Eterovic (2004)	Cares et al. 2006	Peterson et al. 2007
Lack of awareness				✓, -, (-/3)			
Lack of formal methods				✓, -, (-/1)			
Lack of resources				✓, -, (1/4)			
Learning strategy <sup>3</sup>			✓, +, (4) ✓, +, (6)				
Management commitment	✓, +, (2)	✓, +, (4)	✓, +, (5)	✓, +, (1/1)	✓, +	✓, +, (3)	✓, +, (3)
Participation	✓	✓, +, (3)	✓, +, (1)	✓, +, (2/3)	✓, +	✓, +, (4)	✓, +, (2)
Process definition	✓	✓, +, (1)				✓, +, (6)	
Process documentation	✓, +, (1)	✓, +, (6)				✓, +, (1)	
Quality environment	✓, 0						✓, +, (1)
Resource availability	✓			✓, +, (4/3)		✓, +, (11)	
Respect	✓, +, (2)						
Reviews				✓, +, (6/8)			
Separation of process and product concerns					✓, +		
Synchronization		✓, +, (1)				✓, +, (5)	
Team size	✓, 0				✓, +		
Time pressure				✓, -, (2/5)			
Training	✓			✓, +, (3/1)	✓, +	✓, +, (7)	

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<sup>3</sup> 1<sup>st</sup> cell refers to exploitation of existing knowledge; 2<sup>nd</sup> cell refers to exploration of new knowledge.

Niazi, Wilson, and Zowghi (2005a) propose a maturity model for the implementation of SPI programs. They use data from literature and the empirical study they have conducted. In the analysis of factors, Niazi et al. look at how frequently the factors are cited. In the proposed maturity model, they have used the top 50% of the identified factors.

Niazi et al. in a follow-up study (2005b), propose a framework that will provide companies with an effective SPI implementation strategy. The framework is composed of three components: SPI factor, SPI assessment, and SPI implementation. The component that is related to our study is the SPI factor. Based on the results of literature research and interviews, factors cited with a frequency higher than 30% are identified as critical factors.

Another point about Niazi et al. (2005b) is the evaluation of the SPI implementation component of the proposed framework. The authors discuss that based on SEI (2004), the average time required to move from Capability Maturity Model (CMM)-Level 1 to CMM-Level 2 is 22 months, and to move from CMM-Level 2 to CMM-Level 3 an average of 19 months is required. Therefore, it was not possible to complete the evaluation of the SPI implementation component within the time frame of the PhD study of the first author. However, based on our literature review, there are some case studies, (Guerrero and Eterovic, 2004; Akmenek and Tarhan 2003) that have completed the move-up in nearly half the amount of the time that is reported in SEI (2006). These papers will be discussed in Section 2.2.2.

Petterson et al. (2007) have developed a light-weight process assessment framework. While developing the framework, within the several critical success factors mentioned in the previous studies reviewed, the ones related to the study are given as SPI initiation threshold and commitment and involvement. It is said that since SPI programs seem as expensive and time consuming activities, the initiation threshold is usually high. In other words, the reputation of SPI programs

acts like a barrier to initiation. The other factor studied in Petterson et al. is commitment and involvement. The authors include not only upper-level managers but also middle-level managers and developers in their understanding of the factor “commitment and involvement”.

Another study that has used the results of previous empirical studies is Cares et al. (2006). Prior to their agent-oriented process modeling proposal, Cares et al. have also reviewed the literature about SPI success factors. Based on the review results, the most frequently cited thirteen critical success factors (CSFs) have been identified.

Berander and Wohlin (2003) are the authors of one of the papers cited in Cares et al. In this paper, the key factors for successful management and evolution of the software process were identified by using combination of three different approaches: qualitative part-interviews, literature survey, and quantitative part – questionnaire. Factors identified in each part of the study were different from each other. After the overall analysis of the factors, the ranking of the factors from most significant to least is found as: baselining, synchronization, user involvement, management commitment, change management, and documentation.

## **2.2 Case studies in the literature**

The literature was reviewed by the help of the online search engines like Google Scholar and online databases like ACM Digital Library, EBSCO Host, Elsevier Science Direct, IEEE Xplore, JSTOR, and SpringerLink by using the combination of the following keywords: “software process improvement”, “CMM”, “CMMI”, “critical success factors”, and “critical barriers”. The results were reviewed and then the publications which explicitly mentioned a time to move up value from one CMM/CMMI level to another that was smaller than the median values reported in SEI (2004) were selected as the success stories. On the other hand, the cases which had not achieved a clear success were discussed in detail under the

failure stories category. Another criterion employed during the selection of the cases was the information available about the factors in the related study. The major difficulty during the analysis of the cases was that even though the research studies explained what was experienced throughout the CMM/CMMI studies, since their aim was not to discuss the effect of factors on CMM/CMMI success/failure, it was not always possible to gather sufficient information about controllable factors. Such cases were excluded from the analysis.

In this section, case studies on software process improvement retrieved from the literature, will be discussed with the purpose of constructing a model that explains how critical success factors affect SPI duration. These papers can be grouped into three. In the first group, Dyba (2005) has proposed a conceptual research model for predicting the key factors for a successful SPI program, but has not included the time dimension in the model. In the second group of papers, Olson and Sachlis (2002), Akmenek and Tarhan (2003), Guerrero and Eterovic (2004), Zeid (2004), Tufail et al., 2006, and Jackelen (2007) have all presented case studies that have shortened the time to move up from one CMM/CMMI level to another. The reduction in time discussed by these authors is worth studying. Finally, Iversen & Mathiassen (2003), and Balla et al. (2001) present two failure stories that involve spending years for process improvement without clear success.

By investigating the success stories in detail, it is aimed to find a relationship between factors and how they affect the SPI duration over time. How it is possible for one organization to move from CMM Level 1 to CMM Level 3 in 7 months, (Akmenek and Tarhan, 2003), when another takes 14 months (Olson and Sachlis, 2002), and what cause(s) the difference, are some of the questions that we aim to investigate.

### **2.2.1 Dyba's model**

Dyba (2005) has proposed a conceptual research model to investigate the relationship between SPI success and the factors defined in the model. The model is composed of three groups of variables: independent, moderating and dependent variables. Variables are selected according to the results of previous research by the same author (Dyba, 2000; Dyba 2003 as cited in Dyba, 2005). The role of each variable is analyzed using the results of a questionnaire that is applied to 120 software and quality managers from 55 companies. The dependent variable is SPI success; moderating variables are organizational size and environmental condition.

Based on that model, it is concluded that six independent variables affect the success of SPI in the following ranking order, from most to least significant: employee participation, business orientation, concern for measurement, exploitation of existing knowledge, involved leadership, and exploration of new knowledge.

### **2.2.2 Is it possible to shorten the SPI duration?**

In addition to the studies discussed above, experience reports about CMM/CMMI studies also provide detailed information about the settings and conditions in which various SPI exercises have been carried out. In this section, software improvement case studies from literature will be discussed and factors that influence SPI duration will be identified. These case studies consist of six success and two failure stories. In identifying success factors, only explicit statements in the referred publications are interpreted. As precise definitions of the success factors will be formulated in presenting the hypotheses derived from this review, how individual factors were identified in each study being reviewed will not be detailed here. APPENDIX A presents a discussion of the actual terms used in each study to refer to each one of these factors.

### *2.2.2.1 Success stories*

#### **Success Story #1: Move up from CMM-Level 1 to CMM-Level 2**

Guererro and Eterovic (2004) discuss a case that has managed to move from CMM Level 1 to CMM Level 2 in 10 months which would be completed in 19 months on the average according to SEI data (SEI, 2004). The authors have analyzed ten factors that affect the adoption of CMM in small organizations. These ten factors are grouped into two as environment-dependent and – independent SPI factors. The term environment encompasses the elements of organization size, project size, customer budget, educational level of developers, rigor and formality, and type of systems. Environment-dependent SPI factors are listed as process-related training, developer’s involvement, maintaining momentum, group focus, frequency of process assessments, champions, and visibility into the SPI process.

The environment-independent factors which are management commitment, cultural awareness, and separation of process and products concerns, are said to be preconditions for successful SPI implementation.

#### **Success Story #2: Move up from CMM-Level 2 to CMM-Level 3**

When compared to longitudinal software process improvement programs, (Balla et al. (2001); Iversen and Ngwenyama (2006)), Akmenek and Tarhan (2003) have managed to accomplish the requirements of CMM-Level 3 in 7-months time. At the beginning of the SPI initiative, the organization is said to have a quality system with missing CMM-Level 2 requirements. Identified factors are: *Management Commitment, Awareness, Staff Involvement, Training, Experienced Staff, Consultants, and Quality Environment.*

### **Success Story #3: Move up from CMM-Level 1 to CMM-Level 3**

Olson and Sachlis (2002) report improvement from CMM Level 1 to CMM Level 3 in 14 months which would be completed in 38 months on the average according to SEI data (SEI, 2004). Main motivation for SPI program was that they had signed a contract stipulating maturity requirements with their largest customer. The organization has realized the benefits of an SPI program like improving productivity and quality and establishing corporate goals for process improvement and maturity. Entry criteria for SPI are given as management commitment and an approved budget. In addition to the factors discussed below, the role of rewarding is also mentioned, in agreement with Akmenek and Tarhan (2003.) Success factors were identified as: *Management Commitment, Staff Involvement, Training, Consultant, Implementation Plan, and Process Documentation.*

### **Success Story #4: Move up to CMMI-Level 3**

Tufail et. al (2006) have described how CMMI Level 3 was achieved in 8 months. The aim of the improvement program was to become CMMI Maturity Level 3 compliant to meet federal requirements. Effective factors were identified in this study as: *Management Commitment, Awareness, Staff Involvement, Training, Experienced Staff, Implementation Plan, Quality Environment, Consultants, and Reviews.*

### **Success Story #5: Move up from CMM-Level 2 to CMM-Level 3**

Zeid (2004) have explained how the organization, IT Soft moved from CMM Level 2 to CMM Level 3 in a very short time like two months. SPI program was initiated in September 2003. CMM Level 2 was achieved in May 2004, in other words in 9 months. Following the achievement of CMM Level 2, the organization continued process improvement activities and met CMM Level 3 requirements by June 2004. The main success factor for that rapid improvement is stated as when the company has achieved CMM Level 2, they also satisfy many of the

requirements of CMM Level 3. Moreover, CMM Level 3 key process areas (KPA) were related to organization rather than project, this enable parallel execution of the some of the CMM Level 2 and CMM Level 3 improvement activities. The success factors were identified as: *Training, Experienced Staff, Quality Environment, Implementation Plan, Process Documentation, and Metrics and Measurement.*

#### **Success Story #6: Move up to CMMI-Level 2**

Jackelen (2007) have initiated a CMMI program with the goal of meeting the CMMI Level 2 requirements within five months. After the analysis of the current status of the company, the management decided to extend the schedule of the program one month. The paper discusses how it was possible to achieve CMMI Level 2 in six months. The factors identified in this study were: *Management Commitment, Experienced Staff, Consultant, Training, Awareness, and Quality Environment.*

#### ***2.2.2.2 Two failure stories***

In this sub-section the negative effects of the lack of various factors will be discussed.

#### **Failure Story #1: Four-years of improvement effort and still CMM-Level 1**

Iversen and Mathiassen (2003) and Iversen and Ngwenyama (2006) have analyzed the difficulties and challenges encountered during the implementation of a software process improvement program aiming for CMM Level 2. The case study was held in a CMM Level 1 software development company. SPI project had two goals: 1) 10% improvement in productivity; 2) to fulfill the requirements for CMM Level 2. Their data collection period lasted four years, from December 1996 to December 2000, but CMM Level 2 certification was not achieved.

### **Lack of separation of process and product concerns**

SPI team thought that data collection during the project development may disturb the project, so they collected data after project completion. The problem in this strategy was that the company was not able to separate the activities of process improvement and product development. The highest priority was given to product development, the process improvement activities were not considered seriously. This resulted in failure in improvement program.

### **Lack of communication**

Results of the data collection were reported as a summary at each quarter. Therefore, reports provided were not helpful in improvement of an ongoing project but in the next project. Moreover, collecting data after project completion lead to indirect and late feedback. Having prepared summary reports did not help project managers who needed detailed information for an effective comparative analysis.

### **Lack of consultancy**

Based on the findings of Baddoo and Hall (2003), if why Iversen and Mathiassen (2003) could not fulfill the original goal of the project is analyzed, the first factor comes out to be “imposing SPI without prior consultation with practitioners”. While defining the primary goal of the program, management did not consult any professional and prematurely established a 10% improvement goal.

### **Lack of Management Commitment & Lack of Staff Involvement & Lack of Experienced Staff & Awareness**

Even though management commitment was available at the beginning of the project, it was missing in the rest of the project. The personnel of the organization was qualified as inexperienced, moreover the involvement of developers was low.

## **Failure Story #2: Eight years in development of quality framework**

Even though the study reported by Balla et al. (2001) is not exactly a failure story, as certain SPI goals were eventually reached, this case is still considered unsuccessful due to the fact that the time taken was significantly longer than originally intended. Balla et al. discuss how they developed a software improvement framework in a software company in eight-years. The quality initiative was started with the aim of getting ISO 9001 certification, which was not realized until nearly four years after initiation. In the following paragraphs, the critical success factors and critical barriers mentioned in this case study are reviewed.

### **Management Commitment**

In the first phase of the program, management commitment was missing. Eventually the employees resisted to apply new standard procedures. Moreover, management was not aware of the fact that improvement activities are complicated activities that could not be succeeded without appropriate team and resources. By the time Phase 3 was reached, management decided to allocate necessary resources with a project management plan. By attending the training session, management showed that they not only supported the SPI program but also were actively involved in the SPI program.

### **Awareness & Separation of Process and Products**

Since employees had little knowledge about the quality issues and the reasons/benefits/outcomes of such a quality program, there were problems with meeting schedules since they did not clearly understand the mechanism of improvement process.

Another reason for low level of adoption of the quality issues and resistance to change may be due to lack of a separate process improvement group. Since the separation of process and products could not be achieved, and the quality related

issues were so different from the current way of work flow, the employees perceived quality activities as extra work. Moreover, management commitment was lacking, thus there was no obligation of the management level about the application of SPI activities. Quality awareness could only be established in Phase 5.

### **Staff Involvement and Training**

At the beginning of the program, there was only one person who was knowledgeable in process improvement. The involvement of staff was increased by providing appropriate training about SPI and forming work groups. Communication channels that inform all employees about the evolution of the project were formed. It is mentioned that communication problems between the developers and managers were diminished and the involvement also increased.

### **Experienced Staff**

Prior to the SPI initiative, the staff had no experience on SPI activities. The whole workload of the improvement program was assigned to a part time employee. It may be due to the lack of knowledge about the improvement activities; the employees could not adopt the SPI initiative in Phase 1. However, as time passed, as a result of the precautions taken, i.e. providing training, establishment of communication channels, the developers got experienced.

### **Implementation plan**

The portfolio of the company consisted of unique projects which make their classification and establishment of a common framework difficult. In the time between Phase 1 and Phase 3, a formal methodology was defined. A positive effect of formal methodology was observed in Phase 4 when the ISO-9001 certificate was received.

## **CHAPTER 3**

### **MODEL DEVELOPMENT**

Models make it possible to analyze the real world problems from an abstract level. When the model is constructed from the perspective which will be examined, the unrelated details that do not belong to that perspective is omitted (Fenton and Pfleeger, 1997). Another benefit of a model is that it enables researchers to see the relationship between the components of the system. If the trend of change can be identified, then it would be possible for managers to plan the development activities more realistically including the SPI activities.

The aim of this study is to investigate the relationship between the factors and CMMI-based SPI duration, so the dependent variable of our model is selected as “time to complete CMMI-based SPI successfully”. The independent variables of the model are the success factors retrieved from the literature review.

First of all, factors which will be investigated throughout the study are defined in Section 3.1. Then, the case studies retrieved from literature are analyzed and related hypotheses are derived in Section 3.2.

### 3.1 Definition of variables

Common points reported in these research papers were observed as quality environment, management commitment, awareness, staff involvement, training, and the existence of experienced people involved with the process improvement endeavours. On the other hand, the reasons that lead to failure can be identified as lack of management commitment, lack of quality environment, lack of SPI awareness, lack of a formal implementation plan, and lack of training.

Based on the literature review and the discussion in Sections 2.2.1 and 2.2.2, the independent variables are selected as *Management Commitment*, *Awareness*, *Staff Involvement*, *Training*, *Experienced Staff*, *Implementation Plan*, and *Quality Environment*. Below, these terms will be defined.

#### **Management Commitment:**

As far as management attitudes towards SPI are concerned, middle managers are always required to participate in SPI activities in various capacities, whereas the commitment and personal involvement of high level managers turns out to be critical. For this reason, in this study, the focus has been upon the attitudes of high level managers. Hence, in this thesis, hereafter, the term “management” will be used to refer exclusively to “high level management”.

SPI initiative should be started by the management who should continue to support the initiative so that employees in other levels of the organization can realize that importance given to SPI activities. Management should be aware of the benefits of SPI programs. Management should know that improvement activities are complicated and should provide necessary resources and support when required. Moreover, in some cases, management may announce some mandatory actions so that priority should be given to SPI activities and separation of process and product concerns are accomplished. In some cases, the involvement of the management to SPI activities, for example training may be

required. On the contrary, Dyba (2005) states that management involvement is an insignificant predictor of SPI success and mentions that what is expected from the managers may not be more than providing the necessary resources.

