



UNIVERSITY OF GOTHENBURG

# Software Process Improvement Framework for Software Outsourcing Based On CMMI

*Master of Science Thesis in Software Engineering and Management*

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## ABSTRACT

*Process improvement in software outsourcing is of growing concern for many reasons such as successful delivery of projects. Software outsourcing companies are reluctant to adapt Process improvement models and methods because of their complex structure and difficult implementation methods. It has been observed that Improvement efforts in outsourcing companies based on process improvement frameworks which are designed for large organizations fails most of the time. CMMI enable companies to enhance performance and rates the maturity of process. This master thesis focuses on identifying the key process areas for software outsourcing and provides best practices and methods for improving a software process. The research will identify the key problems related to process improvement in software outsourcing. The main objective is to develop a model based on CMMI, which can be used by software outsourcing companies in order to implement process improvement activities. All the key activities required for process improvement in software outsourcing are explained with proper guide lines. This dissertation met these research aims through an extensive study of relevant literature and systematic review about CMMI, SPI and outsourcing. The research was based on the CMMI technical reports and case studies about outsourcing projects. The research was divided into multiple phases in order to obtain the results. The mapping of Key process areas and problems is done by analyzing CMMI process area, their specific goals and specific practices. This research produced a number of key findings: Outsourcing case studies help in identifying the problems related to process improvement. CMMI reports helped in identifying the key process areas for outsourcing projects and helped in mapping of the problems and process areas. The main conclusions drawn from this research were that current approaches for process improvement just provide the guiding principles to achieve maturity of the process which are not enough. The ambiguity of CMMI is making it difficult for outsourcing companies to adapt these practices on theoretical instructions. This research identifies the key process areas for outsourcing projects and provides implementation methods in form of key activities which are to be implemented in order to improve the maturity of the process.*

*Keywords: Software Process improvement, Software outsourcing, CMMI, Key process Areas.*

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## ABBREVIATIONS

API	Application program interface
ARC	Appraisal Requirements for CMMI
CAR	Causal Analysis and Resolution (process area)
CL	Capability level
CM	Configuration Management (process area)
CMF	CMMI Model Foundation
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CMMI-ACQ	CMMI for Acquisition
CMMI-DEV	CMMI for Development
CMMI-SVC	CMMI for Services
COTS	Commercial off-the-shelf
CSCI	Computer software configuration item
DAR	Decision Analysis and Resolution (process area)
GG	Generic goal
GP	Generic practice
IEEE	Institute of Electrical and Electronics Engineers
IPD-CMM	Integrated Product Development Capability Maturity Model
IPM	Integrated Project Management (process area)
ISO	International Organization for Standardization
MA	Measurement and Analysis (process area)
ML	Maturity level
OPD	Organizational Process Definition (process area)
OPF	Organizational Process Focus (process area)
OPM	Organizational Performance Management (process area)
OPP	Organizational Process Performance (process area)
OT	Organizational Training (process area)
PI	Product Integration (process area)
PMC	Project Monitoring and Control (process area)
PP	Project planning (process area)
PPQA	Process and Product Quality Assurance (process area)
QPM	Quantitative Project Management (process area)
RD	Requirements Development (process area)
REQM	Requirements Management (process area)
RSKM	Risk Management (process area)
SAM	Supplier Agreement Management (process area)
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SECAM	Systems Engineering Capability Assessment Model
SECM	Systems Engineering Capability Model
SEI	Software Engineering Institute
SG	Specific goal
SP	Specific practice
TS	Technical Solution (process area)
VAL	Validation (process area)
VER	Verification (process area)
WBS	Work breakdown structure

# CHAPTER 1

## 1. INTRODUCTION

The purpose of this section is to provide detailed introduction about this Master's Thesis. This Master thesis can be divided into three sections. First section contains the background, research question, Structure of thesis, reading guidelines in chapter 1 and Research methodology in chapter 2. The second section contains explanation of Software process improvement, Software outsourcing and CMMI in chapter 3, 4 and 5. The last section contains Results and Discussions in Chapter 6 and Conclusion in Chapter 7.

### 1.1. Background

Software development process requires continuous improvement in order to build successful and quality products. The more organized and quality oriented a process is, the better products companies will produce and deliver. Companies are hiring professionals with multiple skills, implementing new technologies and also adapting new methods, standards and techniques to improve their processes so that they can build sustainable and successful software in the market. Integrating processes and its continuous improvement is done both at organizational level and industrial level. It's not easy to integrate new process and replace the old ones. The complexity of the new process can make it difficult to organize and manage process efficiency that could perform all the tasks in parallel and continuously. Moreover companies are expanding their businesses and building new products so rapidly that it has become a challenge to maintain quality of the projects and products via processes and all this requires more cost, time and efforts.

It's our experience that companies are spending too much efforts and resources in order to improve the performance of their overall process but only few companies have been successful in order to do so, many companies face unexpected problems and undesired results when they try to improve their process inside an organization and one of the major reasons is the changes they have to make in their organizational setup. The main problems in starting a process improvement is with managing the resources such as people, methods, practices, tools and technology they use. Furthermore companies are expanding their businesses with other client companies. This is done in order to reduce cost and optimize operations. Companies are hiring more qualified and experienced people who are not part of their companies or organizational process. This is done via outsourcing.

Outsourcing is an emerging industry and it's helping companies to achieve their goals efficiently. The benefits of outsourcing include cost reduction, improved quality; reduced capital investment, improved flexibility and most importantly, companies can focus on their core competencies. It is very important that organizations must be able to effectively manage and control the complex development process. But the problems in outsourcing shows that managing a project during Outsourcing has become a complex job, due to relatively short development time and the complexity of software development environment and the process. Managing projects, maintaining the quality of various projects and products by applying appropriate processes is becoming difficult day by day. This leads projects to take more time and resources than

expected and hence the quality products cannot be produced with in allocated time and budget, thus resulting in failure of most Outsourcing projects. Among many reasons involved the major reasons are poor integration of development process such as project planning, project monitoring and control, configuration management, risk management, requirement management and measurement. It is also very difficult to analyze and evaluate the internal process of various outsourcing companies and organizations. Big companies are focusing on process improvement by improving their methods and techniques and in order to do that they are designing and developing their own models which might not work or even be applicable to outsourcing processes. The companies are also trying to follow standard methods, which do not guarantee successful completion of the outsourcing projects in given time frame due to different organizational structure.

### 1.2. Why CMMI

CMMI is an internationally popular product suite for software process improvement; it provides an effective guiding framework that includes CMMI models, training and appraisal methods. CMMI focuses on different areas of interest for organization such as development, acquisition and services. CMMI contains practices that cover several process areas. One key process area of CMMI is project management and the purpose of this key process area is to provide practices in order to manage projects, process and products throughout project life cycle. The Focus of CMMI is to achieve business goals through a mature process and the benefits one can get by adapting CMMI are Process adherence and cost of quality, improvement performance, improved business efficiency, improved productivity, and improved quality, accelerate schedules, customer satisfaction and return on investments.

No matter how good CMMI model can be, but still it has some problems and one of the main issues with CMMI model is that it just provides you best practices or efforts which are needed to improve the process but it does not tell how to implement them. In short it just says what to do not how to do it. Another issue with CMMI is its focus on organizational internal structure for the process improvement making it a bit complex for the companies which are developing their product from other companies which are not part of their organization. CMMI implementation depends on the specific development and management environment of an organization on different levels. CMMI also explains the capability and maturity level of process improvement for organizations, so there might be a potential challenge of finding an outsourcing company with same capability and maturity level for number of reasons and the major one is less resources.

### 1.3. Problem Statement

Understanding the software process improvement efforts in software development is a complex task for many reasons. Finding the starting point and answering this most difficult question i.e. how to start a process improvement is a challenging task for many organizations. Achieving business goals and objectives in right time and budget has never been easy for organizations. Complex development process is extending their overall resources including development time, cost and also the effort. Companies hire professional people, train them, adapt new technologies and apply best methods in order to manage their

resources, complete the projects in expected time but still they fail to do so.

The major issues involved in failure of most of the projects can be Poor communication, no tracking and management of the projects, immature and inflexible process, no proper documentation of the development process, lack in project monitoring and control, no planning, problems in requirement eliciting, defining and managing, issues in controlling configuration management and last managing and controlling the entire development process.

The problem area selected in this research is process improvement in software outsourcing. Why is outsourcing an important issue and the simple answer is the economic benefits we get from outsourcing, but still most of the outsourcing projects are challenged, run overtime and over budgeted and even fail. The root cause behind all the problems is the infantile process. Several models, frameworks and methods have been developed in order to improve the development process but all come with number of issues and problems.

CMMI framework provides several models and appraisal methods to integrate and improve your process performance. The main issue with CMMI is the ambiguity, lot of technical definitions and lengthy text which make it difficult to understand, implement and accept. The problem with CMMI is that it covers almost everything from initial level process to optimized process performance. Interpreting CMMI for Special cases and to achieve specific business goals is a challenging job. Identifying the key process areas of CMMI for outsourcing and developing a new framework for integration and management of process in software outsourcing is the goal of this research. Identifying the problems and risks in software outsourcing is another challenging job in the current market where outsourcing is done both in-house and offshore.

## 1.4. Research Questions

- How to establish a set of software development process improvement methods for the software outsourcing based on CMMI.
- How to interpret CMMI for outsourcing projects.
- How to develop a model for SPI in Software outsourcing.
- Identify the most important process areas (considering CMMI models) when assessing “process-improvement” in outsourcing projects.
- Identify the main problems in SPI in Software outsourcing.

## 1.5. Research Focus

The focus of the research will be to investigate and analyze software process Improvement methods and models used for process improvement especially CMMI. The research will focus on identifying the best practices and methods required for process improvement in outsourcing projects. The research will focus on analyzing the key process areas as explained by CMMI and will try to identify the most important key process areas required for software outsourcing. The research will also identify the problems

in software outsourcing. On the basis of this research CMMI model will be interpreted for software outsourcing and after identifying the key process areas for outsourcing a model will be developed using specific goals and specific practices. All the key activities required for process improvement in software outsourcing will be explained with proper guide lines.

## 1.6. Overall Research Aims and Individual Research Objectives

It explores CMMI in outsourcing environment and proposes a model that could be applied by outsourcing companies. It also describes the key process areas, key elements and activities which are necessary in order to achieve effective process improvement for projects done via outsourcing. Overall research aims are,

- Understanding life cycle of outsourcing projects to identify main problems in process improvement.
- Identify the key process areas and key elements for process improvement in software outsourcing based on CMMI.
- Design and development of a model that best fits software outsourcing for process improvement.

## 1.7. Value of this Research

This research is important for a number of reasons. The main reason to do this research is to identify and address the problems related to software process improvement in outsourcing projects. The research will highlight the major hurdles for the process improvement for software outsourcing and provide solutions based on CMMI. The research will also identify the key process areas for software outsourcing and provide process improvement methods in those relevant process areas of outsourcing. The research will help Clients and outsourcing companies to share and communicate knowledge in a much better and efficient way to manage and organize projects. Interpreting CMMI for software outsourcing will help companies to achieve better results and build quality oriented products, which will save both time and cost. This research will help companies to adopt a process improvement model with practical implementation methods.

## 1.8. Research Goals

The research should result in software process improvement model for projects done via outsourcing. The description and scope of the Model will be discussed. The foundation of model is based on theoretical study and literature review that investigates the most important and critical software process improvement area, and the vital activities companies would adopt in order to gain maximum benefit when they do outsourcing. In order to design such a model that is based on best practices both the client and outsourcing companies’ process should be analyzed and explored. The model will provide detailed information about the key process areas and major activities to perform in order to improve the performance and maturity of a process.

## 1.9. Structure of the Thesis

This part will describe why this subject software process improvement for Software outsourcing was selected. It will also

give a description of how the work for this master thesis was conducted and what chapters it resulted in. This section will explain briefly about the research approach used for this Master's Thesis and how the research was conducted. This section summarizes the various chapters included in this Master's Thesis and provides brief introduction about each chapter and in what order the chapters in the report could be read will also be presented. The sub-chapters in this section are listed in the same order as the work for the thesis was conducted.

### *1.8.1 Why This Study Area is selected*

The main reason to choose this subject area of SPI was that authors observe that many international and local companies no matter how big or small, they are relying on the outsourcing phenomena in order to survive in fast and growing market. They are spending too many resources such as time and money in order to fulfill the customer's needs and get the products build in time. But the major problems they are facing when they do outsourcing are the quality of the product, managing a product, sharing knowledge and follow the process and the reason behind that is lack of quality in the process or in most cases non-existence of any process. SEI has been working hard on improving the CMMI and various versions have been launched and produced but still it just gives the guideline of improving a specific process but not how to do it. The authors also want to investigate and find a way to interpret CMMI and extract the relevant and required process and best practices for the projects done via outsourcing world. The main reason to perform this research is to develop a process improvement model for outsourcing projects, identify the key process areas in outsourcing and the vital activities involved in process improvement.

### *1.9.1 Chapter 1-Introduction*

The purpose of this chapter is to provide detailed introduction about this Master's Thesis. The chapter contains background of the problem area presented, overall aims and objectives of thesis, focus of the research work done, and basic goals of the research and value of the research work done.

### *1.9.2 Chapter 2- Research*

The aim with the research was to find out the current software process improvement status in outsourcing organizations today. Another important issue investigated was what areas of SPI in software outsourcing companies considered most important in order to achieve better performance, improve business results and develop a model for better software development. The research will explain the major and key activities involved in process improvement in a structure order for the better management of software process which leads to development of high quality products.

#### *1.8.2.1. Research Methods*

Design research is the methodology of this Master's Thesis because the purpose of this research is to investigate CMMI and process improvement in software outsourcing.

This section explains the research methods used in this Master's Thesis in order to produce results achieve aims and objectives and answer the research questions. This section explains how the research methods are explained and organized. The research is conducted in multiple phases and the reasons are explained, why

is it important do that and in last how these methods will guide and help to conduct this research work and find the answer to Research questions.

#### *1.8.2.2. Data Collection*

The part explains what kind of data was collected and how the data was collected about Software process improvement, Software outsourcing and CMMI. The data was collected from multiple resources including Chalmers and Goteborg Library. Lot of research papers, technical reports, case studies, books, journals and articles are collected about SPI, software outsourcing and CMMI and different process improvement models.

#### *1.8.2.3. Awareness of problem*

This part explains how the problems were identified in software process improvement in outsourcing. Why we need a solution of a problem and how we did that.

#### *1.8.2.4. Research Results*

This part presents the result of study to the reader. This part also explains how the results were generated.

### *1.8.3. Chapter 3- Software Process Improvement*

This chapter introduces software process improvement to the reader. This chapter explains the concept of SPI, Importance of SPI and different models and methods used for SPI. This chapter also provides data about process improvement and why SPI is so important for software outsourcing.

### *1.8.4. Chapter 4- Software Outsourcing*

This chapter describes a brief overview about Software outsourcing, introduction and background, importance of Outsourcing, cost and gains of outsourcing factors influencing outsourcing, major problems faced by companies in product development and process improvement and finally a case study of how Projects are done via outsourcing.

### *1.8.5. Chapter 5- CMMI*

In this Chapter capability maturity model integration is described in detail. CMMI evolution, background, purpose, framework, core process areas, capability levels and maturity of CMMI, continuous and staged representation, goals (generic and specific) and practices (generic and specific) of CMMI, all will be discussed in this chapter.

### *1.8.6. Chapter 6- Results and Discussions*

This chapter explains the results obtained by performing this research. This chapter contains the designed Model and the key activities involved in process improvement for an outsourcing project. The Chapter also describes the methods and practices involve in process improvement, their related process areas with specific goals and specific practices and also the architectural framework to show the relationship of the process areas. At the end this chapter contains a section about the problems found in



process improvement when projects are done via outsourcing. The results are discussed in detail.

### 1.8.6.1. The Model, Outsourcing Problems and KPA

The aim was to design a model that was tailored to fit the software outsourcing projects. It should be based on the key process areas identified from CMMI and contain the specific goals and specific practices required in order to start process improvement. The key problems identified in software outsourcing projects are explained in section 6.1.9 and the mapping of KPA with the problems is discussed in section 6.1.10. The key activities are explained in section 6.2.

### 1.8.7. Chapter 7-Conclusion

The conclusion and summary is added in this chapter showing the overall results of research. This section will discuss how the whole research has processed, challenges in the way and conclusion of the whole work. It also gives suggestions for the future work and possibilities to improve the model and framework in order to get maximum benefit.

## 1.9. How the Report Could Be Read

Figure 1 explains in what order this report should be read. Chapter 3, Chapter 4 and Chapter 5 is introduction about software process improvement, software outsourcing and CMMI. Chapter 2 explains the design methodology while Chapter 6 contains the results and discussions. Chapter 7 is conclusion and future work.

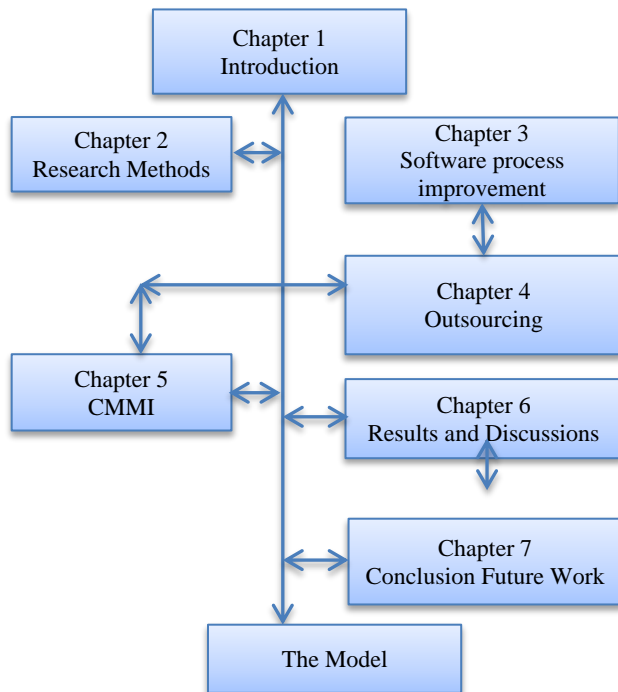


Figure 1. Structure of Thesis

## Reading Guidelines

### Audience

The intended audience for this report is a person with some basic knowledge with the software engineering domain. Efforts are made to explain all the basic principles to the reader, however because of the domain size; it is really not possible to cover all the areas in this report.

Knowledge about SPI, Outsourcing and CMMI are recommended in order to fully understand all the contents of report. Chapter 2 SPI, Chapter 3 outsourcing and Chapter 4 CMMI help readers not familiar with these terms or phenomenon. However it's recommended to have some general knowledge of the SPI field to fully understand the contents of this report.

### Limitations

In order to complete this Master's Thesis within the given timeframe which was two persons for 20 weeks it was necessary to make some limitations.

The process areas selected for outsourcing are from level 2 and level 3 of CMMI. These two levels are selected because the life cycle of outsourcing projects focuses mainly on Project implementation and management. Level 2 and Level 3 of CMMI mainly focus on project management and Project implementation. Another reason behind choosing these two levels is the lengthy and ambiguous structure of CMMI which requires lot of time and efforts in order to move from one level to next. Secondly it's not possible to study, analyze and investigate all the 22 process areas in details in such a short time.

The model designed based on the result of the study was never tested on a real organization.

## CHAPTER 2

### 2. RESEARCH METHODOLOGY

This chapter explains the research methods used in this Master's Thesis in order to produce results achieve aims and objectives and answer the research questions. This chapter explains how the research methods are explained and organized. The research is conducted in multiple phases and the reasons are explained, why is it important do that and in last how these methods will guide and help to conduct this research work and find the answer to Research questions.

#### 2.1. Research Questions

In order to simplify our research we have organized and arranged our research into main research question and sub research questions.

The main Research question is,

How to establish a set of software development process improvement methods for the software outsourcing based on CMMI?

The sub research questions are,

- How to develop a model for SPI in Software outsourcing?
- Identify the main problems in SPI in Software outsourcing.
- Identify the most important process areas (considering CMMI models) when assessing “process-improvement” in outsourcing projects?

In order to find solutions to main research question and sub research questions the research is divided into multiple phases. The reason is that it was done to get better understanding about Software process improvement, outsourcing concepts and CMMI. Another reason was to do the research step by step to make things more clear. The main cause of doing research in multiple phases was the ambiguity of CMMI which makes it really complex to interpret and adopt. In each phase review literature is done to understand the key concepts, definitions related to Software process improvement, Outsourcing and CMMI. Data is collected through books, articles, journals, case studies, CMMI Reports and websites.

The main source of data collection was university libraries. A complete understanding is required about different process areas and the improvement methods and frameworks available in the market. In the end of each phase, the suggestions are given and results are produced and analyzed in order to answer the main and sub research questions. On the basis of these suggestions and results a process improvement framework for outsourcing projects based on CMMI will be designed and developed.

The research is based on constructive research methods as the goal of this Master thesis is to study CMMI and provide a theoretical framework for software process improvement using existing CMMI framework (including models, components and theory). The sections below will explain the different phases of research, how the research took place and what methods were used in order to collect the data and to answer the research questions in details. Figure 2 explains the design methodology used in this research.

In order to understand outsourcing and nature of outsourcing projects and products various case studies and relevant data is collected from books and technical reports presented by CMMI. This Review will help in understanding the complete life cycle of outsourcing projects and understand the business values and importance of process improvement in outsourcing projects. These case studies will also help in identifying the key problems related to outsourcing projects. These problems will be mapped with related key process Areas of CMMI.

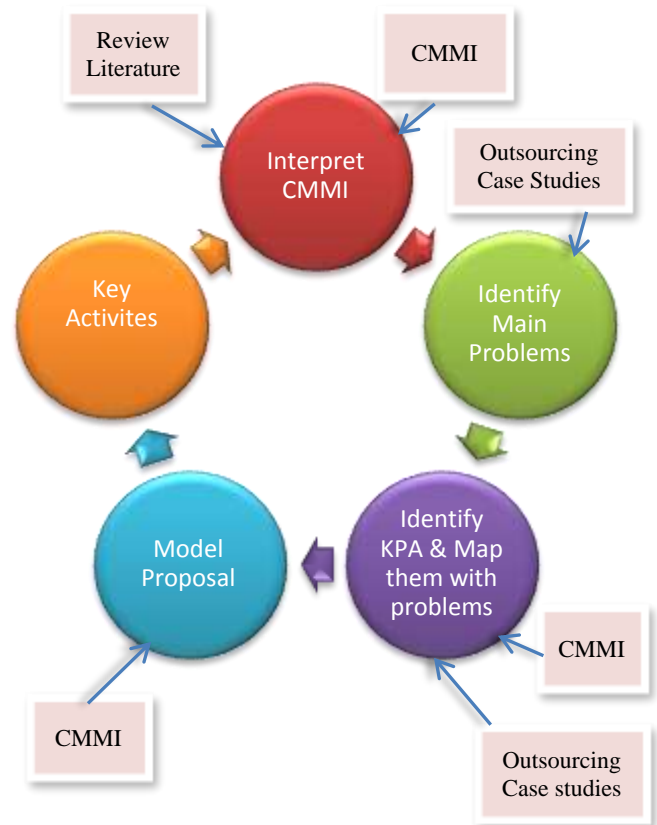


Figure 2. Design Methodology

## 2.2. Phase 1: Interpretation of CMMI

In first phase extensive research on CMMI is performed in order to find out, how CMMI can be interpreted for Outsourcing projects. CMMI product suite allows organization and senior management to interpret and adapt it in different situations according to their specific needs, organizational goals, objective and projects. CMMI suggests that in order to interpret CMMI practices, it is very important to consider the overall context in which these practices are used and to determine how well the practices satisfy the goals of a process area in that context [1]. The CMMI is studied and explored in details to get a better understanding about CMMI concepts, methods and components. CMMI framework and product suite including models, process areas, continuous representation, staged representation, capability and maturity level of different process are reviewed and described in details. Results about CMMI in details can be read in Chapter 5.

The purpose was to have a complete knowledge of CMMI in order to perform the interpretation of CMMI and develop a new framework for process improvement in software outsourcing. To explain the interpretation in details, CMMI framework is studied extensively and the main reason behind that is the complexity of CMMI. CMMI has developed different models, updating and improving the models accordingly and launching new versions after getting feedbacks from organizations and expert. CMMI model for development, CMMI model for acquisition and CMMI model for services and version 1.3 many model has already been developed by CMMI development team. This research will mainly focus on CMMI model for development version 1.3 and the technical reports provided by CMMI on their website.

CMMI structure, capability levels and maturity level, staged and continuous representation, generic goals and practices, specific goals and practices, work example, references and appraisal methods are reviewed in details.

Understanding CMMI concepts set guidelines and ways to interpret CMMI model for outsourcing projects which is part of sub research questions that how to interpret CMMI for outsourcing projects.

To describe this in more details assumptions were made that CMMI framework has the capability to be modified in special cases depending on the structure of organization and nature of the projects and thus interpretation can be made for process improvement in outsourcing projects. Key process areas of CMMI and their relationship were defined in order to identify the possible improvement efforts and practices required in order to start process improvement in software outsourcing projects.

### **2.3. Phase 2: Identify Problems in software Outsourcing process improvement**

Phase 1 explained the interpretation of CMMI for outsourcing project. In second phase research purpose is to explore, identify and find the associated problems in the process improvement for outsourcing projects. An extensive review literature was made about outsourcing projects. Various case studies are selected in order to understand the life cycle of outsourcing projects and identifying the main problems related to process improvement in software outsourcing. Through review literature understanding about the hurdles and limitations of CMMI for outsourcing projects were made. Awareness of problems is really important in order to find out why we need a solution to the problem, and this need can lead us to design a new framework or a model. This research is done by gathering data from the companies doing outsourcing, their reports, case studies and most important, the reports generated by expert opinion and organization on CMMI website. By doing this research a complete understanding of the problems in the process improvement path were identified and analyzed and described in Result section (6.1.9).

This study is based on systematic review of Software process improvement, outsourcing and CMMI key components for outsourcing. Through this literature study the results and suggestions are gathered in order to understand the most common issues related to outsourcing projects. The results will provide insight and deep understanding about how to improve a specific process area by applying appropriate methods in a well-organized and structured manner. This phase sets grounds for new framework and also explains the importance and needs of the new framework in order to perform process improvements.

### **2.4. Phase 3: Identify Key process Areas of CMMI for Outsourcing**

Phase 1 explained the interpretation of CMMI for outsourcing project. In second phase problems were identified in outsourcing projects. The purpose of this research phase is to do the mapping of problems identified to their specific process areas. Through Review literature data about SPI and outsourcing, previous work and research about CMMI in outsourcing is collected and

analyzed. Data is collected from various case studies and books. It is important to identify the most relevant process areas which could be needed to perform process improvement in outsourcing projects. The complete life cycle of projects done via outsourcing is studied, various steps and activities involved in software outsourcing, key process areas are identified and explained in Result section (6.1.8).

Moreover Relevant case studies, reports generated by experts and organizations on CMMI website help collecting facts and figures about software outsourcing. The statistical data about outsourcing projects is explained in Chapter 4. Study and research conducted in this phase allowed to make observations that not all the process areas as explained by CMMI are needed in order to perform process improvement for outsourcing projects. Through literature review and suggestions the most important and key process areas are separated from the ones which are of least priority or even maybe excluded due to their low priority in outsourcing projects. To understand life cycle of outsourcing projects a case study is also explained in Chapter 4. Additional data about main activities involved in outsourcing projects, why few process areas are of most concern and how generic and specific goals can be achieved by applying generic and specific practices and Process improvement methods on basis of CMMI were gathered and statistically analyzed. Reports generated by CMMI experts and their opinions about how process improvement methods can help clients and outsourcing companies are taken into account. Suggestions are made for both the clients and outsourcing companies as how best practices should be performed throughout the life cycle of the outsourcing projects. This thorough study of outsourcing and CMMI will answer one of the sub research question to Identify the most important process areas (considering CMMI models) when assessing “process-improvement” in outsourcing projects.

This detailed study identifies the key process areas for outsourcing under the light of CMMI were identified which are explained in details and can be read in Results Section (6.1.10).

The research provides insight about the most important process areas that include project planning, Risk Management, Requirements Management, Project Monitoring and Control, Configuration Management in Project Management Area of CMMI, Software process and product quality Assurance in Support section of CMMI.

Furthermore case studies help us to understand the gaps and hurdles in process improvement methods in outsourcing projects which allow us to design a model which can help clients and outsourcing firms to improve the main process areas by applying CMMI techniques in more refined and clear form. Section (6.1) presented the results.

### **2.5. Phase 4: Design and Development**

The final phase of design methodology comprises of the suggestions and results. The overall research outcome from different phases provides detailed knowledge to design, develop and establish process improvement methods in form of a model and key activities involved in process improvement in outsourcing projects. The Model is based on CMMI specific goals and specific practices. The Model comprises of key process areas mapped with the identified problems and will provide key activities in order to achieve specific goals and implement the specific activities



provided by CMMI. This whole will work as a process improvement for outsourcing projects. The designed framework allows software outsourcing and clients to focus on important process areas and to achieve the goals and objectives by applying the best practices. The framework for process improvement accommodates organizations to develop products in less time, low budget and better quality.