**Awareness:** Staff at all levels should be aware of the benefits of SPI, their roles and responsibilities in SPI initiative. The cultural impact of SPI should also be considered. Guerrero and Eterovic (2004) prefer not to adopt any idea against the culture of organization in order to avoid resistance to change. On the other hand, a positive side effect of SPI activities is improving the organizational culture of the company. That is no resistance to change is expected. However, when immature organizations are taken into consideration, some resistance to change may be expected. In order to avoid such a resistance and accomplish the requirements of the SPI program in a short time, adopting the activities parallel to the organizational culture may be an effective solution.

**Staff Involvement:** Staff should be dedicated and committed to SPI activities. That is employees should get use of their experiences and knowledge and should actively take role in decisions making processes throughout the SPI program. The organization should encourage the participation of the employees. Resources allocations and team structures should be arrange such that the organization get the maximum benefit from the staff.

**Training:** Training related to improvement activities should be given based on a training program and sufficient resources and time should be allocated to training. How the employees will attend the training sessions may be decided by the SPI team, however, in order to increase awareness, the staff may be advised to attend all the training sessions. When necessary, online training methods can be employed in addition to classical training.

**Experienced Staff:** While allocating the resources, priority should be given to those who have previous SPI experience. Working with consultant companies for the assessment may be beneficial. There should be experts in the SPI teams.

**Implementation Plan:** Effective SPI management is possible with an effective SPI management plan and a formal methodology that is developed based on previous experience. An implementation plan with many but incremental milestones may accelerate the improvement process. When applicable, frequent assessments –either formal or informal- may be applied. This enables the observation of the results of the SPI. For fast move-up, it is advised to prepare process implementation reports and track them regularly. Prior knowledge about process documentation and planning would be helpful. During planning, review activities should also be added since they are critical for process monitoring.

**Quality Environment:** If the organization develops software based on internal standards, or has fulfill the requirements of formal standards or certifications, and then they are more likely to success SPI program. There are three more points about the quality environment. First of all, the SPI goals should be parallel with the business goals. The more there are aligned, the more success is perceived. Secondly, if the quality procedures of the organization are compatible with the requirements of the maturity model that will be applied, then the possibility of accelerated success is higher. Finally, the extent to which the software organization collects and utilizes quality data to guide and assess the effects of SPI activities—has a strong and highly significant correlation with overall SPI success.

### **3.2 Analysis of the results of the case studies retrieved from literature**

The factors affecting the duration of SPI may not be independent from each other, they may be linked to each other, and they may be affected by each other

(Andersen, Fisher, and Gross, 2004). In investigating the stories discussed in Section 2.2.2, comparing the factors and program durations, the aim was to find a relationship between the factors and how they affect the SPI duration over time.

To facilitate the analysis of the success and failure stories in the literature, a two dimensional array was constructed with the identified factors constituting the vertical dimension, and the cases reported in the literature on the horizontal dimension (See Table 5 ) For each one of the eight cases in the literature, existence of the relevant factors was examined. In Table 5 a “+” indicates that the factors exists in the related research, a “-” indicates the lack of the factor and the absence of either sign must be interpreted as nothing being mentioned about the factor in the related research. Subsequently, the cases were compared in a pair-wise fashion. The independent variables were the factors and the dependent variable was the certification time. All pairs of cases with similar initial and final CMM Levels were compared and hypotheses to explain the differences of certification time were constructed. These hypotheses are named using the initials H\_L which stands for Hypothesis derived based on Literature review.

Success Story #1 and Success Story #5 have moved from CMM-Level 1 to CMM Level 2 in 10 and 9 months, respectively. The factors not effective in Success Story #1 but influential in Success Story #5, are *Experienced Staff*, *Quality Environment*, *Process Documentation* and *Metrics and Measurement*. So, hypotheses related to these differences may be as follows:

H\_L #1. Having a *Quality Environment*, *Experienced Staff*, *Process Documentation* and applying *Metrics and Measurement* activities speed up the SPI to CMM Level 2 process.

H\_L #2. Having frequent assessments (formal/informal) slow down the SPI to CMM 2 process.

**Table 5 Factors identified in the case studies retrieved from literature**

	Success Story # 1	Success Story # 2	Success Story # 3	Success Story # 4	Success Story # 5	Success Story # 6	Failure Story #1	Failure Story#2 <sup>4</sup>	
								Ph 1-2	Ph 3-5
<i>Management Commitment</i>	+	+	+	+	+	+	-	-	+
<i>Awareness</i>	+	+	+	+	+	+	-	-	+
<i>Staff Involvement</i>	+	+	+	+	+		-	-	+
<i>Training</i>	+	+	+	+	+	+		-	+
<i>Experienced Staff</i>	-	+	-	+	+	+	-	-	+
<i>Implementation Plan</i>	+	+	+	+	+			-	+
<i>Quality Environment</i>	-	+	-	+	+	+			
<i>Communication</i>	+		+		+		-		
<i>Group Focus</i>	+	+	+		+				
<i>Frequency of Assessments</i>	+	+	+		+				
<i>Separation of Process and Products</i>	+	+	+		+		-		
<i>Process Documentation</i>		+	+		+				
<i>Consultant</i>		+	+	+	-		-		
<i>Reviews</i>				+					
<i>Metrics and Measurement</i>		+	+		+				
Time to Move up	CMM-L1 to L2/ 10 mths	CMM-L1 to L3/ 7 mths	CMM-L1 to L3/ 14 mths	CMMI - L3/ 8mths	CMM-L1 to L2/ 9mths to L3/ 2mths	CMMI - L2/ 6mths	CMM-L2 /> 4 years	CMM-L2/ 8years	

Even though H\_L #2 has been formulated based on the information summarized in Table 5, it is necessary to say that based on the rationale of Gurerrero and Eterovic (2004) frequent assessments seem very beneficial since it is possible to observe the results of the improvement activities immediately and take the necessary actions as soon as the results were observed. However, the disadvantages of not having the factors mentioned in hypothesis H\_L #1 may

<sup>4</sup> This case study can be divided into two: Phases 1-2 can be considered as unsuccessful, and Phases 3-5 can be considered as successful . (Ph stands for Phase)

override the advantages of hypothesis H\_L #2. Based on this discussion, the following hypothesis is proposed:

H\_L #3. The disadvantages of not having the factors mentioned in hypothesis H\_L #1 may override the advantages of *Frequency of Assessments* considered in hypothesis H\_L #2.

Success Story #2, Success Story #3, and Success Story #5 have moved from CMM-Level 1 to CMM Level 3 in 7 , 14 , and 11 months, respectively. The common point in Success Story #2 and Success Story #5 is that prior to the SPI initiative, both organizations partially satisfied the requirements of the upper level. Success Story #2 had an initial quality system with missing CMM-Level 2 requirements. Success Story #5 satisfied the many of the requirements of Level 3 at the final stages of the CMM-Level 2 improvement program, and CMM-Level 3 initiative was started parallel to the CMM-Level 2 initiative. Therefore, hypotheses related to the number of KPAs may be as follows:

H\_L #4. A larger number of KPAs satisfied before the SPI initiative shortens the SPI duration.

The factor that was not observed to be influential in Success Story #5 but was effective in Success Story #2, is whether or not consultancy was received. So, hypotheses related to these differences may be as follows:

H\_L #5. Having worked with *Consultants* speed up the CMM Level 3 move up process.

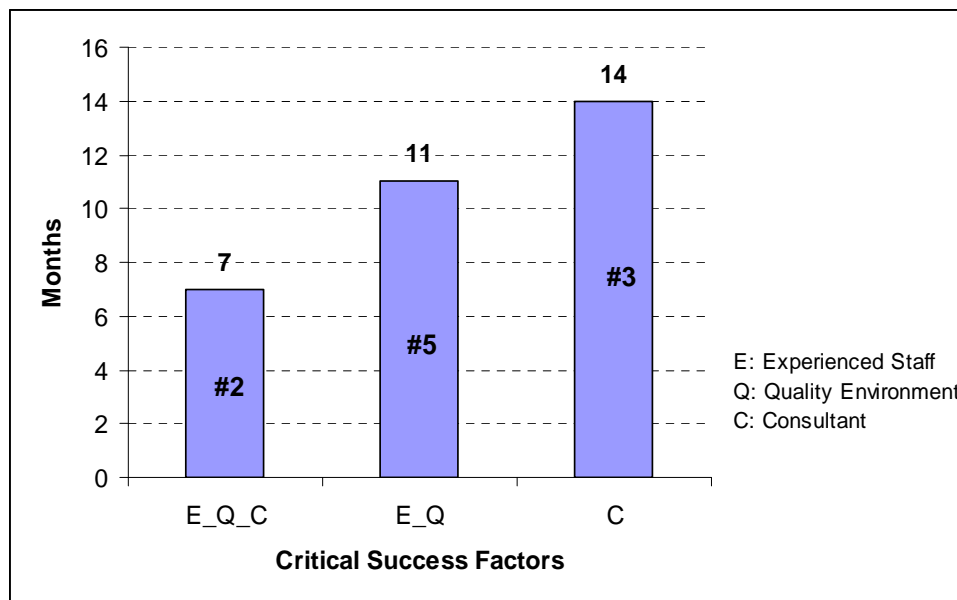
When Success Stories #2 and #3 are compared, it is observed that #2 has worked with consultants, has a quality environment and experienced staff; #3 has worked with consultants but lacks quality environments and experienced staff. The hypothesis related to this difference may be as follows:

H\_L #6. Provided that consultancy has been obtained, having a *Quality Environment* and *Experienced Staff*, speeds up the SPI to CMM Level 3 process.

When Success Story #3 and #5 are compared, it is observed that #3 has consultants but lacks quality environment and experienced staff and vice versa for #5. The hypothesis related to this difference may be as follows:

H\_L #7. The effect of *Quality Environment* and *Experienced Staff* on SPI duration is higher than effect of working with *Consultant*.

Figure 1 shows how success factors differ in Success Stories #2, #3, and #5 and how long it has taken for each company to complete the SPI program. The relative effects of *Quality Environment* and *Experienced Staff* comparison to *Consultant* can be easily observed in this figure. The factors other than *Experienced Staff*, *Quality Environment*, and *Consultant* are common in all three cases; therefore they are not shown in the figure.



**Figure 1 Comparison of Success Story # 2, 3, and 5**

The summary of the hypotheses proposed in this section and how they are related to each case is given in Table 6.

**Table 6 Summary of the hypothesis proposed**

Hypothesis	Factors	Achievement (CMM Level)	Effect on duration	References
H_L #1	<i>Experienced Staff, Quality Environment, Process Documentation, Metrics and Measurement</i>	Level 1 to level 2	Speed up	Guererro and Eterovic (2004); Zeid, (2004)
H_L #2	<i>Frequency of Assessments</i>	Level 1 to level 2	Slow down	Guererro and Eterovic (2004); Zeid, (2004)
H_L #3	<i>Experienced Staff, Quality Environment, Process Documentation, Metrics and Measurement, Frequency of Assessments</i>	Level 1 to level 2	Relative comparison of factors	Guererro and Eterovic (2004) Zeid, (2004)
H_L #4	KPAs satisfied	Level 1 to level 3	Speed up	Akmenek and Tarhan (2003); Zeid, 2004
H_L #5	<i>Consultants</i>	Level 1 to level 3	Speed up	Akmenek and Tarhan (2003); Zeid, 2004
H_L #6	<i>Experienced Staff, Quality Environment,</i>	Level 1 to level 3	Speed up	Akmenek and Tarhan (2003); Olson and Sachlis, (2002)
H_L #7	<i>Experienced Staff, Quality Environment, Consultants</i>	Level 1 to level 3	Relative comparison of factors	Olson and Sachlis, (2002); Zeid, (2004)

## **CHAPTER 4**

### **METHODOLOGY**

In this chapter, qualitative research method, case study research strategy, and interview methods are explained briefly. Moreover, rationale for the adopted research approach, description of the research sample, methods of data collection, and data analysis are also presented.

#### **4.1 Rationale for qualitative research in information systems**

Producing rounded understandings on the basis of rich, contextual, and detailed data is the aim of qualitative research (Mason, 1996). Qualitative research transforms information from observation, reports, and recordings into data in the form of written word. Detailed description of events or people is necessary in qualitative analysis. Because the evaluators study the selected issues in depth and detail, this type of research usually deals with small sample sizes (Patton, 1990; Denscombe, 2000).

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

- To find answers to questions of not only what but also why and how;

- To analyze the relationship between the area of study and social, organizational, and cultural context;
- To investigate the details of the processes;
- To observe the process life cycle rather than its outcomes or impacts.

As discussed in Chapter 2, our main research question is how it is possible for some of the organizations to complete CMMI programs in 30 months, whereas for others in 12 months. To answer this question, it is necessary to investigate the details of the SPI processes of the organizations; to find out the causes behind the outcomes throughout the SPI lifecycle; to find the relationship between the success factors and organizational and cultural contexts.

#### **4.2 Rationale for case research strategy in information systems**

Benbasat, Goldstein, and Mead (1987) state that case research strategy is practical in information systems and lists three reasons as follows. By applying case research, it is possible to observe the organization in its natural setting and derive hypotheses related to the research question. Moreover, case research strategy provides answers to questions of how and why and by this way the details of the organizational processes can be identified. Finally, it is suitable for research areas where there are only a few previous studies.

In the present study, first of all, the aim of the research has been to propose hypotheses on the effect of factors on SPI. Case study strategy as discussed above, enables the researcher to propose hypotheses from practice. The hypotheses would be proposed based on the results of the analysis done after observing the nature of the organization and interviewing the staff.

Secondly, details of the application of the SPI program can be best learned from the practitioners. How the program is initiated, what work is done during the SPI

program, what problems the organization faced, how they were solved, what challenges were encountered, and which lessons were learned from the SPI experience, are some of the questions related to the SPI process. The answers to these questions can be identified by applying case study strategy.

Thirdly, as discussed in Chapter 2, there are a number of studies about factors affecting the success of SPI programs. However, to the best of our knowledge, published research about how these factors are related to SPI program duration are not available. Having decided to address such a relatively less investigated subject is another reason for selecting case study research strategy.

### **4.3 Rationale for semi-structured interview**

There are three ways of data collection in qualitative analysis: (1) interviews; (2) direct observation; and (3) written documents. In interviews, direct quotations from people about their experiences, opinions, feelings, and knowledge are used as a data source. Detailed descriptions of people's activities, behaviors, and actions are gathered from direct observation. Organizational or program records; official publications and reports are the examples of written documents used in qualitative analysis (Patton, 1990).

Interview types can be grouped into three: unstructured, semi-structured, and structured. Unstructured interviews are completely informal. There are a number of themes, which are to be explored, and researchers ask questions about these topics and discuss them with the respondent.

Structured interview is a purposeful conversation in which the interviewer asks prepared questions and the respondent answers them. In structured interviews, it is assumed that there is a common vocabulary for all potential respondents; question formats are equally meaningful to all; the context of each question is obvious. In

other words structured interview can be considered as an oral presentation of a written questionnaire. Questions are set in advance. Each interview is conducted in exactly the same way. The questions and their order are the same for all respondents. The researcher determines the range of possible responses.

The most common data collection method used in qualitative research is semi-structured interview which starts with pre-ordered questions. These questions are usually open-ended and the responses should be taped for later transcription. When compared to structured interviews, semi-structured interviews are more flexible. These questions are used as a guide during the interview, the order of the questions may change during the interview. It is possible that some of the previously identified topics are discussed in detail, whereas some of the topics may not be discussed at all. Semi-structured interviews result in rich and detailed data. Besides these advantages, the possibility of losing the control over the interview is one of the disadvantages, since open ended questions are asked, and respondent may talk about unrelated issues. In these cases, the researcher should re-direct the respondent to the original topic. Another disadvantage is that the interviews may take relatively longer times and as a result it may be difficult to arrange the meetings (Montague, 2009.)

#### **4.4 Sample profile**

A purposeful selection procedure was used to select the cases of the study. This type of sampling provides information-rich cases as is needed during the detailed investigation of the phenomena under accelerated SPI programs (Patton 1990; Silverman 2000 as cited in Bloomberg and Volpe, 2008.)

Cases were selected from the companies which either have completed the CMMI-Level -3 certification or have been through CMMI initiative without certification. An e-mail requesting an appointment was sent to fourteen companies. Seven of

them agreed to participate in the research. To enable comparison and evaluation of cases, interviews were held with six CMMI-Level 3 certified companies. In addition to these, another interview was arranged with an organization that aimed CMMI-Level 3 but did not apply for the official appraisal.

After the interviews with these companies were completed, the analysis of the interviews was performed. Based on the analysis, revised hypotheses were formulated. To safeguard privacy, the names of the organizations have been withheld in the sequel. Brief information about the cases is given below and in Table 7. A detailed discussion of each case is presented in Chapter 5.

**Table 7 Summary of the cases**

<b>Case Name</b>	<b>Number of Employees</b>	<b>Establishment Year</b>	<b>Area of Interest</b>	<b>Number of Interviews</b>	<b>CMMI-L3 Duration</b>
Case A	250	1990	Avionics, electronic and electromechanical systems	4	24
Case B	790	1986	Communication Sector	3	27
Case C	250	1991	Defense Sector	1	25
Case D	190	1991	Information technology research institute	1	30
Case E	1000	1960	Software solution provider	1	24
Case F	2800	1997	IT solution provides	1	12
Case G	15000	1948	Finance Sector	1	12

Case A: Firm A provides solutions for avionics, electronic and electromechanical systems. They have completed the CMMI-Level 3 program in 24 months. Three people were interviewed from Case A: project director, team leader, and process engineer.