The designed framework should best fit the outsourcing projects. This research phase will answer our main research question that How to establish a set of software development process improvement methods for the software outsourcing based on CMMI?

This is described in details in Results section and a complete theoretical model with all the key activities required in different process areas will be presented in order to fulfill the aims, objectives and goals of this research and Master thesis. The model can be seen in Result Section 6.1. The key activities required to improve a process can be found in Result Section (6.2).

The Figure-3 below explains the design and research approach including Process steps, Results and discussions and outcomes and arranged in proper sequence.

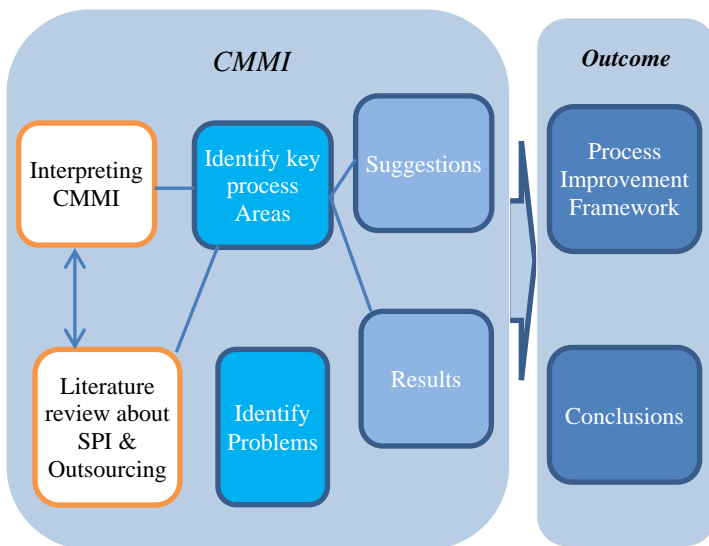


Figure 3. . Research Methodology

## CHAPTER 3

### 3. SOFTWARE PROCESS IMPROVEMENT AND MODELS

The purpose of this chapter is to introduce SPI to the reader. First the basic concepts of SPI and a brief overview of SPI are given. Secondly Importance and reasons for SPI, and Life cycle of SPI is presented. Last in this chapter examples and methods to improve SPI will be discussed.

#### 3.1. What is a Process

SEI defines process as “The organization of people; automated support, procedures and standards into work activities designed to produce a specific end result” [2].

The process integrates the people, tools, and rules, as shown in Figure 4, a process require people who are skilled, trained, and motivated and are able to use tools and equipment. Process should be based on defined rules and methods in order to transfer the raw material (input) to the product faced customers (output).

Three main elements of process:

- People: The people who have the skills, training, and motivation.
- Rules and method: The rule and method to implement task.
- Tools and Technology: Techniques and tools must be needed.

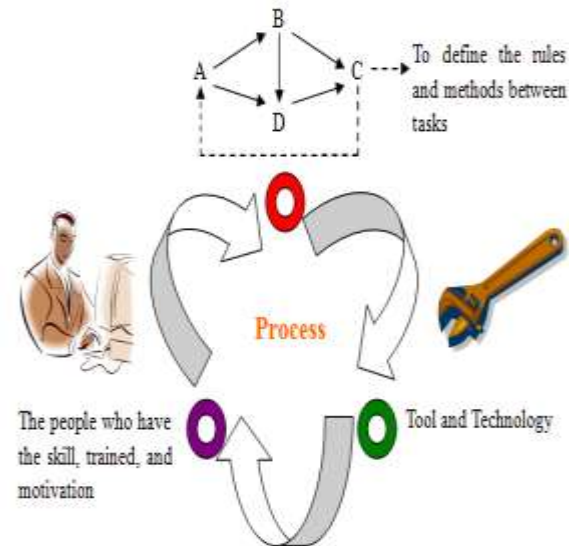


Figure 4. Process

#### 3.2. What is a Software process

According to Watts Humphrey (1993) definition “Software process is the Set of Activities, Methods, and Practices that guide People in the Production of Software [3].”

SEI defined Software process as “The set of activities, methods and transformation that people use to develop and maintain software and the associated products, for example: product plans, designs documents, code, test cases and user manuals” [2].

During the last two decades, the SPI has influenced many enterprises, companies and organizations to put efforts in improving processes for software development in order to develop quality products. The effective software process revolves around the whole system of an organization that includes integrating the people, tools, methods and technologies involved, thus resulting in improving the production efficiency of software development organization, product quality, lower the cost and risks. If the process of an organization is well defined, the organization will make better choices in purchasing tools, efficiency in employing

staff, managing the projects and achieving the goals. A well-defined software process can help organizations to improve their capability and maturity level throughout the business system. Better quality of process will help organization in standardizing software development, improve reusability and consistency of project teams, perform better practices in inter-industry, improve the quality of products, reduce extra cost and save time. It is important to understand the actual position of organization and what are the business goals in order to start process improvement. That is why; companies should identify their process strengths and weaknesses, improvement areas, potential risks and opportunities [4].

Nowadays, the research for the software process can be broadly divided into the following three aspects:

- a. Software process modeling language
- b. Software process support
- c. Software process management and improvement.

### 3.2.1. Software Process- Objective

If the process is not well defined, organized and well-disciplined for example uncontrolled requirements, unmanaged activities, poor project planning, uncontrolled quality, no project tracking and no risks and mitigation plans, uncontrolled release will result in a low quality software product or sometimes even a fail product. We can say that quality of the software product is managed by the quality of the software process and if the process is well defined, managed, controlled, measureable and effective the end result will be according to the expectations.

Organizations find ways to improve their process capability in order to jump from a pre-maturation level to next level of maturity. Much of the effort is put on development tasks, testing and documentation, nobody wants to take responsibility in improving overall development process hence without focusing on quality of the process there will be no improvement in developed software products. It is the responsibility of the top level management to think about process improvement programs inside an organization.

### 3.3. What is Software process improvement

Karl E. Wiegers explains process improvement as simply: “consistently apply the practices that give you good results, and change the practices that cause problems” [5]. The motivation behind SPI is to achieve business goals and develop quality products through a mature process and practices.

The objectives of software process improvement is to set methods in order to improve the development process including project management, eliciting and managing requirements, decision making, measuring performance, planning the work, handling the risks and many more[6]. It’s important that organization should analyze the organizational structure and process and identify the main reasons behind their failed and successful projects and take measures to make improvements wherever needed.

Software organization are using SPI product suites, frameworks, models and self-made techniques in order to improve process capability, and trying to advance from a pre-maturation level of process to an improved and mature process. Many Software

Process Improvement Framework designed by experts provides broad and comprehensive interpretation for the software process improvement. The Software Process Improvement Framework, such as Figure 5 explains the process improvement route map and different components involved in continuous improvement.

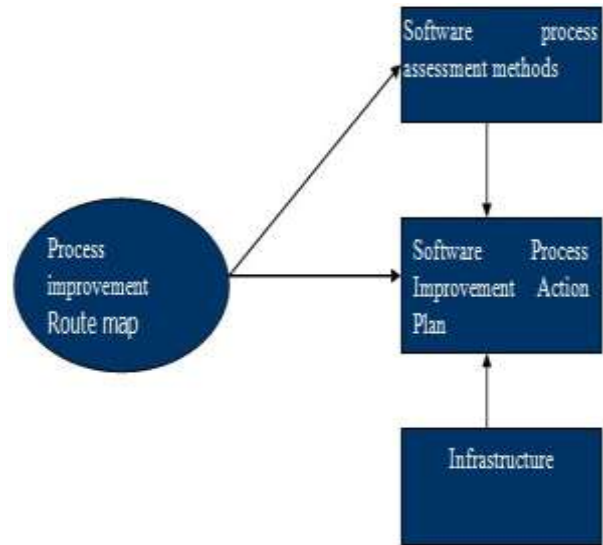


Figure 5. Software Process Improvement Framework [7]

### 3.4. Why SPI is Important

Siakis characterizes the “software crises by an inability to develop software on time, on budget, and within requirements” [8] [9].

Software development has become a complex job in recent decade due to increasing number of projects, competitive environment and the complex development tasks. The competitive market has challenged software companies to complete the projects and develop quality products in desired time and allocated budget. Managing and handling the quality of projects and products is not easy especially when technology changes rapidly. In order to address these issues, it is essential for companies to focus and improve their organizational practices, and processes. The more capable and mature an organizational process the better and quickly they will achieve business results.

It is important to understand that Process improvement means a change in the entire process to get a better output rather than original output. There are lots of factors that will affect the project and product quality, and their role is very important in software process, such as [2]:

- a. Project should be with in time;
- b. Under budget;
- c. Better quality;
- d. For long term business;
- e. Reuse.

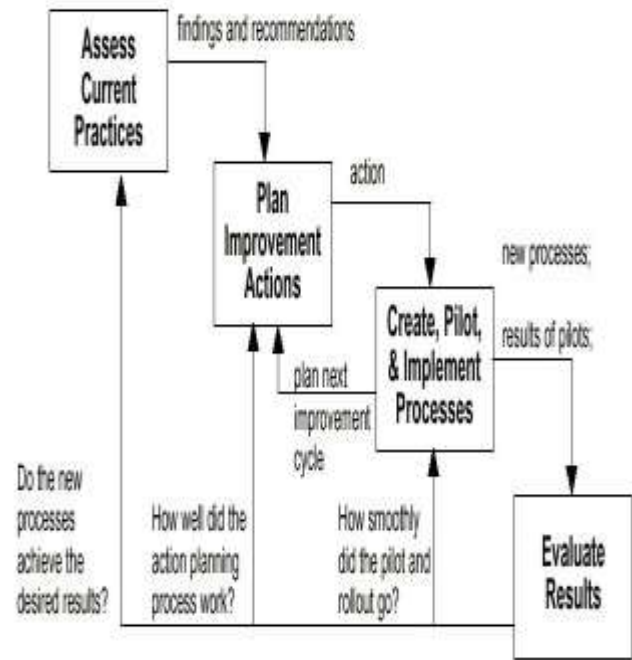
The process improvement methods can help organizations manage their resources effectively, organize people and procedures, update technologies, reduce cost and time and do job in much faster, efficient, quick, safer and easy ways.

Below is the list of some companies and organizations that started to work on SPI and the results they got from the process improvement.

- a. **Motorola Personal Software Process (PSP) Results:** Motorola leads the way with the successful industrial implementation of the Personal Software Process (PSP). A Motorola Division in Boynton Beach, Florida used the PSP to achieve zero defects in use over 18 software projects, removing over 76% of their defects before testing began [10].
- b. **IBM Defect Prevention Results:** Following the publication of Philip Crosby's book, "Quality is Free," an IBM division in Research Triangle Park, North Carolina successfully pioneered, mastered, and used the Software Defect Prevention Process, achieving 50% quality improvement the first time used, and up to 99% quality improvement in other instances, without product appraisal activities, that is Inspection and Test [11].
- c. **Motorola Capability Maturity Model (CMM) Results:** Motorola is a world leader in applying Statistical Process Control (SPC) to hardware design and manufacturing processes. Only recently has Motorola's software development management begun to match their world renowned quality management performance in hardware, electronics, and communications [12]. A Motorola division in Scottsdale, Arizona achieved Level 5 of the Software Engineering Institute's Capability Maturity Model for Software (CMM) [13], in December of 1996 [14]. Motorola has shown that CMM Level 5 organizations perform an order of magnitude better than Level 1 organizations, in terms of productivity, quality, and cycle time.
- d. **Raytheon Network Centric Systems, North Texas, and CMMI-Based Process Improvement:** The organization's Cost Performance Index (CPI) and Schedule Performance Index (SPI) address its business objectives of meeting budget and schedule commitments. These measures are equally applicable to software, systems, and hardware engineering [15].

From above examples of SPI, we made this conclusion that software industry is focusing more on software development process, and by improving and taking right actions at right time on right process can produce high quality process which can deliver high quality products.

### 3.5. SPI Life Cycle



**Figure 6. The Software Process Improvement Life Cycle (Wiegiers 1999) [5]**

The Figure 6 explains the process improvement activities as defined by Karl E. Wiegiers.

1. Define desired organizational business objective and goals.
2. Evaluate the current process, problems and Project outcomes.
3. Do proper assessment of all those processes in order to get clear insight of current process, problems and outcomes and also to explore the best software practices.
4. Set improvement Goals in specific area or process, start from small set of appropriate practices in order to reach the goal smoothly and steadily.
5. Identify the Projects where new process will be pilot and improvement will be created and launched make needed adjustment before implementing it.
6. It's very important to Plan all these new methods and practices in order to get maximum benefit from the process improvement.
7. The most important point is to implement an action plan in order to get successful results.
8. Monitor the changes and make adjustments to make things clearer.
9. Continue the process improvement program in other process as per requirement and data obtained from making various changes and do that according to the needs.

## 3.6. Software Process Improvement Models

This section only describes the names and provides basic introduction about different process improvement models. It does not provide the detailed description and aspects of these models or their relationship with outsourcing, to get more information about these models reader can refer the references.

### 3.6.1. SIX SIGMA

Six Sigma is a process improvement management framework to achieve bottom-line results, and customer's loyalty. In short the objective of Six Sigma is the implementation of a measurement-based strategy that is focused on process improvement and variation reduction (Bendell 2000) [16].

Six Sigma proposes software quality improvement approach called DMAIC which stands for define, measure, analyze, improve and control. Six Sigma helps in improving capability of an organization by providing various tools and methods which help companies to achieve their goals by setting a business strategy. This is done by eliminating defects and providing solutions for quality control. This methodology helps organizations in improving quality of their process, managing the resources and ways to drive out waste. The methods increase performance and efficiency in various activities such as manufacturing and management thus resulting in business profitability and improved operations. Six Sigma is originally designed by Motorola for efficiently managing its process to build cheap and quality products.

### 3.6.2. TickIT Guide ISO 9001

TicketIT project started in 1991 with the purpose of stimulating software system developers to think about process quality, how to achieve the desired quality and how to manage this quality in order to perform continuous improvement. TicketIT also provides a practical framework for the management of software development quality [17].

The basic purpose of this framework was to define and design guidelines for the development teams to follow the ISO 9001 requirements and standards.

### 3.6.3. SPICE

Spice was established by an organization in 1993 and SPICE stands for software Process Improvement and Capability Determination. SPICE was inspired by CMM and other software process improvement models.

Main purpose of SPICE framework is to analyze and assess the software process and on these assessments, provide information about process strengths, weaknesses and capability to achieve its goals. The definition of the term "process assessment" is "A disciplined evaluation of an organization's software processes against the process model or variant model described in this International Standard." [18]

### 3.6.4. BOOTSTRAP

BOOTSTRAP was originally designed by using SEI model as starting point and extended on features from ISO 9001 guidelines [19].

BOOTSTRAP is a European method for software process assessment and improvement that was designed and developed to speed up the application of software engineering technology (Zahran, 1998)[20]. The interesting feature of BOOTSTRAP is its suitability for all kinds of software development organization whether they are small or big. BOOTSTRAP method covers the following key points.

- Focus on organizational goals and business needs as starting point.
- Provide assessment as first step to process improvement.
- Constructive in nature.
- Provide Questionnaires for complete evaluation of projects.
- Provide Consistent procedure and mandatory assessor both for qualification and training.
- Express capability.
- Open questions.
- Immediate feedback and action planning and corrective measures.

### 3.6.5. CMMI

CMMI is a framework that provides a process improvement setup for the software engineering and product development. CMMI combined best practices and basic principles and interlinked them in order to improve the process inside an organization. [6]. CMMI will be explained in Chapter 5, this chapter is particularly important to read for people who have limited experience of CMMI.

## CHAPTER 4

## 4. SOFTWARE OUTSOURCING

The purpose of this chapter is to give a brief overview about Software outsourcing, introduction and background, Importance of Outsourcing, Cost and gains of outsourcing factors influencing outsourcing, major problems faced by companies in product development and process improvement and finally a case study of how Projects are done via outsourcing to explain the life cycle of outsourcing projects.

### 4.1. Introduction to Outsourcing

World has become a global village and globalization allowed people to communicate and share ideas, cultures, thoughts and business. The emerging technology especially internet has opened new doors for business in field of IT and engineering. Offshoring IT work is a great achievement of globalization [21]. There are six key factors explained by Carmel for global offshoring. The most important and recent one is globalization of trade in service [21]. Second main factor is the friendly business environment, and technology parks made by many countries inviting businesses from others countries [21]. India and Philippines are great examples. Third factor is emerging number of engineers in the



market especially from China [21]. Fourth factor is advanced technology which allows people to communicate using various tools for zero cost [21]. Fifth factor is standardization of software development practices and tools and the last factor is wage difference which provides a huge benefit to companies for lowering the cost [21].

Software development has become a key business driver in today's business industry whether it's ticketing system, online transactions, mobile telephones, sensitive data processing, marketing or controlling hardware. Developing quality and improved software has become goal of various Software companies. The growing competition among them and gaining maximum market share has opened new doors and challenges for developers and employees making it worst for clients and customers. The customers need flexible and quality products with efficient performance in low cost and short time, but the software development has become a complex job due to following reasons.

- a. Multidimensionality of Software's products
- b. Intangible Nature
- c. Uncertainty of Software development
- d. Complex process
- e. Advanced technology
- f. Rapid changes

In order to deal with all these challenges companies have started to hire services both in form of products and process from outside world. They contact companies for system development, application development and managing complex operational and organizational process. The phenomenon is called outsourcing or offshore development. James D. Herbsleb explain that a project performed in global environment must have following capabilities, geographic location, plan practices and technology to support the level of coordination, shared understanding of requirements, understanding the architecture and set of tactics to improve the fit and finally effectively manage change[22].

The reason behind software outsourcing was the cost, time, and developing quality products in short time. One another major reason is companies focus on building core products and when they have to integrate their products or add latest features to their products which are not in their domain as per client need or they start new test projects they do not prefer in building an entire new setup for a specific product so they can stay focused on their core competence and to overcome this problem they hire people from outsourcing industry for such products and services.

## 4.2. Outsourcing Background

The phenomenon of outsourcing is not new, it started way back in 1960's and 70's when computers and other related technology tend to be very expensive. Setting up the hardware and big machines with sophisticated mechanism and operations was the major problem for companies to adopt new technology trends. In order to overcome these complex issues companies hired services from other companies with such advanced and complex setups. Mostly the Data process functions and services were hired in order to perform operation management tasks. In 90's when DBMS and other commination tools were launched many companies rely on companies with such skills in order to operate their management tasks. A contract programming agreement was made which was a form of an outsourcing [23].

The real trend of outsourcing started in 1990's when companies built their own setup and started building new innovative products but soon they found lack of resources and technology. The technology was grooming at rapid pace so many new companies were emerging making competition worst for the ongoing companies. They were not finding enough time and resources to build their core products if they started working on innovative products or products which were the requirement of market at that time. In order to sort this issue they hired many companies with basic services such as development, management, engineering and verification and validation of the products.

## 4.3. Why Outsourcing is Important

Software outsourcing has been used for many years, due to its format and clear objectives, however, the major reason companies adopt outsourcing is the effective strategies companies can adopt in order to improve their core business products, processes and services. Outsourcing from past till present has provided low end, non-core and labor intense activities including production, managing and consultations. Now a days outsourcing is multi-dimensional in nature and provide services such as,

- Core Product Development
- IT support
- Project Management
- Requirement Engineering,
- Network support and centers
- Application development and maintenance
- System integration
- System testing
- System development
- Application Development
- Data centers and maintenance
- Data processing
- Databases
- Research and development (R & D)
- Product Development
- IT Security Services and Management
- Risk Management
- Human Resource Management
- Help and Support

Outsourcing can provide a number of benefits that help organizations to improve performance, efficiency and ability to deliver innovative solutions along with increasing reliability and low budget.

Figure-7 shows the main factors to do outsourcing. The stats in the figure are from year 2008 and 2009. Outcomes of the benefits gained by companies in doing outsourcing are cost saving, improve IT efficiency and save time for companies to focus on core business.

TOP FACTORS INFLUENCING DECISION TO OUTSOURCE

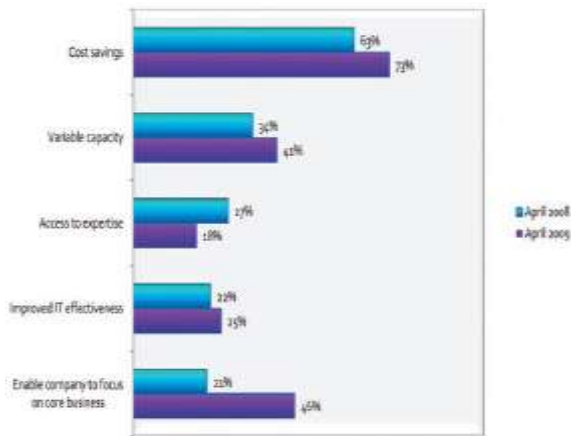


Figure 7. Top factors influencing decision outsource [24]

#### 4.4. Costs and Gains of Outsourcing

It is important to know what can be outsourced and why. Nowadays, many companies and organization choose outsourcing, and these companies and organization are distributing in many different fields, such as: web site hosting, IT infrastructure, pc management, network and communication services and many more. In the CIO magazine, they survey and collect the data of outsourcing market, which show the percentage of company of different field that outsource it service.

From the data of Figure-8, it has been observed that 69% of companies outsource IT services on the basis of market survey. So, the software outsourcing has a large market in the business of world industry.

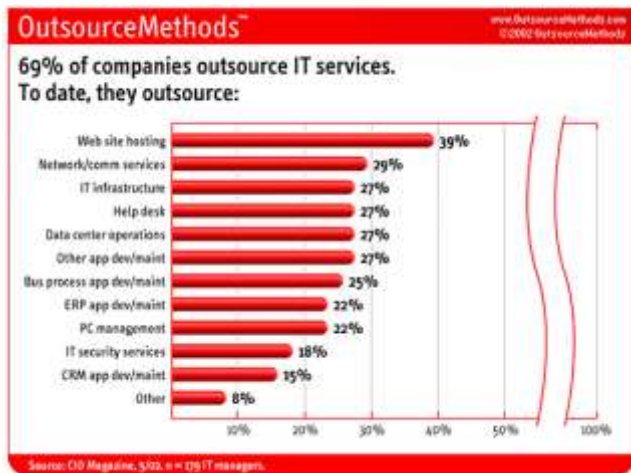
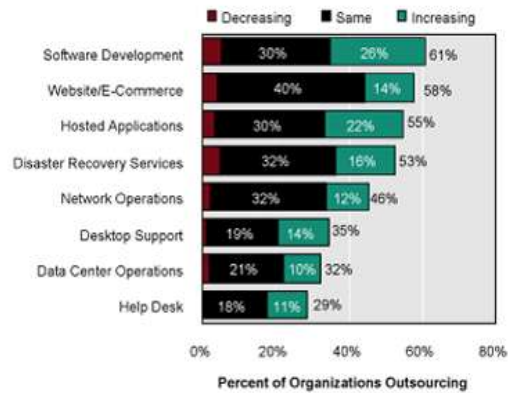


Figure 8. Market survey of outsourcing [25]

According to the 2006 market scenario, the survey department had surveyed and collected lots of data about use and growth of outsourcing in the different fields, and calculates percentage about outsourcing. Figure-9 Shows the decreasing and increasing statistics about software outsourcing.

Use and Growth of Outsourcing: All Sectors



Source: Computer Economics, 2006

Figure 9. Use and Growth of Outsourcing: All sectors [25]

Outsourcing is mostly done in third world countries such as India and Pakistan and among developed countries such as china, turkey and few countries in Europe such as Scotland, England are emerging in this business. The major advantage third world countries provide is the cost, as labor cost and taxes are much lower than some of developed part of the world. Outsourcing in developed countries provides quality products and services in short time which save cost and resources.

#### 4.5. Case Study [26]

In this section, we will study the Microsoft software outsourcing project, in this case, we will find out why Microsoft was in need to outsource few projects, mode of operation, and the problem they will faced.

##### Overview

- Product: FTP Adapter for BizTalk 2002.
- The original development department: E-Business Service Davison.
- The reason of outsourcing: The original human resources transfer to another important project development.
- Outsourcing advocates: Project manager.
- Outsourcing decision-makers: General Manager of department of product development.
- Contractor: Satyam Computer Service Ltd.
- Mode: Virtual team mode.

##### Start-up and signing

- The project manager of Microsoft first contracts the outsourcing contractor through email, and Informs about overall information.
- The project manager of Microsoft meets the local manager of outsourcing contractor, and discusses the project implementation plan from the business perspective (no technology).
- Contractor fills in the RFI (Request for information)

form that project manager of Microsoft provides.

- Project manager of Microsoft provides project design specification to the contractor.
- Contractor does drafting of contract agreement to follow the project design specification (Proposal).
- The department of product of Microsoft discusses the contract agreement through phone meeting with contractor.
- Contractor will provide a Sample Model in two weeks.
- Contractor presents the model in Microsoft.
- Microsoft formally signs the contract with contractor.
- Contractor has two weeks to prepare project, include management and process of Microsoft, and be familiar with the environment.

### Cost accounting

Fixed fee:

- ✓ Development
- ✓ Testing
- ✓ SDK

### Results

◆ Include:

- ✓ Product
- ✓ Source code
- ✓ Design specification
- ✓ Test Automation, code, use case text, specification
- ✓ Product support

◆ Don't include:

- ✓ Product specification
- ✓ Localization

### Team of outsourcing contractor

- Senior decision-makers (Dealing with major issues)
- Project manager (resides in Microsoft)
- Leader of development (master of computer software + work experience of five years)
- Development engineer (work experience of three years)
- Leader of testing (master of computer software + work experience of three years)
- Testing engineer (work experience of two years)

### Daily work

- The project meeting is once a week, the project manager of Microsoft Presides over meeting through NET Meeting.
- Usually, Bug Triage meeting is once a day follows the working condition.
- Project Design Review
- Code review

- Testing Design Review
- Testing code Review
- The contractor project manager of Microsoft who contracts with contractor team at any time.

### Contractor project manager reside in Microsoft

◆ Responsibility:

- To exercises the project management responsibility with project manager of Microsoft.
- Common contact person between contractor and Microsoft.
- To look for help and technology support for contractor team in Microsoft.
- To help Microsoft project manager to understand contractor team's condition, and accurately convey the instructions to contractor team

◆ Condition:

- With strong ability of communication, coordination.
- Understanding technology and can communicate with technical staff of Microsoft.
- Familiar with Microsoft project process and management method.

### The problem between two sides

◆ Microsoft:

- The communication of across time, space and culture.
- To detect the problems of contractor team and project, timely and promptly take appropriate measures.
- To understand contractor corporate management and culture.

◆ Contractor

- Familiar with the Microsoft environment and management of projects quickly.
- Accurately estimate the project effort.
- To achieve Microsoft's quality standards and testing requirements.
- Adapt to differences in culture and management.

## CHAPTER 5

### 5. CAPABILITY MATURITY MODEL INTERGRATION

The purpose of this chapter is to introduce CMMI. First an introduction of what is CMMI, background, purpose and history. Secondly explain the Core process areas, components of CMMI and structure of continuous and staged representation. Finally Generic Goals and Generic practices of CMMI model for Development.

#### 5.1. Introduction

The world has become a global village allowing companies to expand their business across borders and sharing resources with other companies in order to provide better products and services. Rapid growth in technology and changes in business environment have evolved tough competition producing lot of pressure on organizations. Customers increasing needs for cheap, faster and high quality products have lead companies to build more complex and advanced products especially software. Only well-organized and well-structured organization can survive in today's world of Software Engineering. In order to maintain quality of the product and service organizations are hiring staff which is highly skilled and professional not only in development but also in management.

In order to achieve business goals companies need to control and structure their core business process especially project management, control, configuration, quality control, development, risk handling and maintenance process. Companies acquire various methods, techniques, standards and models to properly manage their core business process. However most of the approaches followed by companies now a day lead them to improve some specific process area of the business only not the entire system. Much of the resources go in waste without any positive results. In order to overcome these challenges and provide a complete software process improvement model that should work through the life cycle of product CMMI was developed.

#### 5.2. Process Improvement according to CMMI

CMMI research discovered three key elements in development of any product and service. As shown in Figure 10.

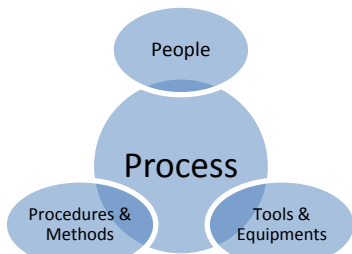


Figure 10. Three Dimensions

In any organization the first major thing is the people who are the key drivers. These are the highly skilled people with lot of motivation and training and they know their goals. The second

driver is the tools and equipment provided by an organization. Latest technologies and advanced setup are built in order to produce best results. Then there are methods and procedures that are needed to be followed in order to achieve organizations goals effectively and efficiently well within time and budget. All these three key drivers form a process. People cannot be good every day, it may require more time and resources to learn new technology trends, procedures and methods may vary in different environment but if an organization has a quality process its performance will increase rapidly because the companies who focus on process don't have to put extra effort in people, procedures and technologies they just work smartly and improve the process.