Case B: Firm B obtained CMMI- Level 3 certification in December 2007, which is approximately 27 months after they initiated the CMMI activities. Three staff members from Case B were interviewed: general manager, project director, and project consultant.

Case C: Firm C has been established in 1991 and has been working in the defense sector. They focus on business areas of product development projects, consultancy services, procurement services. The organization had on-going process improvement studies when the CMMI program was started in October 2004, and the certification was achieved at the end of 2006.

Case D: Firm D is a research institute whose main research area is information technologies. They completed CMMI-Level 3 program in 30 months.

Case E: Firm E is a software solution provider and was certified as CMMI-Level 3 in software engineering in December 2006, 24 months after they initiated the CMMI program (November 2004-December 2006).

Case F: Firm F is a global organization which provides solution for various systems. It was certified as CMMI-Level 3 after 12 months they initiated CMMI program.

Case G: Firm G is a financial institution that have started the SPI program on November 2006 and completed it in November 2007. The main difference between the Case G and the other cases is that the aim of the program was not certification but improving the processes. Therefore, they completed the SPI program requirements on November 2007 but they were not formally certified as CMMI-Level 3.

#### **4.5 Data collection method**

Data was collected in two phases. The first phase consisted of formulating the initial hypotheses based on the literature. In the second phase of the research, data was collected through interviews with seven organizations six of which are CMMI-Level 3. After these interviews, revised hypotheses were formulated.

##### **4.5.1 SPI-CMM/CMMI literature**

First of all, the literature was reviewed to identify the factors for successful SPI programs. After that, CMM/CMMI success and failure stories were analyzed. In investigating these stories in detail, comparing the factors and program durations, the aim was to find a relationship between the factors and how they affect the SPI duration over time. Details of the literature review have been presented above in Chapter 2.

##### **4.5.2 Interviews**

Data collection method used in the second part of the research was semi-structured interviews. Interviews usually lasted around 45 minutes. The aim was to cover as many items as possible. When possible, interviews were held with more than one person in each company, the aim being to capture different viewpoints.

While preparing the interview questions, the aim was to investigate the effect of the selected factors on CMMI-certification duration. *Quality Environment, Experienced Staff, Management Commitment, Awareness, Staff Involvement, Process Documentation, Training and Metrics and Measurement* were selected based on the result of the literature review. Even though *Implementation Plan* was included in the first version of the questions, after the revision of the questions, it was excluded from the factor list because of two reasons: First of all, questions related to *Implementation Plan* were also asked in *Quality Environment*. Secondly, when the definition of the factor given in Section 3.1 was reviewed, it was realized that the definition listed the items an implementation plan should include which are frequent assessments, review activities and review reports. Since these items were also defined as factors/sub-factor, *Implementation Plan* was excluded from the list. The interview questions are given in APPENDIX B.

After interview questions were prepared, it was observed that rather than grouping all the related questions under the same factor, it was possible to form new sub-groups and investigate some of the factors in detail to produce more precise results. Therefore, sub-factors were defined based on the literature review and interviews. For example, *Quality Environment* is associated with the sub-factors *Parallelism between Standards, Frequency of Assessments, Gap Analysis* and *Class-B Appraisal*. A complete list of sub-factors and their associated factors is given in Table 8 .

**Table 8 List of sub-factors and associated factors**

<b>Factor</b>	<b>Sub-factor</b>
<i>Quality Environment</i>	<i>Parallelism between Standards Frequency of Assessments Gap Analysis Class-B Appraisal</i>
<i>Experienced Staff</i>	<i>CMM/CMMI Experience Separation of Process and Products Consultant Reviews</i>
<i>Staff Involvement</i>	<i>Awareness Resistance to Change Rewarding</i>
<i>Training</i>	<i>Annual Training Training Plan</i>
<i>Metrics and Measurement</i>	<i>Metrics Analysis Automated Metrics Tool</i>

#### **4.6 Data analysis method**

The method used in the analysis of the interviews was similar to the one that was used in the analysis of the success and failure stories from the literature. The main difference between the two methods was that, for each factor and sub-factor, a score taking either one of the three values: none-low, medium, or high was assigned. A score of “none-low” means that the factor does not exist in the organization or exists only weakly. A score of “medium” means that the organization somehow practices the factor. A score of “high” means that the organization utilizes the practices of the factor at a significant level. The score matrix is given in Table 9. The details of the notation used in Table 9 are given in APPENDIX C.

**Table 9 Factors identified in the case studies**

Factors	Factor Group	Interviews with Case						
		F	G	A	E	C	B	D
<i>Quality Environment</i>	ISF	high	high	high	high	high	medium	high
<i>Parallelism btw Standards</i>	ISF	medium	medium	high	medium	medium	medium	medium
<i>Frequency of Assessments</i>	PF	high	medium	high	medium	high		high
<i>Gap Analysis</i>	PF	high	high	high		high		
<i>Class-B Appraisal</i>	PF	high	none or low	high	high	high		high
<i>Experienced Staff</i>	ISF	high	high	high	high	high	medium	high
<i>CMM/CMMI Experience</i>	ISF	none or low	none or low	high	medium	medium	medium	medium
<i>Separation of Process and Products</i>	PF	medium	medium	high	medium	medium	high	medium
<i>Consultant Reviews</i>	PF PF	high high	high high	high high	high medium	medium high	high medium	high medium
<i>Staff Involvement</i>	PF	high	high	high	high	medium	high	medium
<i>Awareness</i>	ISF	high	high	high	high	medium	medium	medium
<i>Resistance to Change</i>	PF	medium	high	high	high		high	
<i>Rewarding</i>	PF	medium	medium	high	high	medium		medium
<i>Training</i>	PF	high	high	high	high	medium	high	high
<i>Annual Training</i>	PF	high	high	high	medium	medium	medium	medium
<i>Training Plan</i>	PF	medium	high	high	medium		medium	medium
<i>Metrics and Measurement</i>	ISF	medium		high	medium	medium	medium	medium
<i>Metrics Analysis</i>	ISF	medium	high	high	high	medium	medium	medium
<i>Automated Metrics Tool</i>	PF	medium	medium	high	medium	high		none or low
<i>Management Commitment I</i>	ISF	high	high	high	high	medium	high	medium
<i>Management Commitment II</i>	PF	high	high	medium	high	medium	high	medium
<i>Management Involvement</i>	PF	high	high	medium	high	medium	high	medium
<i>Process Documentation</i>	ISF	high		high	high	high	medium	medium
<i>Time to Move up</i>		To CMMI-L3 in 12 months	Satisfy the req. of CMMI-L3 informally 12 months	CMM to CMMI-3 in 24 months	From 0 to CMMI-3 in 24 months	to CMMI-3 in 25 months	to CMMI-3 in 27 months	to CMMI-3 in 30 months

*Management Commitment* was revised during the analysis of the cases and preparation of the score matrix. As cases and factors were investigated in detail, the necessity to re-define *Management Commitment* as three individual factors which are *Management Commitment I*, *Management Commitment II*, and *Management Involvement*, arose due to the fact that significant differences related to these three factors, which were believed to have an effect on SPI duration, were examined among the cases. Specifically, commitment before commencement of the CMMI program and during the execution of the program had to be distinguished, as well as whether or not managers were actively involved in a hands-on fashion with the SPI activities was noticed to have significant impact.

After the score matrix was constructed, certification times were compared and the influences of the scores of the main factors, which are *Quality Environment*, *Experienced Staff*, *Staff Involvement*, *Training*, *Metrics and Measurement*, *Management Commitment I*, *Management Commitment II*, *Management Involvement* and *Process Documentation*, were examined. The definition of the factors is given in Table 10 .

Upon analysis of the interview results, it was observed that the factors had to be classified as initial status factors (ISF) and progress factors (PF) to distinguish the differences between the factors. Initial status factors are those that are related to the status of the organization upon initiation of the CMMI program. On the other hand, progress factors are related to the progress of the CMMI program. The factors related to the existence of a metrics and analysis program in the organization appear both under ISF and PF categories, as whether such a program exists before the initiation of the CMMI project is significant, but also, how well such a program is established is relevant to the progress of the SPI activities.

**Table 10 Definition of the factors**

<b>Factor</b>	<b>Definition</b>
<i>Quality Environment</i>	The quality standards the organization employed prior to CMMI program.
<i>Parallelism between standards</i>	The existence of the utilization of standards/models like CMM/CMMI/ISO 9001:2000/ISO 12207.
<i>Frequency of assessment</i>	The number of the informal/formal assessments done prior to CMMI certification.
<i>Gap Analysis</i>	Utilization of gap analysis.
<i>Class-B Appraisal</i>	Utilization of Class-B appraisal.
<i>Experienced Staff</i>	Staff' experience on process development/documentation and/or quality standards.
<i>CMM/CMMI Experience</i>	Staff' experience on CMM/CMMI.
<i>Separation of Process and Products</i>	The existence of SEPG prior to CMMI program.
<i>Consultant</i>	Working with a consultant throughout the CMMI studies.
<i>Review</i>	Existence of review groups prior to CMM/CMMI studies.
<i>Staff Involvement</i>	Having staff that is dedicated and committed to CMMI activities.
<i>Awareness</i>	The level of the CMMI awareness of staff.
<i>Resistance to Change</i>	The lack of resistance to change to CMMI studies.
<i>Rewarding</i>	The rewarding mechanism the organization has employed throughout the CMMI studies.
<i>Training</i>	Training related to CMMI is given based on a training program.
<i>Annual training</i>	Training is given on regular basis prior to CMMI.
<i>Training plan</i>	The existence of a training program.
<i>Metrics and Measurement</i>	The utilization of metrics and measurement activities prior to CMMI studies.
<i>Metrics Analysis</i>	Application of metrics selection methods and metrics analysis.
<i>Automated Metrics Tool</i>	The utilization of automated metrics tool during to CMMI studies.
<i>Management Commitment I</i>	The level of top management commitment prior to CMMI studies.
<i>Management Commitment II</i>	The level of top management commitment throughout the CMMI studies.
<i>Management Involvement</i>	The level of top management involvement throughout the CMMI studies.
<i>Process Documentation</i>	The adaptation level of the process documentation activities prior to CMMI studies.

#### 4.7 Trustworthiness of the case studies

According to Yin (2003), there are four tests that are commonly used to establish the quality of case study research. These are construct validity, internal validity, external validity and reliability. These case study tactics recommended by Yin (2003) are reproduced in Table 11.

**Table 11 Case Study Tactics for Four Design Tests (Yin, 2003)**

<b>Tests</b>	<b>Case Study Tactics</b>	<b>Phase of research in which tactic occurs</b>
Construct validity	<ul style="list-style-type: none"><li>▪ Use multiple sources of evidence</li><li>▪ Establish chain of evidence</li><li>▪ Have key informants review draft case study report</li></ul>	Data collection
Internal validity	<ul style="list-style-type: none"><li>▪ Do pattern-matching</li><li>▪ Do explanation-building</li><li>▪ Address rival explanations</li><li>▪ Use logic models</li></ul>	Data analysis
External validity	<ul style="list-style-type: none"><li>▪ Use theory in single-case studies</li><li>▪ Use replication logic in multiple-case studies</li></ul>	Research design
Reliability	<ul style="list-style-type: none"><li>▪ Use case study protocol</li><li>▪ Develop case study database</li></ul>	Data collection

Among the tactics listed in Table 11, replication logic in multiple-case studies was used in the present work to increase external validity and a case study database was constructed to diminish the threats to reliability. The replication approach followed during the multiple case studies is as follows: First of all research questions were developed. After the cases were selected, seven cases were studied and an individual report was written for each case. Later, cross-case conclusions were drawn and hypotheses were revised. Finally, the cross-case report was prepared.

While constructing the case study database, the case study notes and the narratives were consulted. Case study notes were either recorded or handwritten by the

researcher during the interviews and transcribed after the interviews (For these transcripts, please refer to Karagül, 2009.)

## **CHAPTER 5**

### **CASE STUDIES**

This chapter presents the details of the case studies. First of all, a summary of the case, highlighting the important points regarding accelerated CMMI, is given. Then, the existence of each factor is examined based on the interviews.

#### **5.1 CASE A**

CASE A managed to achieve CMM-Level 3 in 7 months in 2003. Since then, they have continued SPI activities and they were awarded as CMMI-Level 3 in June 2007. The interviewees stated that the aim of the organization has not been to achieve a CMMI-certification but to improve the processes; to implement what is written in the documents and/or to write what is being implemented. It has been clearly observed that SPI activities have been a part of the organizational culture.

Three members of the SPI team were interviewed: one process engineer, one team leader and a project director. The project director was familiar with both the CMM and CMMI journey, whereas the process engineer talked about the CMMI studies. The team leader has been working there for about one year, and was not in the organization when the certifications were achieved but provided useful

information about the SPI team structure, training policy, and how organization look at SPI activities.

In the following paragraphs, interviews are discussed based on the success factors.

### **5.1.1 *Quality Environment***

When the CMMI program was initiated, the organization had experience on CMM and other quality standards like military standards and ISO 12207. Therefore, it can be concluded that the parallelism between the standards used and the CMMI model requirements provided helpful insights in the definition of processes in CMMI activities.

#### **5.1.1.1 *Class-B Appraisal***

The process engineer mentioned the role of Class-B appraisal. The Class-B appraisal report provides the information about where the organization is. It clarifies the processes that need improvement. The risk of getting through directly with Class-A appraisal was also mentioned by the project director.

About the frequency of the appraisals, it has been declared by the process engineer that appraisal is not a kind of thing that will be done by saying “let’s do it”. Therefore, it can be concluded that necessity of an appraisal is clear, but frequency of appraisals is discussable.

### **5.1.2 *Experienced Staff***

During the CMM activities, nearly all of the employees were involved in the SPI program. The advantage of such a large group was gathering the experiences from those people, increasing the motivation for SPI activities and speeding up the adoption of SPI. On the other hand, the main disadvantage arose because of the

workload. Thus, the main responsibility of people in that kind of groups was product development rather than process improvement. Despite these drawbacks, having an extended SPI group during CMM program not only increased the SPI awareness of the staff but also made the staff experienced about process improvement. That brought an advantage through the CMMI studies.

#### ***5.1.2.1 Separation of Product and Process***

CASE A had a separate SPI team prior to CMMI program. SPI activities were regarded as projects and they had project plans and a project budget. It was mentioned that it may not be feasible to involve all people in the process improvement activities since this may cause problems in the development of good processes. People may contribute more if they review their processes.

#### ***5.1.2.2 Consultant***

While selecting the consultant company, previous experience with the consultant and the consultant's previous experiences and references were taken into account. They worked with two different companies: one for appraisal and one for training. The appraiser had been in many appraisals and had lots of experience, and could be regarded as a guru of CMMI. What is expected from him was guidance rather than grading. An experienced appraiser knows what SEI asks for, he has observed many other organizations and has experience about how to solve the problems.

“If an experienced consultant warns you about a topic, you should listen to him, because he is always right.” (Project director, Case A)

### **5.1.3 Staff Involvement**

There were two databases which were improvement proposal database and lessons learned database. All employees could access these databases and add their improvement proposals and comments about their experiences throughout the development of projects. The participation of the employees is supported by the SEPG and the management.

Regular annual trainings also increased the involvement of the staff. During training, employees were also encouraged to provide feedback about the process. The technical leader stated that the staff had been actively participating in the SPI program.

#### **5.1.3.1 Awareness**

Even though other standards were applicable, knowledge about CMM was missing in 2003. CMM is different than other standards or models; it includes developers, or staff in the appraisal process. So, to make people understand the CMM, the organization arranged trainings. There had been audits and in these audits when missing points were observed, the staff realized that they should study more and do what is written in the documents. As a result of these activities, it can be concluded that staff were well aware of CMMI, its requirements and its benefits.

#### **5.1.3.2 Resistance to Change**

The organization had adopted quality standards and CMM, before CMMI program, so existing organization was similar to what CMMI required. Still, a smooth transformation was aimed. That was supported with sufficient and continuous training which is also a requirement of CMMI. Most of the work flows

were stable at the time of the interviews. Most of the practices, for example peer review practices were an indispensable part of the flow, nobody thought them unnecessary. Thus, CMMI awareness was completely established in the organization and no resistance to change was observed.

#### **5.1.4 *Training***

The organization had a training plan which was rearranged and updated every year. Based on this plan, employees from software department and all project managers attended the related training sessions. Training metrics were collected by the help of an automated tool. Every employee had access to the tool. Evaluation forms and feedback about training was prepared by the help of the tool.

#### **5.1.5 *Metrics and Measurement***

The organization had been collecting metrics since 2002 which was even before CMM certification. What changed with CMMI was that CMMI emphasized measurement analysis more than CMM, so a measurement analysis process was added to the definitions. As a result, metrics were being collected based on goal-question-indicator-metrics model in a more organized fashion with the help of measurement module. The metrics played an important role in planning, control, and management of the projects.

“We try to measure what we need and we try to get the maximum benefit from what we measure by analyzing the metrics. Such an infrastructure will help us for quantitative analysis requirements” (Project consultant, Case A.)

### **5.1.6 *Management Commitment***

All of the interviewees mentioned the full commitment of management ever since 2003. SPI was regarded as a project and SPI studies were included in the budget every year. The management did not ever withhold the resources dedicated to SPI activities. These were the signs of the fact that there was full management commitment.

“Management never question SPI budget. Sometimes, we ask ourselves if the expenses are really necessary” (Project director, Case A.)