#### 5.3. History of CMMI

In the 1984, the United States Department of Defense (USDD) decided to hire a software company for development of new software. Since there was no way to evaluate the company's ability to develop software, they consigned the Carnegie Mellon University and Software Engineering Institute (CMU/SEI) to research and create a set of engineering system, which can evaluate the capability of Software Contractor and help the Software Contractor to improve the product quality. In the 1987, the SEI created the first Software Capability Maturity Model (CMM), it was CMM 1.0. In 1993, SEI released the CMMI 1.1. After the CMM 1.0 released, there were lots of units and they developed their own CMM series in the different fields, such as: Systems Engineering Capability Maturity Model (SE-CMM), Integrated Product Development Capability Maturity Model (IPD-CMM), People Capability Maturity Model (P-CMM), etc. In the Dec, 2000, the SEI released the Capability Maturity Model Integration (CMMI), which integrated the SW-CMM 2.0, Systems Engineering Capability Model (SECM), and IPD-CMM 0.98. In the subsequent development process and the principle of continuous improvement, CMMI product team continues to assess the change request and the corresponding changes and gradually to the current version CMMI 1.3. As shown in Figure 11.

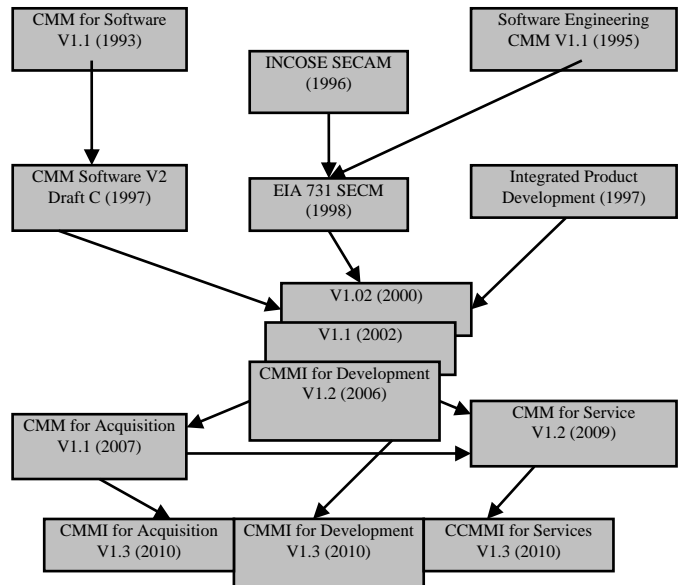


Figure 11. CMMI History Chart [1]



## 5.4. Evolution of CMMI

CMMI evolved by combining various CMM models in order to solve an issue of using different versions of CMM. The intentions were to build a complete framework using predecessors that should cover all the key process and core business areas. Companies were invited for process improvement program over the years and by collecting their feedback the engineers accommodated a model with multiple dimensions and a single improvement model evolved.

## 5.5. CMMI Framework

The CMMI Framework provides the structure needed to produce CMMI models, training, and appraisal components. To allow the use of multiple models within the CMMI Framework, model components are classified as either common to all CMMI models or applicable to a specific model. The common material is called the “CMMI Model Foundation” or “CMF” [1].

## 5.6. CMMI

CMMI model is designed and generated from CMMI framework that provides a process improvement setup for the software engineering and product development. CMMI combined best practices and basic principles and interlinked them in order to improve the process inside an organization.

Some of the main elements of a CMMI model include specific practices, generic practices, specific goals, generic goals, process areas, capability levels, and maturity levels [1].

### 5.6.1. CMMI for Development

CMMI for Development is a reference model that covers activities for developing both products and services. Organizations from many industries, including aerospace, banking, computer hardware, software, defense, automobile manufacturing, and telecommunications, use CMMI for Development [1].

CMMI for Development contains practices that cover project management, process management, systems engineering, hardware engineering, software engineering, and other supporting processes used in development and maintenance [1].

## 5.7. Why Use CMMI

The major advantage of using CMMI by an organization is to reduce cost, utilize resources effectively, stream line things and manage the resources of organization in order so it could produce the products which are of high quality and low cost. The focus of CMMI is on improving the quality of the process. As we explain the importance of the process in section 3.4, it’s clearly understood that a quality process can certainly help building quality products by eliminating waste and reducing the consumption of too many resources such as time, money and efforts.

### • **Implementation vs. Institutionalization**

It’s important to understand these two important terms:

- **Implementation** according to CMMI is defined as the tasks which are performed within a process area such as project management or configuration management.

- **Institutionalization** is defined as the outcome and result that we get from process implementation within a process area is called institutionalization.

### **Process Areas and Components**

CMMI covers 16 core process areas that are the base to process improvement in different areas such as CMMI for acquisition, development and services. The components of CMMI are categorized into three categories which are required, expected and informative. Figure 13 shows the relationship of components.

#### **Required Components**

These are the most essential components in order to satisfy a process area. They should be focused first inside an organization and implemented right away in order to improve a specific process area. It consists of specific goals and generic goals.

#### **Expected Components**

In order to fulfill the requirements for the required components CMMI provide certain activities which are specific practices and generic practices. Expected components are for estimation experts who want to improve the quality of a required process.

#### **Informative Components**

Informative components are the relevant information in form of examples, references, sample work, notes and detailed information about how to satisfy and understand required and expected components. As shown in Figure 12 and Table 1.

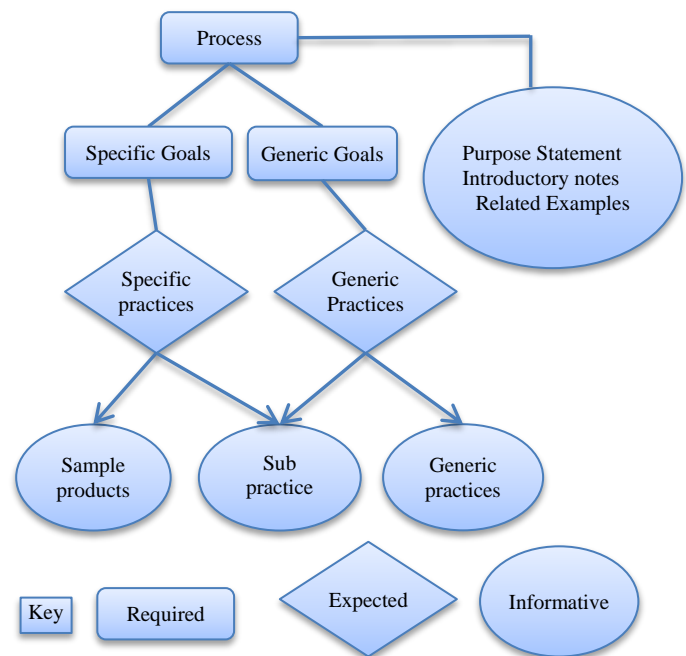


Figure 12. CMMI Components [1]

**Table 1. Process improvement components and purpose**

Component	Purpose
Purpose statement	Describes the purpose of the process area.
Introductory notes	Describe the major concepts covered in process areas
Related Process	Reflects the high level relationship among the related process areas.
Specific Goals	Describe the unique characteristics that must be present to satisfy the process area.
Generic Goals	Describe the characteristics that must be present to institutionalize processes that implement a process area.
Specific practices	Describe the activities expected to result in achievement of the specific goals of a process area.
Generic practices	Describe the activities that are expected to result in achievement of the generic goal and contribute to the institutionalization of the processes associated with a process area.
Sample products	The example work products section lists sample outputs from a specific practice.
Sub practices	Sub practices may be worded as if prescriptive, but they are actually meant only to provide ideas that can be useful for process improvement.

**5.8. Process Areas**

A process area is set of related practices which are used to improve the performance of a process by applying them collectively and satisfying set of goals. There are 22 Process areas. The list of complete process areas can be seen in appendix A.

The process areas in CMMI are grouped into four categories:

- Process Management
- Project Management
- Engineering
- Support

Table 2 below explains the process areas and their classifications.

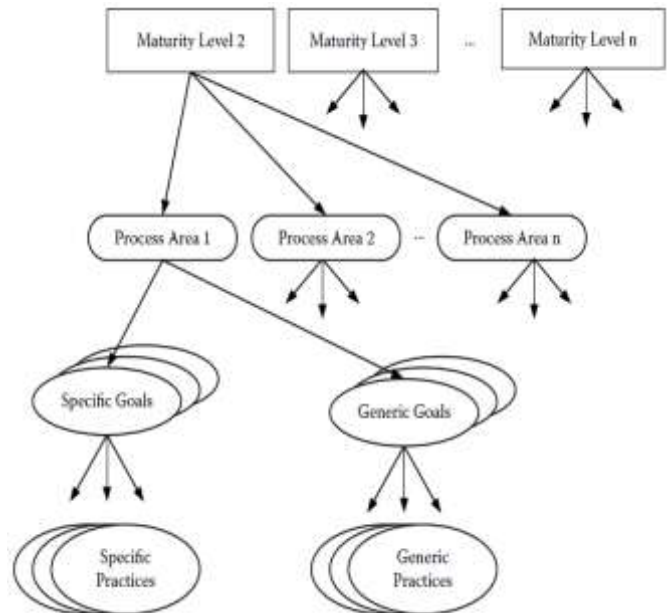
**Table 2 Process areas and their classifications**

Process Management	Project Management	Engineering	Support
OPF OPD+IPPD OT OPP OID	PP PMC SAM RSKM IPM+IPPD QPM	RD REQM TS PI VER VAL	MA PPQA CM CAR DAR

**5.9. Structure of the Continuous and Staged Representation**

CMMI comprises of continuous and staged representation. The difference between them is that staged representation uses step by step approach inside an organization while continuous representation uses individual process area from any level.

In the representation, the process areas are divided by the organizational maturity levels. The staged model provides pre-defined routes for the process improvement by the grouping, verified order and relationship between organizations. There are five maturity levels, which are: Initial, Managed, Defined, Quantitatively Managed, and Optimizing. The “stages” are the representation method of model and these methods describe the pre-defined routes as the stage of “maturity level”. The Figure 13 shows the Structural relationship of component in the Stage representation.



**Figure 13. CMMI model components in the staged representation [1]**

From the Figure 14, it can be seen that the specific goals organize specific practice, the generic goal organize generic practice, every specific practice and generic practice correspond to a capability

level. The specific goal and specific practice just can be used in the individual process area.

### 5.9.1. Maturity level

Maturity level simply stands for level of performance expected from an organization. There are five maturity levels in CMMI. Maturity level provides the method of predictor of future performance in the collection of specific disciplines or subject. Every maturity level of staged is Interdependent, the high level include all the goals and practices of low level. Each level is continuous, and gap does not exist, the organization does the process improvement cannot cross-grade, it means that if you do not archive the level 2, you cannot reach or start level 3, as it provides the “route” for the organization to do the process improvement. The Figure 14 shows the Structured Chart of staged Maturity level.

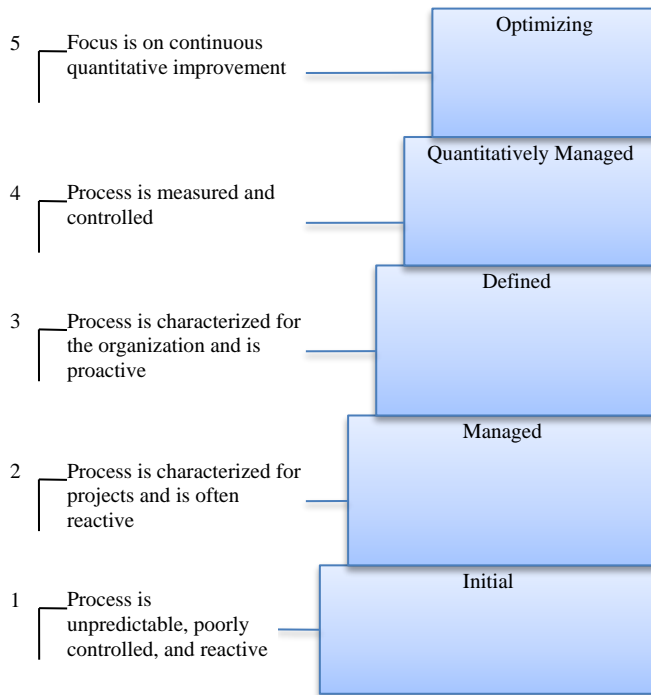


Figure 14. Structure Chart of staged maturity level

### 5.9.2. Maturity level and process area

Table 3 explains the different process areas and their maturity level in staged and continuous representation.

In the staged representation, process area and maturity level have the only corresponding relation, maturity level includes the fixed name and number of process areas, and the process area just belongs to the specific maturity level, the same process cannot exit in different levels.

Table 3. Process Areas with Maturity Level and Category [1]

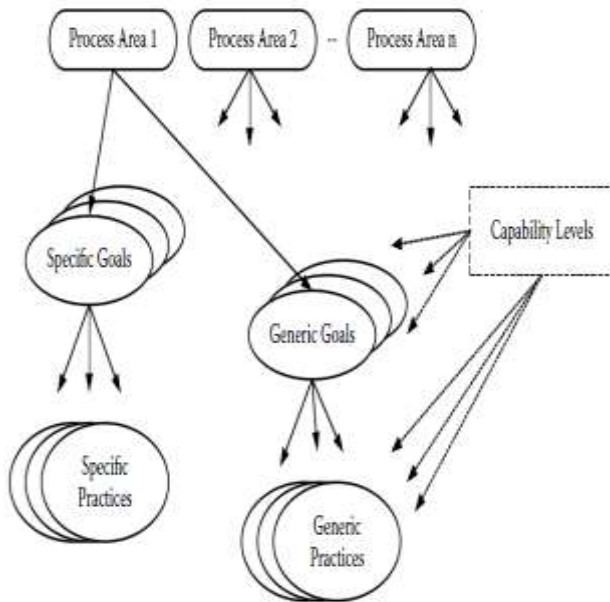
Process Area	Maturity Level (Staged Representation)	Process Area Category(Continuous Representation)
Requirement Management	2	Engineering
Project Planning	2	Project Management
Project Monitoring and Control	2	Project Management
Supplier Agreement Management	2	Project Management
Measurement and Analysis	2	Support
Process and Product Quality Assurance	2	Support
Configuration Management	2	Support
Requirement Development	3	Engineering
Technical Solution	3	Engineering
Product Integration	3	Engineering
Verification	3	Engineering
Validation	3	Engineering
Organizational Process Focus	3	Process Management
Organizational process Definition (with IPPD)	3	Process Management
Organizational Training	3	Process Management
Integrated Project Management (with IPPD)	3	Project Management
Risk Management	3	Project Management
Decision Analysis and Resolution	3	Support
Organizational Process Performance	4	Process Management
Quantitative Project Management	4	Project Management
Organizational Innovation and Deployment	5	Process Management
Casual Analysis and Resolution	5	Support

### 5.10. Continuous representation:

The continuous representation of CMMI has same information but it's arranged in different order. The focus of Continuous representation is to improve a process with a specific process area.