## **5.2 CASE B**

CASE B has achieved CMMI- Level 3 certification in December 2007, which was twenty seven months after they initiated the CMMI activities. Three members of CASE B were interviewed: general manager, project director, and project consultant.

CASE B worked with multi-processing projects which were either for in-house use or for their customers. They faced some problems in the management of those projects and realized the importance of portfolio management. The CMMI program was initiated with the aim of providing solutions to their problems. The staff adopted CMMI activities quickly because they were unhappy about the chaotic environment and with the help of CMMI, improvements were achieved. Even though CMMI mainly focused on software development, CASE B has adapted the process to other practice areas.

What is observed about CASE B was that there was a harmony between the general manager and the SPI team. The general manager declared that they could not have achieved CMMI-Level 3 if SPI team had not supported the activities:

SPI team owned the program and that attitude resulted in success. On the other hand, the SPI team mentioned that without management commitment, motivation and support, they could not be where they are.

A detailed discussion of the factors is given in the following paragraphs.

### ***5.2.1 Experienced Staff***

#### ***5.2.1.1 Separation of Process and Products***

The SPI team was composed of one core group and different sub-groups. The competency of the employees was the critical point in the selection of group members. The manager said that he chose the ones that would contribute the most to SPI activities. The schedules were arranged such that some of the product development workload of the SPI team members were re-allocated to SPI activities. The general manager declared that:

“I have chosen the right ones. Their project managers were not willing to allocate the ones I have chosen because they were good at their jobs. However, I transfer them to SPI activities.” (General Manager, Case B)

### ***5.2.2 Staff Involvement***

#### ***5.2.2.1 Resistance to Change***

The upper management mentioned that the staff especially the ones working for 7-8 years, supported the program and did not show resistance to change but also added that it was difficult to change the ones that have been working for 15 or 20 years.

On the other hand, there were some activities which had started as a requirement of CMMI, and after some time, these activities had become a part of work flow, for example peer review. The project director declared that the staff would not

give up peer review, even if the management announces that they would not require peer reviews anymore.

It was stated that they expected to experience some problems during documentation. In order to facilitate documentation, they looked for a solution such that while modeling the processes, the documentation will be completed, as well. While designing the systems, if they utilized tools like UML this would also help documentation.

### **5.2.3 *Metrics and Measurement***

The general manager stated that they have allocated quite a lot of resources to both training and metrics definition. However, it was critical to use the metrics in real life. The main target was to produce high quality products; therefore the metrics had to be defined and analyzed regarding the main target.

## **5.3 CASE C**

CASE C was established in 1991 and has been working in defense sector. They focus on business areas of product development projects, consultancy services, procurement services. The organization had on-going process improvement studies when the CMMI program was started in October 2004, and the certification was achieved at the end of 2006.

The quality manager of Case C stated that accelerated CMMI achievement can happen with sufficient resources, effective planning and effective experience. In the following paragraphs, a detailed discussion on success factors is given.

### **5.3.1 *Quality Environment***

CASE C Quality Management System has certifications of CMMI-Level-3, ISO 9001:2000, ISO 27001, NATO AQAP-160. Prior to CMMI-Level 3 achievement, the organization had achieved ISO 9001:2000 certification which was considered to be helpful during CMMI journey.

### **5.3.2 *Experienced staff***

Most of the staff had previous process development and quality standard experience.

#### **5.3.2.1 *Separation of Process and Products***

Even though the SPI program started in 2004, the full time SPI team named SEPG was formed 6 months before CMMI- Level 3 appraisal. Before that, a full-time employee was responsible from CMMI activities and other employees were assigned CMMI activities for short terms when necessary. The SEPG consisted of a full time process manager, and two part-time representatives from the disciplines of software engineering, system engineering, project management, quality assurance, configuration management, acquisition, contract management, marketing & planning, human resources. Even though the formal SEPG was formed 6 months before the certification, the quality manager stated that he got the support he wanted during CMMI program.

### **5.3.3 *Staff Involvement***

There existed an improvement proposal database where employees added their improvement proposal, read other proposals, monitored what was going on about any proposal. Each proposal was discussed in the Process Group review meetings.

#### ***5.3.3.1 Rewarding***

After the appraisal, all process group members were graded with a performance grade of A: Rewarding was said to have increased staff commitment.

#### ***5.3.3.2 Awareness***

The staff was happy about the CMMI activities. 240 improvement proposals in 8 months was a sign of how staff accepted CMMI. If the lessons learned are applied to future projects and staff observes the benefits of them it can be said that CMMI is successful.

#### ***5.3.4 Metrics and Measurement***

To satisfy the requirements of ISO 9001:2000, the company collected metrics before CMMI-Level 3 certifications, but nothing extra was done about metrics analysis. However, CMMI requires the analysis of the metrics. Therefore, it was stated that after CMMI, metrics collection became more meaningful. The staff realized the benefits of metrics and that increased motivation.

#### ***5.3.5 Management Commitment***

Another success factor mentioned during interviews was the level of resource allocation. It was stated that the duration of the SPI program depends on the resources – both budget and human- the management provided. In addition to that, management had to provide effective project planning and define the business goals.

Another interesting point was that the quality manager of Case C stated that if the management had wanted an accelerated CMMI certification, they would have provided additional resources:

“Those all depend on resources.” (Quality manager, Case C.)

## **5.4 CASE D**

CASE D is a research institute whose main research area is information technologies. The CMMI program was initiated in May 2006 and the organization achieved CMMI-Level 3 in December 2008.

### **5.4.1 *Quality Environment***

Case D has started quality studies around 1999s. The organization got ISO 9001:2000 in 2002; AQAP 160 in 2003; and ISO 14001 in 2005. These studies formed the background of the quality culture of the organization. The work that was completed before 2006 can be regarded as internal study.

### **5.4.2 Experienced staff**

The SEPG manager had participated in Class-A and Class-B appraisals of other organizations as an SEI team member. Moreover, the staff was knowledgeable about product development and quality standards.

#### **5.4.2.1 *Separation of Process and Products***

For every process to be improved, a process group was formed. The institute manager actively participated in the selection of the members. Assignment of the personnel was made based on the current process he/she worked on and

background. Number of staff involved in process groups was forty. SPI activities were not the full-time responsibility of these people, but they tried to contribute to SPI activities as much as possible.

After the Class B appraisal in November 2007, process management team who would be responsible from the organization of process activities was formed. The team prepared an improvement plan based on the results of Class B appraisal. At the beginning of 2008, the improvement plan was initiated. Process management team was composed of 12 members. However, the problem of separation of processes and products was also encountered in this organization. Since the main responsibility of each member was product development, s/he could not fully concentrate on SPI activities. When it was observed that work by a team of 12 slowed down the improvement, sub-groups were formed.

### **5.4.3 *Staff Involvement***

The organization had a process assets library portal. User friendliness of the portal was again an important parameter. An employee could download anything he needs about the processes like forms, standards, templates, etc. Employees also shared the lessons learned and risks observed via that portal. Moreover, data about time tables and days off were also available in that portal. Configuration management related problems were decreased by the utilization of such a portal. In addition to these, there was an improvement proposal database where all employees had access.

The main problems arose during documentation, therefore the organization tried to minimize the documentation effort and used tools for that purpose.

#### ***5.4.3.1 Rewarding***

Due to the structure of the organization, it could not be possible to allocate resources for rewards like holidays, picnics, or celebration dinner. On the other hand, being an SEPG member was said to be an advantage in performance grading.

#### ***5.4.4 Training***

In order to increase the awareness of the staff, CMMI was explained to the staff in 2006. Some internal training sessions about the processes were also held. A Class B appraisal was planned at the end of 2007 and it was decided to take “Introduction to CMMI” training. The institute manager and institute vice manager, all project managers and work packages leaders, a total of 60 people, were trained. This training was accepted as a milestone for the organization.

#### ***5.4.5 Metrics and Measurement***

During the Class B appraisal, metrics related processes were missing. During the interview, it was stated that they expected to have completed the metrics analysis plan by October, 2008. The organization collected metrics manually. They planned to automate metrics process because it was difficult to perform such a task manually.

#### ***5.4.6 Management Commitment***

The manager not only supported, but also participated in the SPI program as mentioned above in the 5.4.4 *Training* subsection.

It has been stated that there had been no problems during the allocation of financial resources. Moreover, the management announced some mandatory

actions to increase the adoption of the CMMI so that it was mandatory to use the automated tools in the projects undertaken in 2008.

## **5.5 CASE E**

Case E was certified as CMMI-Level 3 in software engineering in December 2006, 24 months after they initiated their CMMI program (November 2004-December 2006).

### **5.5.1 *Quality Environment***

Case E had employed ISO 12207 in some of their projects. Even though there had been no certification, the process documentation of ITIL and AQAP 110 had been completed.

Case E had defined the processes prior to CMMI studies. However, after the pre-evaluation performed by the consultant firm, it was observed that they had to perform so many revisions to the process definitions that they decided it would be better if they started from the scratch.

#### **5.5.1.1 *Class- B Appraisal***

The organization had taken Class- B appraisal six months before the CMMI final appraisal. It was said that such a pre-assessment was extremely beneficial for their CMMI studies.

## **5.5.2 Experienced staff**

### ***5.5.2.1 Separation of Process and Products***

The SPI team was composed of ten people one of whom had previous CMM experience and was knowledgeable about the organization. However, other team members were experienced on software processes. Some of the team members were knowledgeable about ISO 12207 somewhat similar to CMMI. Before the CMMI initiative, two members of the team were trained about CMMI. As the CMMI program was initiated, the rest of the team attended the CMMI trainings.

The SPI team members were selected by the software director from the team leaders of the software process areas like software project management, design, development, test, and quality. That brought the advantage that each team member could define the processes of his/her area. Knowing English was stated as another advantage.

Management provided full support for CMMI activities. They allocated more people to product development so that SPI team could focus on SPI activities. Despite the allocation of new people, both SPI and product development teams worked overtime. Moreover, in critical situations, SPI team members also participated in product development. However, none of them complained about the overtime. The SPI team was enthusiastic about the CMMI studies.

“We worked so hard, but the result was worth it.” (Quality manager, Case E)

### ***5.5.2.2 Reviews***

Weekly review meetings were arranged during the CMMI program. In some cases, review meetings were planned every other day. During these meetings, SPI

progress reports were presented. Moreover, employees other than team members were also informed about the progress by posters, newsletters, etc.

#### **5.5.2.3 Consultant**

During the selection of the consultant, working with a company who had previous CMMI experience was preferred as the organization had no CMMI experience.

#### **5.5.3 Staff Involvement**

Staff was enthusiastic about SPI activities. They were informed about CMMI prior to the program so there was no resistance to change during the program. Workload of the employees was arranged such that adequate amount of time was allocated to CMMI activities. Moreover, management wanted the staff to actively participate in improvement activities.

##### **5.5.3.1 Rewarding**

During the CMMI program, in order to motivate the staff, management arranged informal lunches and dinners. After CMMI certification, employees were rewarded with a three-day vacation.

##### **5.5.3.2 Awareness**

Two of the SPI team members who had been trained on CMMI prior to the initiative trained the others about related concepts. In addition to this internal training, these two members arranged meetings in twenty project offices to explain CMMI. These trainings and meetings was said to have had an important role in the establishment of awareness prior to the CMMI program.

In order to increase awareness, the SPI team arranged trainings where every process owner made a presentation about the progress in his/her own process area. Moreover, they recorded what was going on during the studies by video camera. They prepared posters and social activities to motivate the employees.

In some cases, they made the necessary modifications to ensure that the improvement progressed in a compatible way with the corporate culture.

#### **5.5.4 Training**

During the SPI program, training sessions with appropriate evaluation of outcomes were organized. However, after CMMI certification, the frequency of training sessions was reduced because of the high turnover rate in the organization.

#### **5.5.5 Metrics and Measurement**

Prior to the CMMI program, metrics were not collected specifically; the company had specified some metrics which were later determined to be insufficient. With the CMMI program, they introduced automatic tools which enabled them to manage and monitor the processes by collecting and analyzing metrics. The metrics to be collected were selected based on the results of an analysis: the organization decided to collect the metrics that would be useful to them.

#### **5.5.6 Management Commitment**

There was full support of management and this motivated the SPI team. Management did not unduly question the budget and time schedule of CMMI studies. They provided the necessary trainings. During the interview, the quality

manager mentioned strong management commitment. Management not only supported and motivated the CMMI activities but also appreciated what was done.

## **5.6 CASE F**

Case F is a global firm that provides solutions and services for information and communication technologies. The organization was certified as CMMI-Level 3 12 months after they initiated the CMMI program.

### **5.6.1 *Quality Environment***

Case F had previously utilized ISO 9001:2000, AQAP 160 and internal standards. Being a part of a global company enabled them to benefit from the previous experiences of the firm.

Prior to the CMMI initiative, around 40-50% of the process definitions were already compatible with CMMI. Within the process areas, Organizational Training was fully satisfied and nine other process areas, namely Configuration Management, Product Integration, Technical Solution, Verification, Validation, Project Monitoring and Control, Project Planning, Requirements Development, Risk Management were partially satisfied.

#### **5.6.1.1 *Frequency of Assessments***

Prior to SCAMPI A assessment, Case F performed Class B and Readiness Review. In addition to these formal assessments, internal reviews were performed every two weeks.

### ***5.6.2 Experienced Staff***

SPI team members did not have previous SPI experience but they were enthusiastic about SPI. However, they had been working in the company for 2-3 years and they had, on the average, about five years of experience on software project development. Within the team members, the group manager had 10-year experience on software development which helped the team members a lot during the CMMI program.

#### ***5.6.2.1 Separation of Process and Products***

SPI team members were responsible from defining the rules, processes, standards, template, etc. It was composed of a group manager, a configuration manager, a quality manager, a project manager and software developers. Since they were experienced about the related process areas, group diversity had positive effects on CMMI studies.

While selecting the team members, it was important that they were experienced, open minded and adopted the idea of continuous SPI.

While preparing the work plan, resource allocation was done based on the experience of the employee. Each team member was responsible from the process area in which s/he was experienced. Resource allocation to process and product activities was done with alternating priorities such that when it was more critical to deliver the product, the SPI team were assigned to product development, in other times they focused on process improvement.

#### **5.6.2.2 *Reviews***

Regular review meetings every two weeks and internal assessments were performed. In addition, progress reports were prepared. Moreover, staff was informed about the progress of the CMMI work by team leader, group manager, and department manager.

#### **5.6.2.3 *Consultant***

The consultant company was selected based on the previous references.

### **5.6.3 *Staff Involvement***

Prior to SPI, staff was positive to SPI activities.

#### **5.6.3.1 *Awareness***

Prior to the SPI program, management was aware of the benefits, outcomes and required budget; staff was partially knowledgeable about the benefits of SPI.

During the interview it was mentioned that, staff were aware of their responsibilities and workload. It was also added that the SPI team worked overtime when necessary without questioning.

During the program, the parallelism between the improvements and corporate culture was taken into account. Improvements which were not parallel with the corporate culture were withdrawn.

#### **5.6.3.2 *Communication***

A full time employee was assigned the responsibility for the communication between the SPI team and the assessor.

### ***5.6.3.3 Rewarding***

Rewarding during the CMMI program was done based on the performance of the employees.

### ***5.6.4 Training***

Besides mandatory CMMI trainings, a systematic training schedule was not available. However, after CMMI certification, a regular training program was planned.

### ***5.6.5 Metrics and Measurement***

Prior to the CMMI program, Case F did not utilize metrics collection and analysis. Even though some of the project groups had collected some internal data, they did not use that data in project or SPI planning. Therefore, it can be said that there was no practice of measurement and analysis.

Even though they did not have a previous metrics practice, during the metrics selection, they had the advantage of being a global company. They used the metric documentation template which was prepared by the main office. The availability of such documentation enabled them to overcome the difficulties of metric selection and analysis.

### ***5.6.6 Management Commitment***

Management provided full support and commitment for CMMI activities. When necessary, they approved the budget revisions related to training program and resource allocation. They also attended the meetings, which was a sign of their participation in CMMI studies.

## **5.7 CASE G**

Case G is a financial institution that started their SPI program in November 2006 and completed it in November 2007. The main difference between Case G and the other cases is that the aim of the program was not certification but improving the processes. Therefore, they completed the SPI program requirements on November 2007 but they did not apply for formal CMMI-L3 appraisal. It was stated that if they had aimed certification, they would have managed to be certified as CMMI-L3 in approximately one and a half year.

Interviewees mentioned that they could not have achieved the requirements of the program without the commitment and involvement of the vice general manager.

### **5.7.1 *Quality Environment***

Prior to the SPI program, they had ISO 9000-2001 certification so the organization had defined the analysis, plan, design, implementation and testing processes.

#### **5.7.1.1 *Gap Analysis***

At the beginning of the program, the consultant performed a gap analysis and the results of the gap analysis showed that the organization was somewhere near CMMI-Level 2. They prepare a detailed implementation plan as if they would be certified as CMMI-Level 3 and whatever happened, they did not deviate from the plan. Within one year, they identified the tool requirements, issued the purchase order, and started the implementation.

### ***5.7.2 Experienced Staff***

Team members of the SEPG were experienced on SPI, even if not specifically on CMMI. Furthermore, these people knew the organizational background and structure.