### 5.10.1. Component structure model

Continuous representation is grouped for the process areas in order to follow affinity, and point out the capability level of process improvement in every process area. Figure 15 shows the structural relationship between elements.



**Figure 15. CMMI model components in the continuous representation [1]**

From the Figure 16, it can be seen that the specific goal organizes specific practice, the generic goal organizes generic practice, and every specific practice and generic practice correspond to a capability level. The specific goal and specific practice just can be used in the individual process area.

### 5.10.2. Capability level

CMMI has six capability levels starting from 0 to 5. The capability level comprises of related specific practice and generic practice of process area which can improve the process. The capability levels include: Table 4 explains the capabilities of different levels.

**Table 4. The Capability Levels**

5	Optimizing
4	Quantitatively Managed
3	Defined
2	Managed
1	Performed
0	Incomplete

#### 5.10.2.1. Capability Level 0 Incomplete

The capability level zero has no process capability to perform any generic and specific activities of capability level 1 as described by CMMI.

#### 5.10.2.2. Capability Level 1 Performed

Capability level one is the initial stage of the process improvement in which organizations do something at very basic level. Performance is unstable and nothing can be measured in terms of quality, cost and schedule.

#### 5.10.2.3. Capability Level 2 Managed

At capability level 2 the process complies with the organization policies as they are well planned, controlled and organized. The people performing the tasks are highly skilled and motivated who utilize the resources in structure manner. All the tasks are performed according to defined process and capability level 2 provide the project status can be seen by at certain defined points such as deliverable and mile stones.

#### 5.10.2.4. Capability Level 3 Defined

At capability level 3 the process structured process tailored from the organization's set of standard and more over are described processes, tools and methods with complete understanding and definition. A defined process clearly states the purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria [25].

#### 5.10.2.5. Capability Level 4 Quantitatively Managed

At capability level 4 organizations define the process by controlling it using quantitative and statistical techniques. [56]. Life cycle of the project is managed through out by applying statistical and quantitative methods in terms of product quality, process performance and service quality.

#### 5.10.2.6. Capability Level 5 Optimized

At capability level 5 a process is improved by incremental and innovative improvement. Capability level 5 focuses on analyzing and studying the results and on the entire business process and finds the existing problems in process improvement and fixes them accordingly.

### 5.10.3. Process area capability profile

In the continue representation, the capability profile is a list for the process area and the capability. To combine with the capability level and the profile represent organization achievement of every process area, the process area capability is the result profile. And when the profile represents the process improvement goal of organization, the process area capability is the goal profile. When compare to the goal profile, the result profile can let you not only track the process improvement progress rate, but verify the management results of organization. Process area capability profile can be represented as the two-dimensional point set, they are process dimension (what to do) and capability dimension (how about the work do). See the Figure

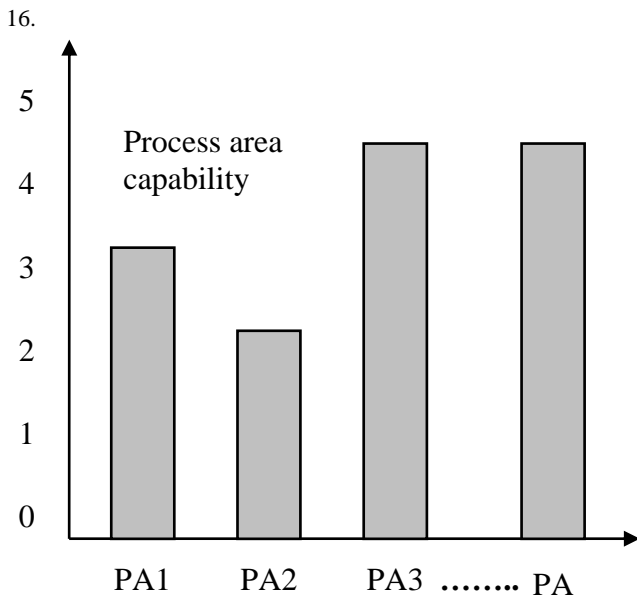


Figure 16. Process area capability profile

### 5.11. Relationship between Goals and practices

To satisfy a certain process area we need certain goals associated to it, we have specific goals which are related to a specific process area and we have generic goals which are common and related to multiple process area and are interlinked.

#### Practices

Practices are set of activities performed in order to satisfy the goals within a process area and each practice related to only one goal at one time. We have specific practices which are related to specific set of goals and we have generic practices which are associated to generic goals in order to perform Institutionalization. Table-3 shows the CMMI Process Area Classification.

#### Relationship among Process Areas

It's important to understand the relationship among various process areas to get a clear picture of how process is implemented and improved and how one process area depends upon the implementation of other process area. CMMI can be applied in more productive and organized way by understanding the key relationship among different process areas.

#### Business Objectives

To initiate a process improvement it's very important to understand the objectives of an organization which are to be achieved by implementing generic and specific practices in particular process area. For example if the goal is to manage the quality of the products the relating process area resides in the support and process improvement initiative should be taken in process and product quality assurance process.

### 5.12. Process Management

Process management is the set of activities, tools and methods required to manage, control, organize, measure, deploy, implement and improve process.

The five main process areas in process management are,

- Organizational Process Definition (OPD)
- Organizational Process Focus (OPF)
- Organizational Performance Management (OPM)
- Organizational Process Performance (OPP)
- Organizational Training (OT)

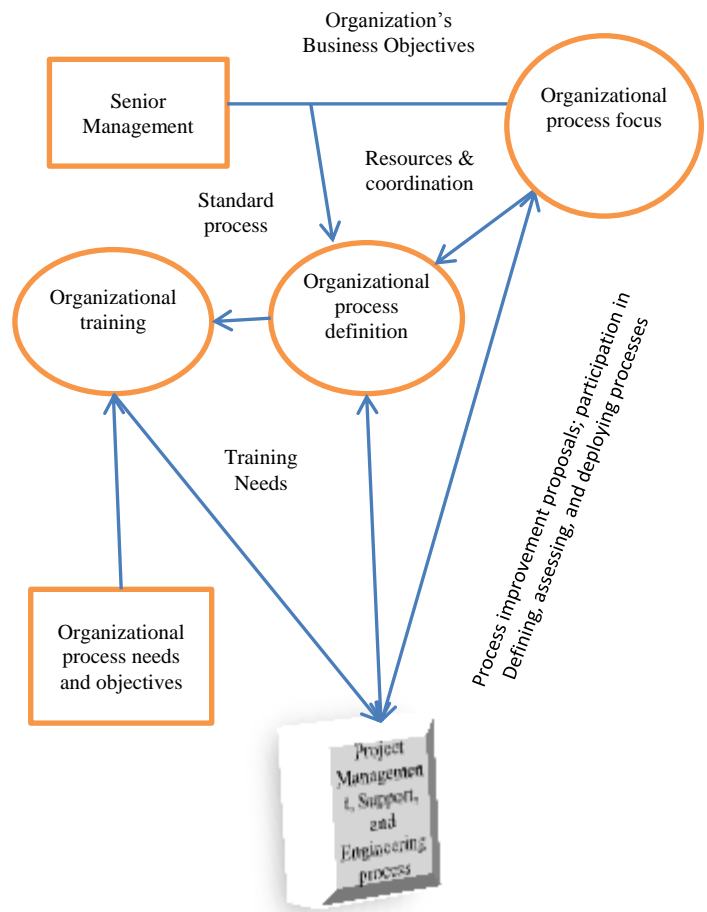


Figure 17. Basic Process Management Process Areas [1]

Figure 17 explains the basic process management process areas and activities involved in improvement.

### 5.13. Project Management Process Areas

Project management process area covers all the activities related to planning, controlling, organization, and monitoring the project. The key process areas of project management process Areas are,

- Integrated Project Management (IPM)
- Project Monitoring and Control (PMC)



Project Planning (PP)  
Quantitative Project Management (QPM)  
Requirements Management (REQM)  
Risk Management (RSKM) Supplier Agreement Management (SAM)

The areas of project management we going to focus in outsourcing project are,

- Project Monitoring and Control (PMC)
- Project Planning (PP)
- Requirements Management (REQM)

Project Monitoring and Control (PMC)

The project monitoring and control process area covers the activities involved in controlling and managing the project, understanding the process capability and controlling it time to time and take corrective actions in case something is wrong or not working according to the plan.

Project Planning (PP)

The purpose of this process area is to describe a complete plan of activities, tasks, resources and milestones in an ordered fashion. The plan also covers all the development and management activities of the project.

## 5.15. Support

Supporting activities contain the process area which is involved in maintenance and development phase by supporting other process areas.

The five Support process areas in CMMI-DEV are as follows

Causal Analysis and Resolution (CAR)  
Configuration Management (CM)  
Decision Analysis and Resolution (DAR)  
Measurement and Analysis (MA)  
Process and Product Quality Assurance (PPQA)

*Process and Product Quality Assurance (PPQA)*

The Process and Product Quality Assurance process area supports all process areas by providing specific practices. The purpose of these practices is to evaluate the performance of a process, work products and services against the applicable process, standards and procedures. PPQA also provide practices to fix the bugs and issues which are found during review.

*Configuration Management (CM)*

The Configuration Management process area supports all process areas by establishing such as configuration control, audits, status, identification and configuration identification. The configuration management products are the ones delivered to customers. IT also includes internal work products, tools and acquired products [1]. Plans, process descriptions, requirements, design data, product specifications, code, compilers, data files, and technical publications are all examples of configuration management work products.

Requirement Management (REQM)

The REQM process area manages and controls the management activities related to requirement engineering such as change in the requirement, change in the requirement or updating of the requirement. It provides traceability of requirements from customer requirements to product requirements to product component requirements [1]. This process area also controls the change in all the plans and activities when a requirement is changed.

## 5.14. Engineering

Engineering process area covers the core activities involved in development and maintenance phase of Engineering disciplines.

The five Engineering process areas in CMMI-DEV are as follows:

Product Integration (PI)  
Requirements Development (RD)  
Technical Solution (TS)  
Validation (VAL)  
Verification (VER)

## Generic Goals and Generic Practices

Defining all Generic goals and generic practices of CMMI are way beyond the scope of this Master thesis, hence the generic goals with their Generic and Sub practices are summarized in Check Appendix B for complete list of Generic Goals, Generic practices and related practices and work example work products.

# CHAPTER 6

## 6. RESULTS

The purpose of this chapter is to describe the Results obtains by conducting this research. First section contains the proposed model which the authors of this thesis have designed. It was totally based on system review of CMMI, outsourcing and Software process improvement and results from different sections of CMMI and outsourcing. Different sections of model including scope, level, architecture and relationship of different components of models are discussed briefly. Second section describes the problems identified in the outsourcing projects by the authors of this thesis. This was done by understanding the life cycle of outsourcing projects and after that by reading many case studies about outsourcing projects. Lot of content provided by outsourcing companies on their websites about the problems they faced in process improvement was studied and reviewed. This section also explains how the key process areas are identified on basis of these problems and how they are categorized. The last section describes the key activities required to perform by outsourcing companies in identified process areas in order to start software process improvement.

## 6.1. Model Proposal

The proposed name for this model is “SPIMO” which stands for software process improvement model for outsourcing.

The SPIMO-Model is a framework that could be applied by software outsourcing organizations to guide them in improving their software processes. This model explains the key components which are required to achieve an effective process improvement. The activities explained by SPIMO model provide ways to improve the efficiency and performance of Outsourcing organizations.

The SPIMO-Model is based on CMMI best practices. It describes Process areas, Specific goals, Specific practices and key activities which if processed and implemented according to specific guide can help outsourcing companies to achieve their business goals effectively.

### 6.1.1. Scope

Only the important process areas and key activities related to those process areas are identified in SPIMO-Model. SPIMO-Model can only be used for outsourcing project both in-house and offshore development.

### 6.1.2. Foundation of Model

SPIMO-Model is totally based on CMMI and the reason to that was CMMI has been working with many enterprises and companies over the year to make changes to their existing models on the feedback. So this model is based on up-to-date research. However the architecture has been tailored to best fit the outsourcing projects so some changes are made.

- Process areas are identified for process improvement.
- Implementation methods were defined for every process areas.
- Key activities are included to support implementation of practices and achieving specific goals.

The differences between CMMI and the SPIMO-model is that CMMI only explains what are the specific goals and what practices revolved around those specific goals but SPIMO provide set of activities which will provide a support for implementation of those best practices with defined criteria as shown in Figure 18 and Table 5.

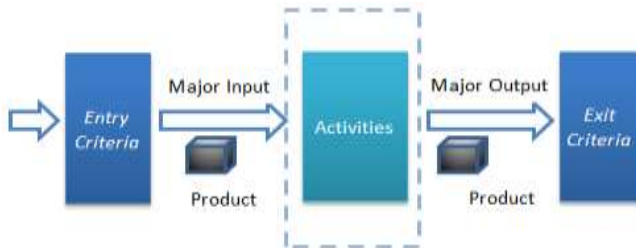


Figure 18. Process of Key Activities

Table 5. Process of Key Activities

<b>Entry Criteria</b>	A prerequisite for entering the process
<b>Major Input</b>	Required data and documents for implementing the activities of process
<b>Activities</b>	Related work required
<b>Major Output</b>	Data and documents generated by ending the process
<b>Exit Criteria</b>	necessary conditions for exiting the process

This version of the SPIMO-Model covers six process areas and their specific goals and specific practices. As shown in Figure 19.

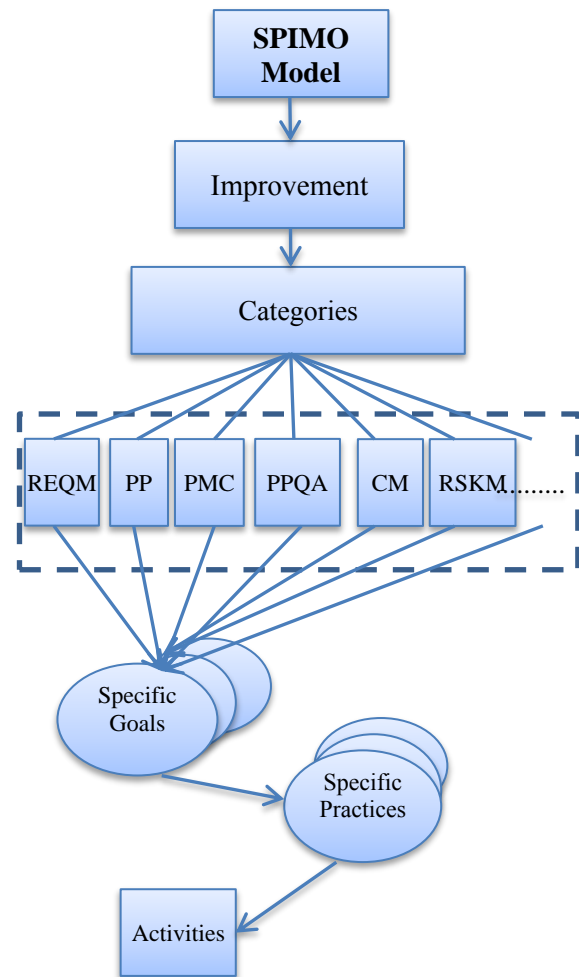


Figure 19. Architecture of the Model

### 6.1.3. Main Sections of The model

**Improvement section** support outsourcing companies to identify the key process areas which they need to focus on for process improvement.

**The categories section** categories the process areas into different categories.

The key process areas identified by us in this research are six. But if outsourcing companies identify more process areas they can include them in the model.

Specific goals and Specific practices sections are same as explained by CMMI.

Activities section provides support for the implementation of specific practices in order to achieve the specific goals. Activities section is to integrate specific practices into activities, which can help project team to understand the process area quickly and what and how to implement in order to improve software process.

#### 6.1.4. How to Use SPIMO-MODEL

The purpose of the improvement section is to support outsourcing companies in establishing defined processes. It indicates the areas that an organization should focus on to improve its software processes. This section consists of 6 categories where each category contains number of specific goals, specific practices and key activities. This structure was influenced by CMMI with the difference that a CMMI provide the specific goals and specific practices but does not tell how these practices should be implemented or practically performed.

The SPISO-Model was designed to assist outsourcing companies and organizations in selecting software process improvement strategies. This is achieved by determining the key process areas. The KPAs are identified by finding the problems and issues most critical in process improvement by understanding the life cycle of outsourcing projects and mapping them with KPAs. When this is done the organization can put their focus on a specific set of activities that needs to be performed in order to start improvement and begin their work towards a more mature process.

#### 6.1.5. Importance of SPIMO-MODEL

The SPIMO-Model was designed to assist software outsourcing companies in selecting software process improvement methods in order to improve their software process. This is achieved by identifying the most important process areas and explaining their specific goals and specific practices. When this is done the organizations can put their focus on improvement methods which are filtered set of activities that needs to be implemented in order to start process improvement. By focusing on a filtered set of implementation activities will save time and efforts for outsourcing companies.

#### 6.1.6. Excluded Areas

The aim with the SPIMO-model was to identify the most important process areas for outsourcing projects and SPI models and exclude the areas that were considered unnecessary software outsourcing. This was done by reading many research papers and case studies about outsourcing projects. The life cycle of outsourcing projects was analyzed and evaluated to filter the most relevant process areas. Sixteen process areas in total were excluded for SPIMO-Model.

#### 6.1.7. How SPIMO-MODEL can be used in Agile

Agile Methods are implemented in software outsourcing because of not defined requirements and rapid changes. Agile methods are also used when there is requirements stability, geographical dispersion of the workforce, and technical complexity.

The goals of Agile development is Satisfy the customers, manage and control the changes made in requirements, deliver software in quick successions and in short time scale, tie business teams and developers, bring motivation to the individuals and provide them environment and trust they need and close communication channels.

Some of the Agile Methods are: Extreme Programming (XP), Scrum and Lean software development. SPIMO-MODEL will help companies using agile methods by CMMI concept of institutionalization using generic practices of level 2 and level 3. These generic practices can be aligned with agile methods such as GP 3.1 suggests 1 Establish a Defined Process. The purpose of this practice is to define a process tailored from organization set of standard process. This can be done for Agile methods by Establishing and maintain the Agile Methods. List of Complete Generic practices is given in Appendix B.

#### 6.1.8. Interpretation of CMMI

A general conception about adopting Capability Maturity Model Integration is that it is applicable for large organizations. Small companies found CMMI adaptation difficult for number of reasons.

- Adopting issues
- Complexity
- Cost
- Difficult to Implement
- Require lot of change
- Difficult to interpret

Technical staff and trained professionals are required at a sufficient level inside an organization to define quality related activities. These people are responsible for ensuring that organization is following the right processes as written in order to produce effective results. From the study of CMMI authors have come up with Problem-Goal-Question-Metric approach about process improvement in outsourcing projects. This approach will help interpreting CMMI for outsourcing project. The life cycle of outsourcing projects and studying the existing problems in software outsourcing process improvement provide guidelines to interpret CMMI. This approach will focus on key problems exists in a process areas and measures to improve the process will enable staff to structure process improvement activities. This can be done by reviewing daily basis activities.

- *Problem:* Identify the problems in a Process area.
- *Goal:* To improve the process where problems are identified.
- *Question:* How to improve a process?
- *Metric:* Activities involved in improving specific process areas and time it take for implementation.
- *Associated process areas:* Map the problems with associated process areas.



By following this technique CMMI can be interpreted for software outsourcing. This approach will structure the existing process and take measures whenever or wherever are required in order to bring a process to maturity level.

### 6.1.9. Problems identified in Outsourcing projects

The purpose of this research question was to identify the main problems and issues related to process improvement when projects are done via outsourcing. For this purpose various case studies were selected in order to identify the problems. The results we obtained are summarized in this section.

Outsourcing problems can generally be divided into people, process, technology and other problem areas:

- Problems related to human resource are people is a critical issue, the main factors involved in causing these problems can be attitude issue, cultural issue, social issue, communication issue, cooperation issue, low performance of the people and lack of confidence in team and organizational structure.
- Process problems generally result from how the operations are set up; how the decisions are made, assigning responsibilities, giving authorities; and how the activities are defined and processed.

Technology problems generally relate to the acquisition, implementation, and maintenance of equipment or systems. These problems can have their root causes in either party, and addressing the problems is a shared responsibility.

This section identifies and describes the important problems faced by outsourcing companies in process improvement. The reason to identify these problems is very significant. If the outsourcing company wants to complete project in given time span, improve the quality of their products and satisfy clients, they should pay attention to these problems. While reviewing various case studies of outsourcing project and relevant literatures, it was observed that most of the problems are relevant and are of same nature and if the processes are tailored these problems can be tackled efficiently. In later section, mapping between Existing Problem and Corresponding Process Area is explained in order to understand the relevance in the problems.

#### 1. Requirement problems

**Understanding and management of requirement:** Most of the outsourcing project team lacks in understanding the requirements in right manners, misunderstanding the requirements can influence the project development tremendously. Requirement change is common in the outsourcing projects, an effective process is required to manage and control the changed requirements in order to avoid disaster.

**Cannot reach the end customer:** Most of the time, the outsourcing project team is not responsible for eliciting requirements from the end customers, and they just get a list of requirements from clients. This lack of end customers information and gap in the communication can lead to development of a bad quality product.

#### Case study 1: Development of Internet Conversion Application for Achievement Technologies [27]

SkillsTutor is a product line offered by Achievement Technologies that provides their customers with instruction and test preparation.

Orbital was secured by Achievement Technologies to develop an application that could convert educational content developed by SkillsTutor so that it could be used for interactive learning over the Internet.

*Main challenges:*

- Overcoming inherent limitations of delivering interactive learning content to the Internet.
- Develop a solution with necessary compression ratio.
- Develop a solution to satisfy technical requirements.

#### Case study 2: Assignment Tracking System™ (ATS) for Riverdeep [28]

Riverdeep secured Orbital to develop the key components of an educational software product referred to as Assignment and Tracking System (ATS). Teachers use ATS as a powerful tool for enhancing and monitoring the computer activities of their students. Using this product, teachers can enroll students, create assignments, install new educational products, and print class reports.

*Main challenges:*

- Cross-platform development of ATS on Windows and Mac platforms
- Integration of 25 applications into ATS to provide additional functionality
- Creation of a Windows Installer for ATS

#### Case study 3: AppleWorks® File Converter Microsoft® Word X for Mac [29]

Orbital was approached by Microsoft Corporation (Microsoft) and asked to develop AppleWorks converters for Microsoft Word X for Mac. These converters were needed to allow Word X for Mac users to easily convert AppleWorks 5, 6 and 6 Japanese documents into Microsoft Word documents.

*Main challenges:*

- Develop converter while Microsoft Word X for Mac was still under development.
- Develop a method of importing tables from AppleWorks to Microsoft Word X for Mac.
- Account for significant cultural difference between Western and Asian languages.

**Solutions:**

Form the challenges of the case study, we find that the outsourcing companies face challenges in specific requirements (such as using different platform to develop product, and integration of 25 applications, etc.), REQM process area provide Specific Goals (SGs) and Specific Practices (SPs) to manage the requirements of the project's products and product components,

and to identify inconsistencies between those requirements and the project's plans and work products.

## 2. Project plan problems

**Life cycle is not complete:** Most of the projects come with incomplete project requirements which results in delaying the process of project analysis. This scenario ultimately slows the project acceptance phase. CMMI clearly states that a project should adapt a life cycle from start till end. Organizational process Definition requires that a company or an organization need to define the life cycle model based on organizational level, from the requirement of maturity-3 it's important to perform process tailoring [25]. However, if some outsourcing project are such as coding or development based, then, its complex to distinguish own Life cycle model, and what process tailoring needs are required.

**Difficult to control the progress of software development:** As the software outsourcing was starting in 1990s. Nowadays, there are lots of new outsourcing companies, and they do not have too much experience, and data accumulation, so, it will take some difficulties (e.g. schedule and workload estimation.) to project. With the outsourcing project become bigger and bigger, staff or resources are more complex, software development is difficult to ensure completion on schedule.

### Case study 1: Updating Learn to Speak German for eLanguage [30]

eLanguage is the leading developer in language learning products, providing award-winning educational software that teaches users how to speak, read and write in English, French, Spanish and German. When eLanguage wished to update its *Learn to Speak German* product to version 9.5 to match its similar products for English, French and Spanish, it chose Orbital.

eLanguage had recently acquired the *Learn to Speak* software titles from another software company. Although there had been German releases of the application prior to eLanguage acquiring the software, the most recent version (version 9.5) only featured English, French and Spanish. eLanguage needed the updated German product in multiple configurations to meet a quickly approaching customer commitment.

#### Main challenges:

- eLanguage had limited available development resources and a tight timeframe to complete the work.
- To meet a customer commitment, eLanguage needed a development partner to first assess the code, ensuring that it had all of the necessary pieces to update the software, then to develop a plan, code and deliver the updated product in six weeks' time.

### Case study 2: SVG Converter for Adobe [31]

Adobe Systems Incorporated (Adobe) secured Orbital to develop a Scalable Vector Graphics (SVG) converter for Version 7.0 of its Adobe Frame Maker software on Windows, Macintosh and UNIX (Solaris). SVG is an emerging file format that allows images to be scaled to variable sizes without becoming distorted.

#### Main challenge:

- Apply an existing library that was not from Adobe.
- Manage for rapid turnaround time required by Adobe.
- Dynamic allocation of human resources to ensure optimal efficiency.

#### Solutions:

From the challenges of case study, we can find that the outsourcing projects face these problems (such as: a tight timeframe to complete the work, for meeting a customer commitment), the PP process area is to establish and maintain plans that define project activities, which provides Specific Goals and Practices for this Process Area (such as: Establish estimates of work product and task attributes, Define project life cycle, Establish the budget and schedule) to solve the problems.

## 3. Project Monitoring and Control problems

**Inadequate project monitoring and control:** In lots of outsourcing company, basic monitoring and control of historical project monitoring depends the project manager's personal capacity, and Lack of uniform reporting mechanism

### Case study: Big (case study is based on four projects executed in an organization that we name Big) experiences [32].

The projects observed develop information technology (IT) solutions in the context of outsourcing. As such, they evolve around the relation between a customer, a domestic (on-site) team and an offshore team. Both teams belong to Big.

Since these projects are large, customer and vendor need to put in practice mechanisms to manage the complexity of designing in the large and to maintain the consistency between business goals and the system's architecture in spite of having multiple teams geographically distributed.

#### Main challenges:

- Control large complex projects with geographically (and culturally) distributed teams
- Challenges are related to large project size and complexity, and requirements transfer (e.g., sub-optimal understanding of tacit requirements or too late understanding).

#### Solutions:

From the main challenges of case study, it is observed that in order to achieve the requirement of clients, the outsourcing companies need to have the ability of project monitoring and control in order to monitor and control the project. PMC process area is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.

## 4. Quality assurance problems

**The right of Quality assurance is not completed:** The outsourcing project team cannot grasp the quality indicators of work product, the Final quality verification of the product evaluated by most of the clients with unsatisfactory remarks.

**Case study 1: Luxoft Helps International Telecom Company to Implement a New HR Assessment Tool [33]**

Astelit Ltd. launched **life** – a new GSM operator of Ukraine in January 2005. Quickly, **life** established itself as the third largest Ukrainian mobile telephone network operator, covering 96% of the country's population. Today, the mobile operator serves more than 11.9 million subscribers (as of Q1, 2010).

With the company's growth came a need for better personnel and performance management tools. Astelit turned for help to Luxoft and other vendors to develop and implement a customized internal solution.

*Main challenges:*

- Find the right software testing and quality assurance professionals to complete user testing; thereby letting Astelit employees focus on their primary job responsibilities and goals.

**Case Study 2: Updating and Porting Report View for Business Objects [34]**

Business Objects is a leading provider of business intelligence (BI) solutions. Business Objects provides world-class BI solutions that allow organizations to gain better insight into their business, improve decision making and optimize enterprise performance. BusinessObjects XI, offers the most advanced and complete BI platform and BI tools for reporting, query and analysis, performance management, and data integration.

Business Objects contracted with Orbital to assist in updating one of its sample report applications to match the current product version, BusinessObjects XI.

*Main challenges:*

- Business Objects decided to update one of its sample report applications to the latest version of its leading business intelligence software.
- It needed the work completed within six weeks to meet an internal target, while ensuring best development practices to maintain the high quality standards of its software.

**Case Study 3: Online Booking System for a Travel Agency [35]**

Client is a US-based leading online travel agency and their Industry is based on Travel, eCommerce. The client is offering the best rates on airline tickets, hotel reservations, car rentals and more.

*Main challenges:*

- The outsourcer had to meet tough professional skills criteria and to have a proven track record to ensure the quality.

**Solution:**

From the challenges of case study, it is observed that the outsourcing project often face the quality assurance problem. The PPQA process area is to provide staff and management with

objective insight into processes and associated work products, and ensure the project have the good quality.

**5. Configuration problems**

**Degree of autonomy, controllability of project management is not comprehensive:** The outsourcing project manager just can do the project planning, tracking, control in the task they get from the client, and they do not have the capability to do the independent and comprehensive project management. Especially when they find some of the problems that need to be explicitly judged, it is difficult to do the reason analysis.