#### ***5.7.2.1 Separation of Process and Products***

During the CMMI studies, SEPG was composed of employees from different department who were willing to participate in a SPI program. In order to be a team member, being experienced on the related process areas was a prerequisite. When necessary, team members participated in the decision making process. The SEPG was composed of around 30 people who were team leaders and developers. Even though the SPI project had been completed, a core group which was composed of team leaders, had been formed from that SEPG and they were responsible from continuous process improvement.

#### ***5.7.2.2 Consultant***

They worked with a consultant throughout the CMMI studies. While selecting the consultant, Case G considered the references of the company, their knowledge and experience about the whole process, their international relationships, the number of consultants in the company, and the cost.

#### ***5.7.2.3 Reviews***

Bi-weekly review meetings with management presentations were held. Every month, a review meeting with the vice general managers was arranged. During the interview, it was mentioned that vice general managers not only attended but also played a critical role in these review meetings. He provided effective solutions when SEPG team had problems.

### **5.7.3 Staff Involvement**

Employees' attitude towards SPI activities was positive and they actively participated in the activities of SPI. However, there was not a separation of process and product.

Coordination between the consultants and SEPG group was required. However, it was mentioned that the allocation of a full-time personnel who is responsible from the coordination was not necessary.

#### **5.7.3.1 Awareness**

Since the organization had ISO 9001:2000 certification, the personnel were already aware of the benefits of the SPI program. They knew their responsibilities and work load. In addition to this, with the internal and external audits, the awareness of the organization had been increased. Moreover, there was a web portal where the employees could follow the progress of the program and submit their comments.

While implementing the improvements, the SEPG also considered the organizational culture. It was stated that since they were a large organization, parallelism between the improvement and culture was critical. Another important point was that they provided in-house software development; therefore they had to consider organizational culture. The quality manager stated that they asked themselves the question "evolution or revolution?"; since the parallelism was important, they chose evolution.

#### **5.7.3.2 Rewarding**

The rewarding mechanism was based on performance grading. During the interview, it was stated that rewarding, even though not in material terms, also had

a positive impact on motivation of employees` such that they were in contact with management more easily and frequently than the ones who were not allocated to the SPI program. It was also added that such recognition by the management level might have been more important than material rewarding.

#### **5.7.4 Training**

Training on CMMI awareness, quality assurance, function point analysis, and test engineering were given to the team members either by the consultant company or in terms of in-house training. Since they continued process improvement, the company did not terminate the training program after completing the SPI schedule proper.

#### **5.7.5 Metrics and Measurement**

Prior to the SPI program, the organization had been collecting metrics but they were analyzed in an ad-hoc way. At the beginning of the SPI program, a report was prepared based on these metrics and the SPI program was planned according to this report.

#### **5.7.6 Management Commitment**

The CMMI initiative was initiated by the vice general manager. At the beginning of the SPI program, a meeting was arranged where processes were explained. The vice general manager made an opening speech in that meeting. It is said that, after that meeting, each employee realized that full support was provided for the program.

During the interview, it was clearly observed that management provided a strong leadership and support throughout the SPI program. The SEPG did not face any resource allocation problems. In addition to management commitment,

management involvement was also observed, as the vice general manager actively participated in monthly review meetings as mentioned earlier.

## **CHAPTER 6**

### **FINDINGS**

This chapter presents the key findings obtained from the investigated cases, under three categories, according to their CMMI program durations. The first group (Group I) has an average duration of 12 months and consists of Cases F and G; the second group (Group II) has an average duration of 25 months and consists of Cases A, B, C, and E; finally the third group (Group III) consists only of Case D which has 30 months CMMI duration. Comparisons were done both between the groups and within the groups. Hypotheses derived based on these comparisons are presented in Section 6.1. The hypotheses derived from literature (the ones with names starting with H\_L #), hypotheses re-formulated after case studies (those with names starting with H\_C #), and interviewees' comments are discussed in Section 6.2.

#### **6.1 Hypotheses re-formulated after the case studies**

After the analysis of the cases, hypotheses are re-formulated. Even though the term “re-formulated” is used in the title, it is necessary to mention that most of these hypotheses except H\_C # 2 and # 3 are different from the hypotheses derived after literature review. In the following sections, these hypotheses are discussed.

### 6.1.1 Hypotheses based on comparison between groups

Table 12 presents the results of the case studies in terms of the scores which are recalculated based on their groups. While constructing Table 12, data of Table 5, are re-scored by calculating the mode of each factor. For example, for *Quality Environment*, there are three high scores and one medium score in Group II. Then the mode of the factor which is high is the score of the factor for Group II. If the modes of two score are equal to each other, e.g. for *Management Involvement*, there are two high and two medium scores, then an intermediate score like medium-high is defined and the score of the corresponding factor for Group II is given as medium-high. Since there is only one case in Group III, scores of the Group III equal the scores of Case D.

The analysis of the table is done as follows:

1. If the scores of the factors are indirectly proportional to the CMMI duration, in other words when the CMMI duration is short and the score of the factors are high and when the CMMI duration is longer and the score of the factor is low, then it is concluded that the related factors have an accelerating effect on CMMI duration. These factors, which are written in bold in Table 12, are *Reviews*<sup>5</sup>, *Awareness*, *Management Commitment II*, and *Management Involvement*.
2. If the scores of the factor for each group are equal to each other, then it is concluded that existence of that factor is a prerequisite for successful CMMI program. These factors are *Quality Environment*, *Parallelism between Standards*, *Gap Analysis*, *Class-B Appraisal*, *Experienced Staff*, *Consultant*, *Training*, and *Metrics and Measurement*.

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<sup>5</sup> Definition of the factors is given in Table 10 .

**Table 12 Average scores of the groups for each factor**

<b>Factors</b>	<b>Factor Group</b>	<b>Group I</b>	<b>Group II</b>	<b>Group III</b>
<i>Quality Environment</i>	ISF	High	High	High
<i>Parallelism btw Standards</i>	ISF	Medium	Medium	Medium
<i>Frequency of Assessments</i>	PF	Medium-high	High	High
<i>Gap Analysis</i>	PF	Medium-high	High	High
<i>Class-B Appraisal</i>	PF	High	High	High
<i>Experienced Staff</i>	ISF	High	High	High
<i>CMM/CMMI Experience</i>	ISF	None or low	Medium-high	Medium
<i>Separation of Process and Products</i>	PF	Medium	Medium-high	Medium
<i>Consultant</i>	PF	High	High	High
<i>Reviews</i>	<b>PF</b>	<b>High</b>	<b>Medium-high</b>	<b>Medium</b>
<i>Staff Involvement</i>	PF	High	High	Medium
<i>Awareness</i>	<b>ISF</b>	<b>High</b>	<b>Medium-high</b>	<b>Medium</b>
<i>Resistance to Change</i>	PF	Medium-high	High	Medium
<i>Rewarding</i>	PF	Medium	High	Medium
<i>Training</i>	PF	High	High	High
<i>Annual Training</i>	PF	High	Medium	Medium
<i>Training Plan</i>	PF	Medium-high	Medium	Medium
<i>Metrics and Measurement</i>	ISF	Medium	Medium	Medium
<i>Metrics Analysis</i>	ISF	Medium-high	Medium-high	Medium
<i>Automated Metrics Tool</i>	PF	Medium	High	None or low
<i>Management Commitment I</i>	ISF	High	High	Medium
<i>Management Commitment II</i>	<b>PF</b>	<b>High</b>	<b>Medium-high</b>	<b>Medium</b>
<i>Management Involvement</i>	<b>PF</b>	<b>High</b>	<b>Medium-high</b>	<b>Medium</b>
<i>Process Documentation</i>	ISF	High	High	Medium
Average Time to Move up		12 months	25 months	30months

3. If a direct relationship cannot be observed, then that means that the existence of the factor does not have an effect on CMMI duration. For example, the cases where the group having CMMI duration longer has

score of high for some of the factors but medium/none-or low for others. These factors are *CMM/CMMI Experience, Separation of Process and Products, Resistance to Change, Rewarding, and Automated Metrics Tool.*

### **6.1.2 Hypotheses related to comparison of the cases**

In this sub-section, hypotheses derived based on the comparison of the cases are presented. First of all, starting from Group I, the cases in each group are compared and contrasted. After that, cases, independent of their groups are analyzed.

#### **Comparison of Case F and Case G**

In terms of the existence of a metrics analysis program prior to the CMMI project, Case G seems to have some advantages. However, Case F seemed to overcome the effects of not having an established metrics analysis program by effective work throughout the CMMI project.

**H\_C\_#1:** *Metrics and Measurement* activities undertaken during the CMMI program have a greater effect than the ones performed prior to CMMI program.

#### **Comparison of Case E and Case F**

Case E and Case F completed the CMMI program in 24 and 12 months, respectively. When scores are compared, it is observed that whereas Case E has high scores for *Resistance to Change*, and *Rewarding*, Case F has medium scores for these factors. On the other hand, Case F has higher scores for *Frequency of Assessments*, and *Annual Training*.

**H\_C#2:** Other factors being equal, the effects of *Frequency of Assessments* and *Annual Training* are higher than that of *Resistance to Change, Rewarding, and Metrics and Measurement.*

Another point to be discussed is the starting point of the program. During the interviews, quality manager of Case E stated that even though they had process definitions compatible with ISO 9001:2000, rather than reusing these processes, they started from scratch and defined the processes according to CMMI requirements. However, Case F had a pre-defined set of processes but this set was not in detail. Moreover, Case A and Case C had previously adopted *Process Documentation*, whereas Case B and Case D were known to have experienced problems during process documentation. When their certification times are compared, it is observed that it took much longer for Cases B and D to receive CMMI-Level 3 certification. Finally, when scores of Cases A and D are compared, it is observed that Case A has higher scores on *Staff Involvement, Metrics and Measurement, and Process Documentation*. In addition to this, Case C has higher scores on *Process Documentation* than Case D.

**H\_C#3:** Having *Process Documentation, Staff Involvement, and applying Metrics and Measurement* activities accelerate the CMMI-L3 process.

### **Comparison of Case A and Case B**

Duration of CMMI-Level 3 studies for Cases A and B are 24 and 27 months, respectively. When scores of Cases A and B are compared, it is observed that, for most of the factors (16 of 24), the scores of Case A are higher than Case B's. When CMM experience of Case A is considered, a larger difference between the durations of the two CMMI studies would be expected. However, Case A completed CMMI studies in only three months earlier than Case B. Therefore, the comparison of these two cases requires further investigation.

One of the reasons for such a result may be due to the relative effects of some of the factors discussed. For *Management Commitment II* and *Management Involvement*, Case B has higher scores than Case A. These two factors may have a relatively higher impact on CMMI duration and having higher scores on these

may close the gaps that may arise because of the rest of the factors. In the following paragraphs, these two factors will be considered.

Even though both of the cases have mentioned strong commitment of management prior to CMMI program, in Case B, the manager not only supports but also is personally involved in the CMMI studies. During the interviews, the general manager mentioned how he supported the CMMI activities and how he was involved in the CMMI studies. Also, the project director has stated that they could not have achieved such a success without the general manager's support. During the interviews with Case A, the interviewees also mentioned management commitment and the fact that managers did not question the work items in software process improvement activities. However, when the two cases are compared what is observed is that, the management commitment throughout the CMMI program in Case B is stronger than that in Case A.

**H\_C #4:** The effect of *Management Commitment II* and *Management Involvement*, are greater than the rest of the factors.

#### **Comparison of Case A and Case C**

Cases A and C achieved CMMI certification within almost the same duration. However, their scores are not equal for all factors. For *Quality Environment, Metrics and Measurement*, and *Process Documentation*, both cases have high scores. For *Staff Involvement, Training* and *Management Commitment I*, Case A has higher scores than Case C.

**H\_C #5:** The effect of *Quality Environment, Metrics and Measurement*, and *Process Documentation* are more significant than *Staff Involvement, Training* and *Management Commitment I*.

#### **Comparison of Case B and Case D**

Case D has higher scores on *Quality Environment* and *Experienced Staff*. On the other hand, Cases B and D have the same scores on *Training, Metrics and*

*Measurement*, and *Process Documentation* whereas Case B has higher scores on *Management Commitment I*, *Management Commitment II*, *Management Involvement* and *Staff Involvement*. However, Case D completed CMMI-Level 3 certification in 30 months. Comparison of Cases B and D support the H\_C #4. When the CMMI program durations of the two cases are compared, we arrive at the following hypothesis:

**H\_C #6:** Other factors being equal, if two organizations have provided the same level of *Training* and *Metrics and Measurement*, the one with higher *Management Commitment I*, *Management Commitment II*, *Management Involvement* and *Staff Involvement* will finish the CMMI-Level 3 studies earlier.

#### **Comparison of Case C and Case D**

The scores of Cases C and D differ in two factors. Case C has higher score on *Process Documentation*, whereas Case D has higher score on *Training*.

**H\_C #7:** Other factors being equal, the effect of *Process Documentation* is higher than the effect of *Training*.

#### **Comparison of Case D and Case F**

When Cases D and F are compared, it is observed that Case F has high scores for factors *Management Commitment I*, *Management Commitment II*, *Management Involvement* and *Process Documentation*, whereas scores of Case D for these factors are medium.

Moreover, comparison of Cases A and F reveal that Case A has high scores for all factors and sub-factors except *Management Commitment II* and *Management Involvement*. On the other hand, Case F was scored as high for these factors.

**H\_C #8:** *Management Commitment I*, *Management Commitment II*, *Management Involvement* and *Process Documentation* have a significant effect on reducing CMMI duration.

## 6.2 Comparison of the hypotheses based on the literature and findings from case studies

To begin with, it is necessary to note that cases were selected exclusively from CMMI-Level 3 organizations, whereas hypotheses derived from the literature were based on the review of cases from different CMM levels, including CMM-Level 1, CMM- Level 2, and CMM-Level 3. It is obvious that not only the level of the organizations but also the model on which they are assessed are different. Therefore, throughout the discussion in this section, our focus has been on the factors that may accelerate SPI in general, rather than the specific process areas of CMM or CMMI.

It was possible to compare H\_L #1 with H\_C #3 and H\_L#2 with H\_C#2 since they were about the same factors. For the rest of the hypotheses derived from literature, with the analysis of the cases, it is aimed to find out points that support the literature hypotheses. Findings are discussed in the following paragraphs.

When H\_L #1 and H\_C # 3 are compared, it is observed that both emphasize the effect of *Experienced Staff*, *Process Documentation*, and *Metrics and Measurement*. Therefore, it can be concluded that H\_C # 3 supports the H\_L #1.

H\_L #2 say frequent assessments slow down the SPI process, on the other hand H\_C # 2 say frequent assessments accelerate the process. The validation of these hypotheses is done by the analysis of the interviewees' comments about factors. Project director from Case A, project consultant from Case B, quality manager from Case C and Case F mentioned the importance of gap analysis, Class B appraisal and readiness review. It was highlighted that such a report accelerates the SPI activities. Moreover, it was mentioned that the frequency of the assessments –both formal and informal- was important. The above discussion results in the following revision in the hypothesis: Formal/ informal assessments

are required for accelerated CMMI provided that their frequency is determined systematically.

Project Director of Case B stated that there are three factors that may lead to success in SPI programs. These three should work together and absence of one of them may lead to failure. These are *Experienced Staff*, *Quality Environment*, and *Staff Involvement*. These comments support H\_L # 3 which is about the relative effect of *Quality Environment*, *Experienced Staff* over *Frequency of Assessments*.

Following H\_L #3, it would be appropriate to discuss H\_L # 6 and H\_L #7 which are about the *Consultants*, *Quality Environment*, and *Experienced Staff*. When the comments of the interviewee` are compared it is observed that, 56 % of them mentioned the role of *Quality Environment* and *Experienced Staff*, whereas 18 % of them mentioned the role of *Consultant*. These are supportive comments from the interviews for H\_L # 6 and H\_L #7.

To observe the effect of process areas satisfied before SPI initiative, Cases E,F, and G would be compared based on what interviewees` said about where they were at the beginning of the program. Case E declared that even though they had process definitions that were compatible with ISO 9001:2000, they started from the scratch because they believed that revising the process definitions would take more time than writing them. So, Case E rewrote all the software engineering process definitions according to CMMI requirements. On the other hand, process definitions of Case F were 40-50% compatible with CMMI requirements. Finally, even though Case G was not officially certified as CMMI-Level 3, the gap analysis done at the beginning of the program showed that they were somewhere around CMM-Level 2. Case E, F, and G completed the program in 24, 12, and 12 months, respectively. The comparison of these three cases showed that number of process areas satisfied before SPI initiative shortens the SPI duration (H\_L #4).

All the cases have taken consultancy services during the CMMI studies. Therefore, it is not possible to compare the cases based on the existence of consultant. However, during the interviews, it was mentioned that what was expected from the consultant and what consultant provided regarding this expectation is the critical point. The consultant should provide guidelines for CMMI application rather than just providing a check list. The interviewee from Case C declared that, consultants would be beneficial in gap analysis phase because they would be objective. He also added that what was expected from the consultant would be more than gap analysis but guidance about how to be an effective CMMI-Level 3 organization. On the other hand, another interviewee, who is from Case D, said that the consultant provided the motive force that they lacked at the beginning of the CMMI program, especially in planning phase. Therefore, it can be concluded that the effect of consultant on CMMI duration is also depend on how satisfactory the consultant is. The expectations of each side – both consultant and the organization – should match each other. The common point about the consultant in all cases was that the organization wanted the consultant provided them guidance and effective solutions.

Table 13 shows comments of the interviewees about the factors. The following notation is used in the table: a '+' sign indicates that the interviewee thinks that the factor has a positive effect on accelerated CMMI.; a '0' indicates that the interviewee thinks that the effect of that factor depends on the situation. Whereas an 'NA' means that the interviewee thinks that the factor is not applicable for the specific case.

**Table 13 Interviewees' comments on factors**

Factors	Factor Group	Interviews with Case										
		A			B <sup>6</sup>			C	D	E	F	G
		PC	TL	PD	PC	PD	GM					
<i>Quality Environment</i>	ISF	+		+	+	+					+	
<i>Parallelism btw Std.</i>	ISF				+							
<i>Frequency of Assessments</i>	PF	0									+	
<i>Gap Analysis</i>	PF			+	+			+				
<i>Class-B Appraisal</i>	PF			+	+			+				
<i>Experienced Staff</i>	ISF				+	+	+	+		+	+	
<i>CMM/CMMI Experience</i>	ISF								+			
<i>Separation of Process and Products</i>	PF				+							
<i>Consultant Reviews</i>	PF PF			+				0	+			
<i>Staff Involvement</i>	PF	+				+				+	+	+
<i>Resistance to Change</i>	PF			NA								
<i>Metrics and Measurement</i>	ISF											
<i>Metrics Analysis</i>	ISF							+				
<i>Automated Metrics Tool</i>	PF							+	+			
<i>Management Commitment I</i>	ISF	+			+	+		+	+	+	+	+
<i>Management Commitment II</i>	PF				+	+		+	+	+		+
<i>Management Involvement</i>	PF				+				+	+		+
<i>Process Documentation</i>	ISF										+	

<sup>6</sup> GM stands for General Manager, PC for Project Consultant, PD for Project Director, TL for Team Leader

## CHAPTER 7

### DISCUSSION

In this chapter, after a brief summary of the work done, findings of the case studies performed will be compared and contrasted with the hypotheses formulated based on the cases published in the literature, also considering opinions of various interviewees on SPI acceleration. Conclusions will be drawn from the study carried out. The chapter concludes with limitations of the study and recommendations for future work.

#### 7.1 Summary of the study

In this study, first of all, factors of SPI success were identified from the literature. After that, hypotheses based on CMM experience reports were derived. Those hypotheses provided a starting point for the second phase of the research. In order to identify the factors that affect CMMI program duration, interviews with CMMI-Level 3 companies were held. Based on the analysis of the interviews, final hypotheses were formulated which can be summarized as stating that *Management Commitment* throughout the CMMI work, *Management Involvement*, and *Process Documentation* have significant effects on CMMI certification duration. The results of this study may provide guidelines to organizations that wish to accelerate their CMMI work.

## 7.2 Factors that accelerate CMMI duration

Three of the factors identified, *Management Commitment II*, *Management Involvement* and *Process Documentation* were the most cited ones in the hypotheses. Therefore, these three factors are discussed in detail below.

The role of management commitment was mentioned by all the interviewees and a majority of the participants (57%) described how actively their management were involved in CMMI activities. When the hypotheses are reviewed, it can be observed that the role of management commitment is mentioned in H\_C # 4, 6, 8; and management involvement in H\_C # 4, 8. It is obvious that the role of management is critical for CMMI activities (Wilson et al. 2001; Berander & Wohlin, 2003; Guerrero & Eterovic, 2004; Dyba, 2005; Niazi et al. 2005a; Niazi et al. 2005b; Cares et al. 2006; Peterson et al. 2007. )

Moreover, the level of management committed to the CMMI activities is another important issue. In all of the cases, the CMMI initiative was started by management. That means, management was aware of the benefits, outcomes and requirements of CMMI. Both Project Consultant and Project Director of Case B talked about how management commitment was important in Turkish companies and added that management should support CMMI activities not only during the CMMI program but also after certification.

The SEPG manager of Case D said that both upper management and especially the team leader of the SEPG should be dedicated, motivated, and committed to CMMI activities. The manager of Case D not only supported, but also participated in the SPI program. That interviewee also gave an example of how management involvement influenced CMMI studies: if the institute manager and vice manager had not attended the training sessions, then it would have been more difficult for middle managers to understand the need for the SPI program and to find solutions to problems regarding SPI.

In addition to *Management Commitment II*, *Management Involvement* plays an important role in Turkish companies. Interviewees from Cases B, E, F, and G clearly emphasized that they could not have completed the CMMI program without the support from their management. Their managers actively participated in CMMI activities and provided effective solutions when the SPI teams were stuck.

In addition to *Management Commitment II* and *Management Involvement*, *Process Documentation* is the third factor that was cited most frequently in the hypotheses. Wilson et al. (2001), Berander & Wohlin (2003), Cares et al. (2006) also mention the role of process documentation and rate this factor as the most important one among other factors. The interviewee from Case F which completed CMMI-Level 3 certification in 12 months, declared that only few organizations had set of process definitions prior to CMMI studies and that documentation helped them a lot during CMMI program.

### **7.3 Factors that are prerequisite for CMMI program**

Among the factors that are listed as prerequisites for a successful CMMI program in Section 6.1.1, there are supportive comments from the interviewees for *Quality Environment*, *Experienced Staff* and *Metrics and Measurement*.

The first factor to be discussed is *Quality Environment*. Project consultant of Case B stated that the SPI model, the corporate culture and working style should be compatible with each other. Selecting a model that is not suitable for the company may result in failure.

Project Director of Case A pointed out the factors for a successful and accelerated SPI as having a quality background, existence of a trend toward CMM and declaration of the major national procurement agency, Undersecretariat for

Defense Industry, that CMM conformance would be required from all bidders in their procurements.

The second factor that is a prerequisite for CMMI program is *Experienced Staff*. The SEPG manager of Case D and quality managers of Cases C and F stated that SPI experience of people in SPI team was important, because when there was a problem, the team knows how to overcome the situation. So, the solution would be provided immediately without interrupting the activities.

The role of SPI team was also discussed. Interviewees from both Cases E and F highlighted how hard the SPI team worked throughout the program but the staff never complained about it. The skills required to be an SPI team member were listed as being ambitious to participate and work; being knowledgeable about CMMI, the processes, and corporate culture; and not being very busy. Here, another factor comes into the scene: the selection of SPI team members. During the interviews, two of the participants, the general manager of Case B and quality manager of Case F, emphasized the role of the managers who were responsible for the SPI activities and added that allocating the right staff for CMMI activities had an important effect in their success.

The third factor to be discussed is *Metrics and Measurement*. All of the cases had ISO 9001:2000 certification prior to CMMI studies; that is why they were already collecting metrics, even if not compatible with CMMI requirements. However, except Case A which was a CMM-Level 3 organization, the cases did not practice metrics analysis activities prior to CMMI. However, with effective planning and selection of the right metrics, all the cases fulfilled the requirements of CMMI-Level 3.

After grouping the cases, the analysis showed that *Metrics and Measurement* is a prerequisite for CMMI program. On the other hand, H\_C #1 says that “*Metrics*

*and Measurement* activities undertaken during the CMMI program have a greater effect than the ones performed prior to the CMMI program.” These two statements seem to be contradicting each other. However, this is not the case because the *Metrics and Measurement* score for all groups were medium which means “the organization has utilized metrics and measurement as a requirement of CMMI during CMMI activities” (See APPENDIX C for Notation used for the interviews.) Therefore, the results of the grouping also showed that it is more critical to employ effective measurement activities throughout the CMMI program for successful CMMI application.

#### **7.4 Factors that do not have an impact on SPI duration**

The result of the analysis of the case groups in Section 6.1.1 showed that *CMM/CMMI Experience, Separation of Process and Products, Resistance to Change, Rewarding and Automated Metrics Tools* do not have an effect on CMMI duration. Among these factors, *Resistance to Change* is discussed below.

The project director of Case A believes that resistance to change in Turkey is not as high as it is in United States. The organizations in Turkey are younger and the employees do not have an established way of working.

The vice general manager of Case B stated that there were employees who had been working for about 15-20 years. It was difficult to change those people and some resistance to change was observed. However, the key group was the ones who had been working for 7-8 years, they owned the SPI process. It can be concluded that some resistance to change is acceptable, but the point is the employees should understand the benefits of the program and complete the work packages. The only hypothesis derived related to *Resistance to Change* is H\_C # 2, which says that this factor does not have a significant effect on SPI duration.

The comments from the interviewees` also support H\_C # 2 and results of the grouping.

### **7.5 Comparison of ISF and PF**

The factors were classified as initial status factors (ISF) and progress factors (PF) to observe their effect on SPI duration. When the appearances of the factors in the hypotheses are counted, the frequency of *Process Documentation*, *Management Commitment II*, and *Management Involvement* are found to be greater than the rest of the factors. *Management Commitment II* and *Management Involvement* are PF, whereas *Process Documentation* belongs to the group ISF. *Process Documentation* is related to the organizational background, whereas *Management Commitment II* and *Management Involvement* are related to the behavior of the manager. When the effects of ISF and PF on SPI duration are compared, it can be concluded that in case of organizational issues, ISF has a stronger effect on SPI duration than PF. However, in case of managerial issues, PF has a stronger effect on SPI duration than ISF.

### **7.6 Conclusions**

The major conclusions that can be drawn from this study can be listed as follows:

Role of management is critical both before and during the CMMI program. If managers initiate the program and show their commitment at the beginning but then they leave the rest of the responsibility to the SPI team, an accelerated CMMI program could not be achieved. Therefore, management should not only support CMMI program but also participate in CMMI activities and provide solutions when necessary.

Another issue that management should pay attention to is process documentation which is a cutting edge. Having previous process documentation accelerates CMMI studies. On the other hand, when not performed properly, process documentation is accepted as one of the reasons for CMMI failure. Therefore, management should be aware of the fact that process documentation is a critical activity for CMMI certification.

For an organization that is planning to get CMMI certification, there are also investments that must be done prior to the initiative. These are related to the quality culture of the organization and staff allocation. Having established a quality environment or utilized quality standards that are parallel to CMMI are the requirements of a successful SPI program. However, management should be aware of the fact that even if they have allocated the right staff and utilized quality standards prior to CMMI, without the existence of the factors discussed in the above paragraphs, an accelerated success cannot be achieved.

Finally, it is necessary to mention that this study does not establish a firm theoretical foundation for prediction and control of the duration of software process improvement initiatives that is valid under all circumstances. However, this study should be interpreted as compilation and evaluation of accumulated experience with the investigation of seven cases from the literature and seven cases directly investigated by the researcher.

## **7.7 Limitations and future work**

This study has a number of limitations. First of all, the sample consists only of CMMI- Level 3 companies. There are ten CMMI awarded organizations in Turkey and except one of them which is CMMI-Level 5, they are all at the CMMI- Level 3 (Philips, 2008). Hence, factors on the duration of achievement of CMMI certification at other levels definitely requires further study.

Secondly, it was not possible to interview all the people who participated in the CMMI studies in the organizations. In Cases C, D, E, and F – only one interview, which was usually with quality manager of the organization, could be held due to unavailability of the personnel. Therefore, results are discussed from the managers' point of view and they may be subjective.

Thirdly, qualitative analysis has been applied as research strategy. Besides its advantages, qualitative analysis is known to possess various disadvantages (Denscombe, p.313, 2007): 1) data may be less representative due to small sample size, 2) the studies own identity, background, and beliefs may have a role in the creation of data and analysis of data, and 3) there is a possibility of transforming the meaning of the data.

Certain threats to the validity of the research must also be considered at this point. As qualitative research has a subjective nature in data collection and analysis, it is possible that different researchers may investigate the same research question in different ways and may reach different conclusions (Kaplan and Maxwell, 1994). There are strategies that can be used in qualitative study to overcome these validity threats and increase the credibility of the results. Maxwell (2008) lists these strategies as long-term participant observation, collecting rich data, respondent validation, identifying discrepant evidence and negative cases, triangulation, quasi statistics, and comparison. It is also added that it may not be feasible to apply all these strategies; moreover, it is possible that they will not work for every study. Two of the strategies given above were applied in the context of the present study: collecting rich data and comparison. While preparing the interview questions, the aim was to cover as many items as possible so that we can end up with detailed data and picture what is going on in the organization. Moreover, the interviews were audio-recorded whenever permitted. Whenever possible, multiple interviews were arranged to obtain the viewpoints of different staff from the same organization. The second strategy applied to enhance validity

was the comparison of the cases. Maxwell (2008) states that even though explicit comparison is usually used in *quantitative* research, there are also examples of usage in *qualitative* research (Regan-Smith, 1992 as cited in Maxwell, 2008). In the present study, not only the hypotheses retrieved from the literature were compared with the hypotheses revised after the case studies, but also the cases directly investigated by the present researcher were compared among themselves in a pair-wise fashion.

Recommendations for future research in this area are closely connected to the limitations mentioned above. First of all, to analyze how various factors are related to the CMMI Levels, the research scope can be extended to a comparative study that covers organizations at different CMMI Levels. Secondly, since this study covers only CMMI based SPI, another open research area is related to the effects of the factors on SPI programs based on models other than CMMI. Results of those studies can be analyzed to propose generally valid principles for accelerating SPI programs.

Thirdly, to benefit from the viewpoints of the staff other than managers and to diminish the necessity for an interview which may last at least 45 minutes, an online survey can be prepared and administered to CMMI awarded organizations.

Finally to overcome the disadvantages of qualitative analysis method, sample size can be increased and factors affecting the duration of SPI programs can be analyzed by quantitative methods. In spite of the obvious practical difficulty of such an attempt, establishing any generally valid theory in this area would definitely require a broader research scope.

## REFERENCES

Akmenek, F., & Tarhan, A. (2003) The Leap to Level3: Can It Be a Short Journey?, *SEI- ESEPG Conference*, London, England.

Andersen, L., Fisher, M., & Gross, J. (2004). *Case Study: IRS Business System Modernization Process Improvement*. (CMU/SEI-2004-TR-002). Pittsburg, Pennsylvania: Carnegie Mellon University, Software Engineering Institute .

Baddoo, N. & Hall, T. (2003). De-motivators for software process improvement: an analysis of practitioners' views. *Journal of Systems and Software* 66, 23-33

Balla, K., Bemelmans, T., Kusters, R., & Trienekens, J. (2001). Quality Through Managed Development and Implementatin of a Quality Management System for Software Company, *Software Quality Journal* 9, 177-193.

Benbasat, I., Goldstein, D., K., & Mead, M. (1987). The Case Study Research Strategy in Studies of Information Systems. *MIS Quarterly*, 11, 369-386.

Berander, P. & Wohlin, C. (2003). Identification of Key Factors in Software Process Management – A Case Study, *Proceedings of the 2003 International Symposium on Empirical Software Engineering (ISESE'03)*, Rome, Italy, 316-325.

Bloomberg, L., D., & Volpe, M. (2008). *Completing Your Qualitative Dissertation*, USA:Sage.

Cares, C., Franch, X., Mayol, E., & Alvarez. E. (2006). Goal-Driven Agent oriented Software Processes, *Proceedings of the 32<sup>nd</sup> EUROMICRO Conference on Software Engineering and Advanced Applications*, Cavtat/Dubrovnik, Croatia, 336-342

Demirors, O. (2009). "Introduction to CMMI Staged", Retrieved May 22, 2009, from Middle East Technical University, Informatics Institute web site: [http://www.ii.metu.edu.tr/~sm511/course\\_material/lectures/Lecture09-CMMi\\_Intro\\_V1.01.pdf](http://www.ii.metu.edu.tr/~sm511/course_material/lectures/Lecture09-CMMi_Intro_V1.01.pdf)

Denscombe, M. (2000). *The Good Research Guide*, Buckingham, Open University Press

Denscombe, M. (2007). *The good research guide: for small-scale social research projects*, 3rd edition, McGraw-Hill International.

Diaz, M., & Sligo, J. (1997). How Software Process Improvement Helped Motorola, *IEEE Software* 14, 75-81.

Dyba, T. (2000). An Instrument for Measuring the Key Factors of Success in Software Process Improvement. *Empirical Software Engineering* 5, 357-390

Dyba, T. (2005). An Empirical Investigation of the Key Factors for Success in Software Process Improvement, *IEEE Transactions on Software Engineering* 31, 410-424.

Fenton, N.,E., & Pfleeger,S., L. (1997). *Software Metrics: A Rigorous and Practical Approach*, 2<sup>nd</sup> edition, PWS Publishing Co. Boston, MA, USA

Guerrero, F., & Eterovic, Y. (2004). Adopting the SW-CMM in a Small IT Organisation, *IEEE Software* 21, 29-35.

Herbsleb, J., Carleton, A., Rozum, J., Seigel, J., & Zubrow, D. (1994). *Benefits of CMM-Based Software Process Improvement: Initial Results*, (CMU/SEI-94-TR-013), Pittsburg, Pennsylvania: Carnegie Mellon University, Software Engineering Institute .

Herbsleb, J., Zubrow, D., Goldenson D., Hayes, W., & Paulk, M. (1997). Software quality and the Capability Maturity Model, *Communications of the ACM* 40, 30-40.

Iversen, J. and Mathiassen, L. (2003). Cultivation and engineering of a software metrics program, *Information Systems Journal* 13, 3–19.

Iversen, J. and Ngwenyama, O. (2006). Problems in measuring effectiveness in software process improvement: A longitudinal study of organizational change at Danske Data, *International Journal of Information Management* 26, 30–43.

Jackelen, G. (2007). CMMI Level 2 Within Six Months? No Way! *CrossTalk The Journal of Defense Software Engineering*, (February 2007), 13-16.

Jones, L., & Soule, A. (2002). *Software Process Improvement and Product Line Practice: CMMI and the Framework for Software Product Line Practice*. (CMU/SEI-2002-TN-012), Pittsburg, Pennsylvania: Carnegie Mellon University, Software Engineering Institute.

Kaplan, B. and Maxwell, J.A. (1994). Qualitative Research Methods for Evaluating Computer Information Systems. J.G. Anderson, C.E. Aydin and S.J. Jay (eds.) in *Evaluating Health Care Information Systems: Methods and Applications*, (pp. 30-55). Thousand Oaks, CA: Sage.

Karagül, Y.(2009). *Critical Success Factors for CMMI-Based Software Process Improvement Initiatives*. (METU/II-TR-2009-17), Ankara, Middle East Technical University, Informatics Institute.

Mason, J. (1996). *Qualitative Researching*, London, Sage Publications.

Maxwell, J.A. (2008). Designing a qualitative study. Retrieved on 17.June.2009, from [http://www.corwinpress.com/upm-data/23722\\_Ch7.pdf](http://www.corwinpress.com/upm-data/23722_Ch7.pdf)

Montague, J. (2009). Qualitative Interviewing. Retrieved on 11.May.2009, from University of Derby web page <http://psychology.derby.ac.uk/system/modules/view/output.php?number=2120>

Niazi, M., Wilson, D., & Zowghi, D. (2005a). A maturity model for the implementation of software process improvement: an empirical study, *The Journal of Systems and Software* 74, 155-172.

Niazi, M., Wilson, D., & Zowghi, D. (2005b). A framework for assisting the design of effective software process improvement implementation strategies, *The Journal of Systems and Software* 78, 204-222.

Olson, T. G., & Sachlis, M. (2002). Aggressively Achieving CMM Level 3 in One Year. *SEPG 2002*, Phoenix, AZ.

Patton, M.,Q. (1990). *Qualitative Evaluation and Research Methods*, USA, Sage Publication

Petterson, F., Ivarsson, M., Gorschek, T., & Ohman, P. (2007). A practitioner's guide to light weight software process assessment, *The Journal of Systems and Software* 81, 972-995.

Philips, M. (2008). *CMMI Update*, Unpublished Presentation, Carnegie Mellon University, Software Engineering Institute.

Rainer, A., & Hall, T. (2002). Key success factors for implementing software process improvement: a maturity-based analysis. *Journal of Systems and Software* 62, 71–84.

Rainer, A., & Hall, T. (2003). A quantitative and qualitative analysis of factors affecting software processes. *Journal of Systems and Software* 66 (1), 7–21.

SEI. (2004). *Process Maturity Profile*, Software Engineering Institute, Carnegie Mellon University, Pittsburg, Pennsylvania.

SEI. (2006). *CMMI<sup>®</sup> Executive Overview*, Carnegie Mellon University, Software Engineering Institute. Accessed on 02.May.2009 <http://www.sei.cmu.edu/cmmi/adoption/pdf/cmmi-exec-overview06.pdf>

SEI. (2007). *Capability Maturity Model<sup>®</sup> Integration (CMMI<sup>®</sup>) Version 1.2 Overview*, Carnegie Mellon University, Software Engineering Institute. Accessed on 02.May.2009 <http://www.sei.cmu.edu/cmmi/adoption/pdf/cmmi-overview07.pdf>

SEI. (2009). *Process Maturity Profile CMMI for Development SCAMPI<sup>SM</sup> Class A Appraisal Results 2008 End-Year Update*, Carnegie Mellon University, Software Engineering Institute. Accessed on 16.June.2009 <http://www.sei.cmu.edu/appraisal-program/profile/pdf/CMMI/2009MarCMMI.pdf>

Tufail, Z., Kellum, J., & Olson, T. (2006). *Rapidly Defining a Lean CMMI Maturity Level 3 Process*, 6th Annual CMMI Technology Conference & User Group, Denver, Colorado.

Wilson, D., N., Hall, T. & Baddoo, N. (2001). A Framework for evaluation and prediction of software process improvement success, *The Journal of Systems and Software* 59, 135-142.

Yin, R.,K. (2003). *Case Study Research Design and Methods*, USA: Sage Publication

Zeid, S. S. (2004). Moving from CMM level-2 to CMM level-3, Egypt -*SPIN Newsletter*, (Issue 6), 3-8. Retrieved April 17, 2008 from <http://www.secc.org.eg/SPIN%20Newsletter.asp>

# APPENDICES

## APPENDIX A UNIFICATION OF FACTORS

The definition of factors in Table 4 that are investigated in more than one research paper and how the factors with different names but similar meanings have been grouped are presented in this appendix.

- a) ***Clear and Relevant SPI Goals:*** Niazi et al. (2005a), Niazi et al. (2005b), and Dyba (2005), and Wilson et al. (2001) have analyzed this factor using different names as shown in Table 14. Even though they have named this factor differently from each other, they have all investigated the alignment of SPI goals and business goals.

**Table 14 Studies that have studied *Clear and Relevant SPI goals***

<b>Research</b>	<b>Factor Name</b>
Niazi et al. (2005a), Niazi et al. (2005b)	Clear and relevant SPI goals
Dyba (2005)	Business orientation
Wilson et al. (2001)	Goal, stated objectives, needs driven

b) **Staff Involvement:** This is one of the two factors that is common in all the studies reviewed. It is defined as the involvement of staff in SPI activities. Each researcher used a different name for this factor as shown in Table 15.

**Table 15 Studies that have studied *Staff Involvement***

<b>Research</b>	<b>Factor Name</b>
Wilson et al (2001)	Participation
Niazi et al. (2005a) ,Niazi et al. (2005b)	Staff involvement
Berander & Wohlin (2003)	User involvement
Dyba (2005 )	Employee participation
Guerrero & Eterovic (2004)	Developers' involvement
Peterson et al. (2007)	Involvement
Cares et al. (2006)	User involvement

c) **Quality Environment:** Wilson et al. (2001), Peterson et al. (2007) have investigated the role of quality environment. Wilson et al. state that having ISO9000 certification is an indicator that a quality environment has been established. Peterson et al. mention that having adopted an SPI initiative is the most important critical success factor (see Table 16.)

**Table 16 Studies that have studied *Quality Environment***

<b>Research</b>	<b>Factor Name</b>
Wilson et al. (2001),	Quality environment
Peterson et al. (2007)	SPI threshold

d) **Process Definition:** Wilson et al. (2001), Berander and Wohlin (2003), Cares et al. (2006) have investigated the role of process definition which is defined as the definition of processes adequately at the appropriate level of detail. How each study names the factor is shown in Table 17.

**Table 17 Studies that have studied *Process Definition***

<b>Research</b>	<b>Factor Name</b>
Wilson et al. (2001),	Process definition
Berander and Wohlin (2003)	Baselining
Cares et al. (2006)	Baselining

e) **Management Commitment:** Management commitment is another factor that is common in all of the papers reviewed in the literature. The naming and definition of the factor differ slightly among the papers as shown in Table 18 . Wilson et al (2001), Niazi et al. 2005a, and Niazi et al. 2005b discuss the senior management commitment; Dyba (2005), Petersen et al.(2005) and Cares et al. (2006) states that managers from all levels and staff should commit; Dyba (2005) and Petersen et al. also mention management involvement.

**Table 18 Studies that have studied *Management Commitment***

<b>Research</b>	<b>Factor Name</b>
Wilson et al (2001)	Management commitment
Niazi et al. (2005a), Niazi et al. (2005b)	Senior management commitment
Berander & Wohlin (2003)	Management commitment
Dyba (2005 )	Involved leadership
Guerrero & Eterovic (2004)	Management commitment
Peterson et al. (2007)	Commitment and involvement
Cares et al. (2006)	Management and staff commitment

f) **Resource Availability:** The way resourcing is studied in the papers below (Table 19) are different from each other. Wilson et al. (2005) included the question “Was the SPI program resourced properly?” in order to measure the effect of resourcing in SPI success. Niazi et al. (2005a), Niazi et al. (2005b)

define five practice areas for the factor “staff time and resources dedicated to SPI”. Cares et al. (2006) identify the lack of resources as a critical barrier and include the factor resource availability as a success factor in the proposed model. This factor is renamed as “Resource Availability”.

**Table 19 Studies that have studied *Resource Availability***

Research	Factor Name
Wilson et al (2001)	Resourcing
Niazi et al. (2005a),Niazi et al. (2005b)	Staff time and resources dedicated to SPI
Cares et al. (2006)	Resource availability

**g) *Team Size*:** The effect of team size on SPI success is analyzed in Wilson et al. (2001) and Guerrero and Eterovic (2004). The results of the two studies do not match with each other. Wilson et al. conclude that team size has no significant effect on SPI success. On the other hand, Guerrero and Eterovic (2004) identify team size as a key success factor. Having different sample groups and analysis methodology may have led to such a contradiction. How each study named the factor is shown in Table 20.

**Table 20 Studies that have studied *Team Size***

Research	Factor Name
Wilson et al (2001)	Team size
Guerrero and Eterovic (2004)	Group focus

**h) *Training*:** Wilson et al. (2001) analyze the role of training under two perspectives, Input and Process, by using the questions “were resources allocated to training” and “was adequate training in SPI is carried out”, respectively. Niazi et al. (2005a), Niazi et al. (2005b) define five practice areas for the factor “Training and Mentoring”. Cares et al. (2006) have unified the factors training and mentoring, staff involvement, staff time and resources

and experienced staff under the name “Training and Experienced Staff”. How each study named the factor is shown in Table 21.

**Table 21 Studies that have studied *Training***

<b>Research</b>	<b>Factor Name</b>
Wilson et al. (2001)	Training; adequate training
Niazi et al. (2005a), Niazi et al. (2005b)	Training and mentoring
Cares et al. (2006)	Training and experienced staff
Guerrero and Eterovic (2004)	Process related training

i) **Implementation Plan:** Wilson et al. (2001) analyze the role of “Implementation Plan” by asking the question “Was a firm implementation plan published?” Niazi et al. (2005a), Niazi et al. (2005b) define five practice areas, which are about how the plan is prepared and how the plan is adopted and improved within the organization, and named the factor as “Formal Methodology”. Guerrero and Eterovic (2004) mention the importance of implementation plan, and give guidelines to organizations about how they may prepare their implementation plans. Under the factor named “Managing the Improvement Process”, Cares et al. (2006) have also included the factors creating process action teams, setting relevant and realistic objectives. When the results of the studies mentioned above are compared, it is observed that all the researchers but Wilson et al. mention this as a key success factor. How each study named the factor is shown in Table 22.

**Table 22 Studies that have studied *Implementation Plan***

<b>Research</b>	<b>Factor Name</b>
Wilson et al (2001)	Implementation plan
Niazi et al. (2005a),Niazi et al. (2005b)	Formal methodology
Cares et al. (2006)	Managing the improvement process
Guerrero and Eterovic (2004)	Visibility into SPI process

j) **Change Mechanism:** When the practice areas identified for Organizational Politics in Niazi et al. (2005b) is analyzed, it is observed that they are some issues related to the change management and support. Based on the rationale Cares et al. (2006) stated, the organizational politics factor is included under the name change management and management support. How each study named the factor is shown in Table 23.

**Table 23 Studies that have studied *Change Mechanism***

Research	Factor Name
Wilson et al (2001)	Change mechanism
Niazi et al. (2005a), Niazi et al. (2005b)	Organizational politics
Berander and Wohlin (2003)	Change management
Cares et al. (2006)	Change management

k) **Process Documentation:** Even though different names were given, this factor is renamed as “process documentation” since studies listed in Table 24 all define the factor as documenting the processes to be improved

**Table 24 Studies that have studied *Process Documentation***

Research	Factor Name
Wilson et al (2001)	Initial process definition
Berander and Wohlin (2003)	Documentation
Cares et al. (2006)	Process documentation

l) **Awareness:** Awareness related question in Wilson et al. (2001) is “did everyone know what processes were being improved and why?” On the other hand Niazi et al. (2005a), Niazi et al. (2005b) and Guerrero and Eterovic (2004) investigate whether the organization is aware of the content SPI, its potential benefits, and of organizational roles and responsibilities. Therefore, Wilson et al. factor “Awareness” will also be categorized under

“participation”. Another factor studied in Wilson et al. is “Explanations” which is investigated by the question “were the capabilities provided for users to explain events and phenomena associated with the program?” Words in the question like “capabilities”, “explain”, “events”, “phenomena” are believed to imply awareness since after explaining these details, the organization will be more informed about the SPI program. How each study named the factor is shown in Table 25

**Table 25 Studies that have studied *Awareness***

<b>Research</b>	<b>Factor Name</b>
Wilson et al (2001)	Awareness
Wilson et al (2001)	Explanations
Niazi et al. (2005a), Niazi et al. (2005b)	SPI awareness
Guerrero and Eterovic (2004)	Cultural awareness

**Experienced Staff**: How each study named this factor is shown in Table 26.

**Table 26 Studies that have studied *Experienced Staff***

<b>Research</b>	<b>Factor Name</b>
Niazi et al. (2005a), Niazi et al. (2005b)	Experienced staff
Cares et al. (2006)	Training and experienced staff

m) **Creating Process Action Teams**: Niazi et al. (2005a), Niazi et al. (2005b) define five practice areas under the critical success factor, *Creating Process Action Teams*. The key practice areas are related to how to establish the SPI team, how to monitor the progress, and how to define feedback mechanism in SPI initiative. These issues are also included in Cares et al. (2006) under the name of “Managing the improvement process”. How each study named this factor is shown in Table 27.

**Table 27 Studies that have studied *Creating Process Action Teams***

<b>Research</b>	<b>Factor Name</b>
Niazi et al. (2005a), Niazi et al. (2005b)	Creating process action teams
Cares et al. (2006)	Managing the improvement process

n) **Communication:** Guerrero and Eterovic (2004) employ bidirectional continuous communications during the implementation of SPI. This enabled a direct and real-time link between the workgroups and SEPG in case of feedback and comments about the SPI initiative, and etc. Similarly, Cares et al. (2006) included the factor “Communication and Collaboration to create explicit information resources and cross communication goals”. How each study named the factor is shown in Table 28.

**Table 28 Studies that have studied *Communication***

<b>Research</b>	<b>Factor Name</b>
Guerrero and Eterovic (2004)	Maintaining momentum
Cares et al. (2006)	Communication and collaboration

## APPENDIX B INTERVIEW QUESTIONS

### Interview Questions in English

#### a) *Quality Environment*

Group	Interview Item	Measurement object (where available)
Situation before SPI program	Prior to SPI program, had the organization adopted quality standards?( examples can be any military standards, ISO 12207 standard, NATO released AQAP-160, ISO 9001:2000 certification)	# of quality standards adopted (prior to SPI)
	Prior to SPI program, had the organization developed projects satisfying quality requirements?	# of projects developed with the adopted standards (prior to SPI)
CMM/CMMI compatibility	Are there any SPI models applied other than CMM/CMMI?	
	Are process definitions compatible with CMM definitions?	
	During SPI program, did you observe any PAs that have already been satisfied?	
	The number of PAs that you already satisfied is - _____.	# of PAs satisfied (prior to SPI)
	How frequently did you assess the processes? What are the advantages/disadvantages of frequent assessments?	

***b) Experienced Staff***

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Experiences of SPI team	Does the staff selected for SPI team have experience on software process improvement?	Total SPI effort of each team member
	Has the staff selected for SPI team developed several successful software projects?	# of projects the each SPI team member developed
	Is the staff selected for SPI team knowledgeable with the organization/program being evaluated?	# of total hours of training or # years (# worked hours) the employee worked on the organization
	Does the staff selected for SPI team have experience about writing plans, procedures, and checklists?	# of total hours the selected employee worked in planning activities.
SPI team structure and responsibilities	From whom the SPI team composed of? How was the distribution of the team:  1. Are there any managers in the team?  2. Are there any developers in the team?  3. What is the adv/disadvantage of a mixed group?	
	What are the requirements for being a SPI team member?	
	What are the responsibilities of the SPI team?	
Attitude towards SPI program	Are the product development activities separate from process improvement activities?  Is there any one that is responsible from the coordination of the two groups?	
Review of SPI program	What have been done to review the SPI program?  Can regular and frequent communication be achieved?  Are there any review meetings? Who attended these meetings?	

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
	Have you provided feedback regarding these meetings	
<i>Consultant</i>	What are the criteria while selecting the consultant?	

***c) Management Commitment***

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Management Commitment	Has management provided strong leadership and commitment for SPI? Any examples?	
	Has management been committed to provide training and resources for SPI implementation?	
	When necessary, has management provided mandatory actions for SPI activities?	Number of messages related to mandatory action during SPI
Management Awareness	What is done to inform the staff?  Is staff aware of the commitment the management provided?	
Management Involvement	Has management actively participated in SPI activities?	# total hours management participate in SPI activities

*d) Awareness*

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Awareness before SPI	Before SPI, has staff been aware of the benefits of SPI?	
	Has higher management been aware of investment required and long term benefits of SPI?	
Awareness during SPI	Have staff members are aware of their roles and responsibilities during the implementation of SPI?	
	What have been done to increase the SPI awareness of staff	

*e) Staff Involvement*

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Prior to SPI	What was staff thinking about SPI prior to SPI?	
	Are resource allocations and team structures arranged such that the organization gets maximum benefit from the staff?	
	Has staff actively participated in SPI program? (Like setting goals, creating routines, etc.)	
	What has been done to allocate the time necessary to make staff participation successful?	# of total worked hours while setting goals  # of total worked hours while creating routines
Communication	Is there a full time person (i.e. project leader) coordinating the SPI activities, providing status reports, and being a bridge between the lead appraiser and the team?	
Rewarding	Is there a rewarding mechanism for successful SPI activities?	

**f) Training**

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Training plan	Have you provided training for developing the skills and knowledge needed to perform SPI implementation?	# training hours about SPI implementation
Resources allocated to training	Have sufficient resources and additional time to participate in SPI training been provided to staff member?	Resources and additional time allocated to SPI activities
Sustainable training	Are training program activities reviewed on a periodic basis?	
	Are all future trainings of SPI planned?	

**g) Metrics and Measurement**

<b>Group</b>	<b>Interview Item</b>	<b>Metric (where available)</b>
Metrics Usage	Are quality data (e.g. defects, timeliness) collected from the projects on regular basis?	# of metrics that are related to quality and their content
Selection of metrics	What is the methodology in selection of metrics?	
Analysis of metrics	Can developers, managers, or other staff access to quality data?	
	Have the metrics collected provided a basis for SPI studies?	

## Interview Questions in Turkish

### a) Kalite Ortamı

Grup	Soru	İlgili Metrik (eğer varsa)
Yazılım süreç iyileştirme öncesi örgütteki durum	Yazılım süreç iyileştirme (YSİ) programına başlamadan önce kullanılmakta olan kalite standartları var mıydı? (Mesela askeri standartlar, ISO 12207, ISO 9001:2000, NATO AQAP-160)	Kullanılan standart sayısı (YSİ'den önce)
	YSİ programından önce, şirketin kullandığı kalite standartlarına uygun geliştirdiği projeler var mıydı?	Standartlara uygun geliştirilen yazılım projesi sayısı
CMM/CMMI uyumu	CMM/CMMI dışında kullanılan başka YSİ modelleri var mı? (TSP, PSP vb.)	
	Yazılım süreç tanımları, CMM/CMMI tanımları ile uyumlu mu?	
	YSİ programı öncesi hali hazırda gerçekleştirilen süreç alanları var mıydı? Bunların sayısı nedir?	<ul style="list-style-type: none"><li>• YSİ öncesi tam olarak gerçekleştirilen KPA sayısı</li><li>• YSİ öncesi kısmen gerçekleştirilen KPA sayısı</li></ul>
	Süreçler hangi sıklıkla değerlendirildi? (resmi/gayri resmi değerlendirmeler, şirket içi gözden geçirmeler, SCAMPI C, SCAMPI B, vs.) Değerlendirmenin, daha sık ya da daha seyrek olmasının ne gibi avantaj ve dezavantajları olabilir?	YSİ süresinde gerçekleştirilen değerlendirme sayısı

**b) Tecrübeli Eleman**

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
YSİ takımının tecrübeleri	YSİ takımı oluştururken seçilen kişilerin YSİ üzerine tecrübeleri var mıydı?	Her YSİ takımı elemanının toplam geçmiş YSİ iş gücü
	YSİ takımı oluştururken seçilen kişilerin daha önceden geliştirdikleri başarılı yazılım projeleri var mıydı?	Her bir YSİ takım elemanının geliştirilmesine katıldığı yazılım proje sayısı
	YSİ takımına seçilen çalışanlar, sürdürülmekte olan YSİ programı ve/veya organizasyon ile ilgili bilgili miydi?	<ul style="list-style-type: none"> <li>• Toplam eğitim saati</li> <li>• Organizasyonda çalışılan yıl</li> </ul>
	YSİ takımına seçilen çalışanlar, plan hazırlama, kuralları ve kontrol listelerini yazmada tecrübeli miydi?	Seçilen çalışanların planlama aktivitelerinde çalıştıkları adam-saat
YSİ takımının dağılımı ve sorumlulukları	YSİ takımı kimlerden oluşuyordu? Takımın, dağılımı nasıldı? <ol style="list-style-type: none"> <li>1. Takımda müdürler var mıydı? Hangi seviyede idiler?</li> <li>2. Çalışanlardan, yazılım geliştiriciler de gruba katıldı mı?</li> <li>3. Eğer karma bir grup oluşturulduysa ne gibi avantajları ve dezavantajları gözlemlendi? Veya oluşturulan grubun ne gibi avantajları ve dezavantajları gözlemlendi?</li> </ol>	
	Oluşturulan YSİ takımındaki kişilerde ne gibi özellikler arandı – mesela yönetim gücü yüksek, değişime açık, sürekli iyileştirme fikrini benimsemiş? Yoksa sadece YSİ konusunda tecrübeli olmaları yeterli miydi?	
	Oluşturulan YSİ grubunun sorumlulukları nelerdi? ( mesela: kuralları, süreçleri, standartları ve şablonları oluşturmak )	
YSİ programına yaklaşım	Süreç iyileştirme çalışmaları ile ürün geliştirme çalışmaları birbirinden ayrı mıydı? Bu iki ana grubu koordine edecek tam-zamanlı bir çalışan mevcut muydu?	

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
YSİ programının izlenmesi/gözden geçirilmesi	YSİ gelişimini gözlemek için neler yapıldı? Düzenli ve sık iletişim sağlanabildi mi? İhtiyaçlar ve ilerleme ile ilgili düzenlenen toplantılar oldu mu? (Bu toplantılara örnek: süreç takım toplantıları, yönetim kurulu toplantıları, durum raporları, haber bültenleri, posterler, vs.) Bu toplantılara kimler katıldı? İlerleme ile ilgili bilgilendirmeleri yapıldı mı?	
Danışman firma	Danışman firma seçilirken nelere dikkat edildi?	

**c) Yönetim Desteği**

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
Yönetimin desteği	YSİ programı için, yönetim güçlü bir önderlik ve destek sağladı mı?	
	YSİ uygulaması için, yönetim gerekli eğitim ve kaynak sağlayacağını taahhüt etti mi?	
	Yöneticiler YSİ çalışmalarına verdikleri desteği göstermek için neler yaptılar? Yönetim, YSİ çalışmalarını zorunlu kıldı mı? Hangi etkinliklerde bulundular?	
Yönetimin farkındalığı	Konu ile ilgili çalışanlar nasıl bilgilendirildi? Çalışanlar, YSİ çalışmalarına verilen önemin farkına vardılar mı? Nasıl?	
Yönetimin katılımı	Yönetim, YSİ çalışmalarına aktif olarak katıldı mı?	Yönetimin YSİ çalışmalarında geçirdiği toplam adam-saat

**d) Farkındalık**

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
YSİ öncesi farkındalık	YSİ programından önce, çalışanlar YSİ'nin getireceği faydaların farkındalar mıydı?	YSİ ile ilgili verilen toplam eğitim saati (YSİ başlamadan önce)
	Yönetim, YSİ için gereken yatırımın ve YSİ'nin uzun vadede getireceği avantajların farkında mıydı?	YSİ ile ilgili yönetim kademesine verilen toplam eğitim/toplantı/brifing saati (YSİ başlamadan önce)
YSİ programı boyunca farkındalık	Çalışanlar, YSİ bünyesindeki görev ve sorumluluklarının bilincinde miydi?	Çalışanların YSİ ile ilgili katıldıkları toplam eğitim/toplantı/brifing saati (YSİ bünyesinde)
	Çalışanların YSİ farkındalığını arttırmak ve sürekli kılmak için, eğitimin yanında, ne gibi başka aktivitelerde bulunuldu? (Posterler, takım oluşturma çalıştırmaları, takım eğitimi, sosyal aktiviteler)	
Kurumsal kültür ile YSİ uyumu	Değişim sürecinde alınan kararlarda, kurum kültürü göz önünde bulunduruldu mu?	
	Kurumsal değişim ve süreç değişimlerini birbirini tamamlayan aktiviteler olarak mı değerlendirildi? Kurumun kültürüne paralel olmayan değişimlerde nasıl bir yol izlendi?	

e) *Çalışanların Katılımı*

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
YSİ öncesi durum	Çalışanların YSİ aktivitelerine bakışı nasıldı?	
YSİ katılımını sağlamak için yapılanlar	Kaynak tahsisinde ve takım yapısının oluştururken nasıl bir yol izlendi? ( Kurumun, çalışanından kazanacağı faydayı göz önünde bulunduruldu mu?)	
	Çalışanların, YSİ çalışmalarına yeterli zaman ayırabilmesi için düzenlemelere gidildi mi? (Ürün geliştirme ile süreç iyileştirmenin birbirinden ayrılması) Çalışanların, YSİ sürecinde aktif olarak rol aldığını söyleyenebilir mi? Mesela, kendileri de yeni fikirler ürettiler mi, SPI için hedefler belirlediler mi, kendi çalışma gruplarını oluşturdular mı?	Çalışanların YSİ hedeflerini belirlemede çalıştıkları toplam adam-saat Çalışanların kuralları belirlemede çalıştıkları toplam adam-saat
	Çalışanların katılımını arttırmak için ne gibi aktivitelerde bulunuldu? Çalışanlar SPI sürecinin hangi kısımlarında bil fiil rol aldılar? Bu çalışmaları ile ilgili metrikler var mı?	
İletişim	Değerlendirmeyi yapan kişi ile YSİ grubu arasındaki, ilişkiyi kontrol eden tam zamanlı bir çalışan mevcut muydu?	
Ödüllendirme	Başarılı YSİ çalışmalarından sonra, ödüllendirme mekanizması çalıştırıldı mı?	

f) *Eğitim*

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
Eğitimin planlanması	YSİ uygulaması sırasında gereken yetenek ve becerileri arttıracak eğitimler verildi mi? Eğitim programı nasıl planladı? Daha önceden tanımlı kurs kaydı, kursa devam, kurs planlama gibi eğitim prosedürleri (yöntem/yordam) var mıydı? Eğer yoksa böyle bir eğitim planı YSİ sırasında geliştirildi mi?	YSİ uygulaması için verilen toplam eğitim saati
Eğitime ayrılan kaynak	Eğitim için yeterli kaynak ve zaman çalışanlara sağlandı mı?	YSİ çalışmaları için ayrılan kaynaklar ve zaman
Sürdürebilir eğitim	Eğitim programı düzenli olarak gözden geçiriliyor mu?	
	Uzun vadedeki grup ve kişisel YSİ eğitimleri planlandı mı?	

g) *Metrikler*

<b>Grup</b>	<b>Soru</b>	<b>İlgili Metrik (eğer varsa)</b>
Metrik kullanımı	Geliştirilen projeler sırasında, kalite verileri düzenli olarak toplanıyor muydu? Tanımlı kalite metrikleri nelerdir?	Kalite metriklerinin sayısı
Metriklerin seçimi	Metriklerin seçimi sırasında nasıl bir yol izlendi? Metrikler, iş ile ilgili hayati/zorunlu /elzem konularla mı ilgili?	
Metriklerin değerlendirilmesi /analizi	Kalite verilerini yönetim, yazılım geliştiriciler veya diğer ilgili çalışanlar görebiliyorlar mı?	
	Toplamış olunan veriler, YSİ çalışmaları için bir temel oluşturdu mu?	

## APPENDIX C NOTATION USED IN THE ANALYSIS OF CASES

The explanation of each score in each factor is given below, in the order of appearance in Table 9.

### *1. Quality Environment:*

**high:** if company has employed at least two standards

**medium:** if company has employed any quality standard (ISO 9001:2000, ISO 12207, AQAP 160)

**none or low:** if company has no previous quality study

#### *1.1.Parallelism between Standards*

**high:** if company has previous CMM/CMMI certification

**medium:** if company has either ISO 9001:2000 or ISO 12207

**none or low:** if company has no previous quality study that is parallel to CMM/CMMI

#### *1.2.Frequency of Assessments*

**high:** if company has been assessed at least twice (like gap analysis, Class C, Class B)

**medium:** if company has been assessed less than 2 (like gap analysis, Class C, Class B)

**none or low:** if company has not been assessed other than the Class A appraisal

##### *1.2.1. Gap Analysis*

**high:** if company is aware of the benefits of gap analysis and done one

**medium:** if company is aware of the benefits of gap analysis but not completed any.

**none or low:** if company is not aware of gap analysis

### ***1.2.2. Class-B Appraisal***

**high:** if company is aware of the benefits of Class-B appraisal and done one

**medium:** if company is aware of the benefits of Class B appraisal but not completed

**none or low:** if company is not aware of Class-B appraisal

## ***2. Experienced Staff***

**high:** if most of the staff any process development/documentation and/or quality standard experience

**medium:** if some of the staff has any process development/documentation and/or quality standard experience

**none or low:** if staff has no process development/documentation and/or quality standard experience at all

### ***2.1.CMM/CMMI Experience***

**high:** if most of the staff have CMM/CMMI experience

**medium:** if some of the staff have CMM/CMMI experience

**none or low:** if staff have no CMM/CMMI experience at all.

### ***2.2.Separation of Process and Products***

**high:** if the company has a SEPG prior to CMM/CMMI studies

**medium:** if company has formed SEPG as a requirement of CMM/CMMI

**none or low:** if company does not have an SEPG

### ***2.3.Consultant***

**high:** if company has worked with a consultant throughout the CMMI studies

**medium:** if company has started working with a consultant but then given up

**none or low:** if company has not employed any consultant

#### ***2.4.Reviews***

**high:** if the company has review groups prior to CMM/CMMI studies

**medium:** if company has formed review groups as a requirement of CMM/CMMI

**none or low:** if company does not have any review groups

### ***3. Staff Involvement***

**high:** staff is dedicated and committed to CMMI activities/resources allocation and team structure arranged such that the organization gets maximum benefit from the staff.

**medium:** staff is dedicated to SPI activities but there are some problems in resource allocation

**none or low:** neither staff is dedicated nor the resources are allocated appropriately.

#### ***3.1.Awareness***

**high:** staff at all levels is aware of the benefits of CMMI studies, their roles and responsibilities

**medium:** staff knows something about the CMMI activities and its benefits.

**none or low:** staff is unaware of CMMI activities and its benefits

#### ***3.2.Resistance to Change***

**high:** there is no resistance to change

**medium:** there exists some resistance to change

**none or low:** the organization has showed resistance to change

### ***3.3.Rewarding***

**high:** The organization has a substantial rewarding mechanism.

**medium:** The organization has rewarded employees only in terms of performance recognition.

**none or low:** The organization has no rewarding policy.

## ***4. Training***

**high:** training related to CMMI is given based on a training program. Sufficient resources and time is allocated to training.

**medium:** training related to CMMI is given

**none or low:** no training related to CMMI is given.

### ***4.1.Annual Training***

**high:** annual training is given on regular basis.

**medium:** annual training is given when necessary.

**none or low:** there is no plan of annual training.

### ***4.2.Training Plan***

**high:** there exists a detailed training plan about training sessions, attendees, content and etc.

**medium:** there exists a training plan but it is not in detail.

**none or low:** there is no training plan.

## ***5. Metrics and Measurement***

**high:** the organization has utilized metrics and measurement prior to CMMI studies

**medium:** the organization has collected metrics prior to CMMI.

**none or low:** the organization does not employ metrics and measurement activities prior to CMMI.

### ***5.1. Metrics Analysis***

**high:** Metrics are selected based on a method and the results of the analysis of the results are used in related fields.

**medium:** Metrics are collected but analysis is not performed.

**none or low:** Neither metrics are collected nor they are analyzed.

### ***5.2. Automated Metrics Tool***

**high:** Organization is aware of the benefits of automated metrics tools and utilized them during CMMI studies.

**medium:** Organization is aware of the benefits of automated metrics tools but did not utilize them during CMMI studies.

**none or low:** Automated metrics tools are not utilized.

## ***6. Management Commitment I***

**high:** CMMI studies are initiated by management and management provided full commitment prior to CMMI studies.

**medium:** Management is aware of the benefits and provided commitment prior to CMMI studies.

**none or low:** Management did not provide commitment.

## ***7. Management Commitment II***

**high:** Management provided full commitment during CMMI studies.

**medium:** Management provided commitment during CMMI studies.

**none or low:** Management did not provide commitment during CMMI studies.

## **8. *Management Involvement***

**high:** Management actively participated in most of the CMMI activities.

**medium:** Management actively participated in some of the CMMI activities **none or low:** Management did not participated in any CMMI activities.

## **9. *Process Documentation***

**high:** the organization has adopted process documentation activities prior to CMMI studies.

**medium:** the organization has problems with process documentation activities.

**none or low:** the organization has no experience on process documentation.

# VITA

## PERSONAL INFORMATION

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## EDUCATION

Degree	Institution	Year of Graduation
MS	METU Information Systems	2003
BS	METU Chemical Engineering	1999

## WORK EXPERIENCE

Year	Place	Enrollment
Sep2007- Present	Doğuş University, Department of Computer Technology and Programming	Instructor
Jan 2007- Aug 2007	Çankaya University, Department of Computer Engineering	Ph. D. Scholar

2000-2005 METU, Department of Information Research  
Systems Assistant

## **PUBLICATIONS**

Salihođlu, Y. (2003) Adoption and Utilization of Information Systems in an Emerging Turkish Industrial Town: A Case Study on Gaziantep, *Unpublished Master's Thesis. Middle East Technical University*

Karagöl, Y.(2009). *Critical Success Factors for CMMI-Based Software Process Improvement Initiatives*. (METU/II-TR-2009-17), Ankara, Middle East Technical University, Informatics Institutes

Karagöl, Y. and Bilgen, S. (2009) Factors that affect the duration of software process improvement programs, *The Journal of Systems and Software* (submitted)

## **RESEARCH INTEREST**

Software Quality, Software Process Improvement