**Case study 1: History of outsourcing configuration management for BCS/BSS products [36]**

Industry: Telecommunications  
Service: Outsourcing/Configuration Management  
Customer: The world's leading telecommunications vendor  
Location: Ireland, Sweden, Poland  
Timeframe: 2002 – 2009  
Tools and Technology: ClearCase, PRIM, PiTool, PiWin

*Main challenges:*

- For led the vendor to outsource still profitable but non-core products to one of its most capable partners: Ericpol. Responsibility for the transferred products included configuration management (CM). After meeting customer expectations in terms of keeping product quality high, maintaining uninterrupted end-customer deliveries and reducing R&D costs.

**Case study 2: MINI [37]**

MINI is the world's largest diversified resources company. The major businesses are in aluminum, coal, copper, ferro-alloys, iron ore and titanium minerals, as well as substantial interests in oil, gas, liquefied natural gas, nickel, diamonds, and silver.

The Board of this major global resources firm issued a directive to all management, "Get out of anything not core business, and get cash sales for LOBs (lines of business)". As a result, MINI sold their wholly owned IT subsidiary to a supplier, and in return, the supplier received a long-term deal for all IT services across the globe.

The deal was essentially configured for maximum sale price, hence the full service, geographic and recipient scope, sole supplier, large financial scale, long duration, and total transfer of all resources.

*Main challenges:*

- Faced a major upheaval when the company was reorganized and split off into separate businesses a year after the contract was signed
- Changing the recipient scope to cover the now independent companies under the old contract has become the primary focus of the contract management work.
- Due to inconsistent global capabilities and quality of the supplier coupled with varying organizational requirements of each region, the contract is now renegotiated every day

somewhere in the world evolving.

**Solution:**

From the challenges of case study, for improving the ability of outsourcing configuration and configuring different aspects, the CM process area is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

**6. Risk problems**

Any business plan carries risks because the future is always uncertain. In today's global environment, offshore outsourcing exposes firms to various risks in host countries. However, these risks should not prevent companies from engaging in offshore outsourcing if their strategies anticipate the possible risk factors and include risk mitigation plans. This means that by identifying risks, and collecting and assessing information about them, companies can use accurate assumptions in their strategies and become more proactive in mitigating and offsetting adverse outcomes. As Respondents to our survey rated the importance of the five risk factors in Table-6 [38]

**Table 6. Overall importance ratings of offshore outsourcing risks [38]**

Risk	Importance rating*
Political	4.8
Legal, enforcement of intellectual property rights and business contracts	4.6
Information vulnerability and security	4.5
Immature business environment	4.3
Socio-cultural problems	4.1

\* Based on a scale of 1 to 5, 5 being the most important.

**Case study 1: Banking - Credit Risk and Scoring [39]**

Fierce competition within the Banking and Financial Services Industry and huge revenue losses incurred due to the mortgage crisis and increasing defaults led our client, a Bank in the US, to explore the possibility of engaging an offshore knowledge team to build predictive models to improve credit collections and maximize returns.

**Main challenges:**

- Maximize Recovery-Revenue
- Minimize Collection Costs
- Optimize Collection Efforts
- Identify possible NPA Accounts
- Identify 'Good'/No Action/Auto-Resolution Accounts
- Overall Collection Strategies for various Accounts

**Case study 2: Banking - Protiviti helps client increase risk management effectiveness over capital provision of greater than £1 billion [40]**

The client is a global bank with operations covering retail and commercial banking, investment banking and investment management. Its information technology (IT) department had made significant investments to achieve Sarbanes-Oxley compliance and subsequently, had to comply with a newly implemented operational risk management framework.

**Main challenges:**

- Difficulty in demonstrating effective management of risks deemed significant across the organization due to a lack of an operating model to link the IT control universe to wider business risks
- IT risks were not communicated or considered by the business
- Lack of a formalized process to consistently and accurately identify, assess and aggregate the risk and control position for internal attestation purposes
- Recurring service outages due to an inadequate root cause analysis process

**Solution:**

From the identified risks, the problems and their rating based on their importance can be seen. RSKM is to identify potential problems before they occur, so that risk-handling activities may be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.

**6.1.10. Identifying the Key Process Areas**

The problems identified in Section (6.1.7) were reviewed accordance with CMMI process areas guidelines in order to categorize them. The mapping of process areas with the existing problem was a difficult job. The most relevant problems were mapped in the similar process area to avoid repetition of activities. For solving the Existing Problem of outsourcing project, we map the problems to the CMMI process areas, implement the tailoring for the process areas, and choose corresponding process areas in order to meet the requirement of outsourcing company. It is suggested that on basis of these problems and their mapping with key process areas can help outsourcing companies to implement process improvement activities more effectively. It is important to understand that the problems identified during this research are mainly related to the key process areas of CMMI. Furthermore to assure that right KPA are selected complete life cycle of outsourcing projects was studied and reviewed from various case studies and literature. The life cycle provides the basic activities involved in projects when done via outsourcing. The result of mapping is as shows in the Table-7.



**Table 7. Mapping between Existing Problem and Corresponding Process Area**

Existing Problem	Corresponding Process Area	Goals of Corresponding Process Area
Requirement problems	Requirement management	SG1: Managed Requirements
Project plan problems	Project Planning	SG1: Establish estimates. SG2: Develop a project plan. SG3: Obtain commitment to the plan.
Inadequate project monitoring and control	Project Monitoring and Control	SG1: Monitor project against plan. SG2: Manage corrective action to closure.
The right of Quality assurance is not completed.	Process and Product Quality Assurance	SG1: Objectively evaluate processes and work products. SG2: Provide objective insight
Configuration problems.	Configuration Management	SG1: Establish baselines. SG2: Track and control changes. SG3: Establish integrity.
Risk assessment and control problems.	Risk Management	SG1: Prepare for risk management. SG2: Identify and analyze risks. SG3: Mitigate risks.

The Figure 20 explains the key process areas and their flow in the complete life cycle of a project.

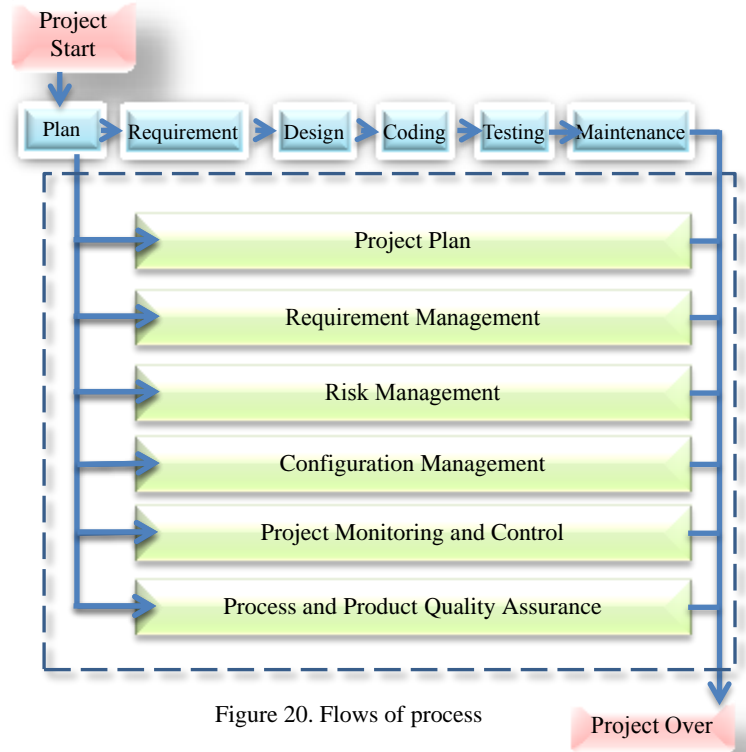


Figure 20. Flows of process

## 6.2. Software Process Improvement key Activities in Key Process Areas.

Results in this section provide the key activities that are to be processed in order to improve a software process in desired process areas.

### 6.2.1. Requirement Management (REQM)

REQM occupies an important position in project management of software outsourcing, as requirement is the foundation and starting point of project, no matter development, testing, and maintenance, all of them are based on requirement. For the developer, they hope that the customer can provide one-time clear requirements and no changes in the future, but in the realistic project, it is impossible, statistics show that more than 90% requirement of outsourcing project have been changed [41]. The goal of requirement management is to manage and control requirement changes, maintain software planning, product, consistencies between project work and requirements, and ensure requirements to be realized in software projects.

REQM is as the first important key process area of CMMI-2, actually, it has permeated in the different levels and many process areas. So, requirement management of CMMI should start from dominant ideas of total Quality Management-“To meet customer demand-oriented”, software development should use the requirement engineering as the core process.

#### Main activities of requirement management

As in the outsourcing project, the possibility of changes is high. In some project, clients want to save the cost and time, so they do not have the detailed and complete design, then send the project

requirements to outsourcing company, which will lead the changes of project requirements to be more frequently and serious. More changes will make program code to become bloated mess, number of defects to be more, and seriously affect the project schedule and project costs.

The goal of requirement management is to manage and control requirement changes, and maintain software planning, product, and consistencies between project work and requirements, and ensure requirements be realized in software projects. In the application of realistic, the main contents of requirements management have three parts: Requirement Determination, Change Control and Requirement Tracking, as shown in Figure 21.

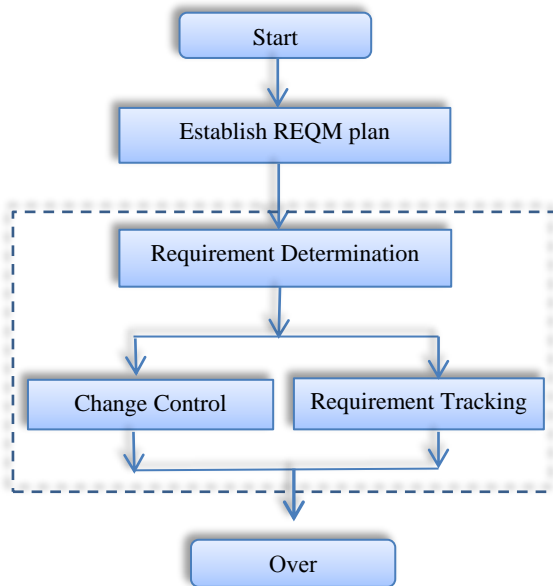


Figure 21. Activities involved in REQM

1. Requirement Determination

When the outsourcing company receives the requirement from client, they need to confirm integrity, feasibility, and verifiability of requirement. Requirement review is an important way, it needs to find potential problem timely, and give the modification suggestions, and have a consensus with stakeholders.

*Purpose:* Client and Outsourcing Company will reach a consensus, do documentation, and both sides confirm the document, which will be as a guide for product development.

*Entry Criteria:* outsourcing company has gotten the requirement documents from client.

*Major Inputs:* <Requirement document>, <Requirement Management Plan>

The main activities in requirement determination:

- (1) **Informal requirement review:** Project manager organizes the project staff to do the informal requirement review in the internal organization.
- (2) **Formal requirement review:** Project manager invites the related stakeholders to review requirement

document, and tries to make requirement to let customer feel satisfied.

*Major Outputs:* < Requirements Specification > both sides have confirmed the document.

*Exit Criteria:* both sides have confirmed the document, and commitment of both sides.

2. Control Change of requirement

In the outsourcing project, when the client changes the requirement, outsourcing company needs to implement work follow the changes have been defined.

In the outsourcing project, due to frequent changes, and the workload is actually consumed which is bigger than expected. The flow of change control of requirement is show in the Figure-22.

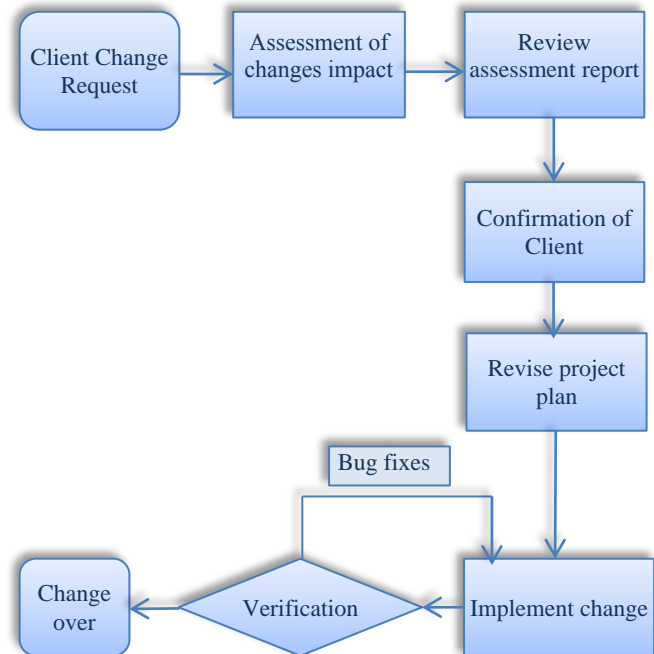


Figure 22. The flows of change control

*Purpose:* To modify the incorrect or if they do not meet client requirements in the Original requirement document, and to make a new requirement document.

*Entry Criteria:* The end-customer or client proposes it.

*Major Inputs:* Original requirement document.

The main activities of change control of requirement:

- (1) Client sends requirement change request of software product to outsourcing company.
- (2) Project manager analysis the impacts of software requirement of outsourcer, workload, cost of finishing the task, and impacts of the project scheduling.

- (3) The software requirement changes can be accepted or not? If yes, turn to step d, if no, let client modify it.
- (4) Revise project plan, the appropriate allocation of human resources for the software changes.
- (5) Implement change.
- (6) Verification of change result, project team informs the related team (such as testing team, quality assurance team, etc.) the information of requirement change, and fixed defects timely.

General, requirements changes may produce the following results:

- Add or delete of task. For example, client may add or delete some function module, which will lead to corresponding increase or decrease of task.
- Time adjustment. For example, client may request outsourcing company to deliver the product ahead of schedule, like this, which need outsourcing company to adjust the task time, and the related staff will receive the notification message of task time adjustment.
- To add and remove participants.

Implementation of change control of requirement:

- Application number: serial number of change request.
- Statement on changes: description of change request.
- Change type: like function change or performance change.
- Analysis of effect: to mainly explain change, this is involved with module, workload, schedule, and member exchange, etc. this is the important point of requirement change.
- State of change request: what stage of development the change request is in?

In the Table-8, it is an example when client proposes requirement change request.

**Table 8. Example of requirement change request**

Project name: XXXXXX	
Application number:	201100051
Statement on changes:	“search function” module need to add the country and city search.
Change type:	function change.
Analysis of effect:	<ul style="list-style-type: none"> <li>● For this module, need to add more lookup field and function.</li> <li>● Will affect the output module.</li> <li>● Need to add workload of one person a day.</li> </ul>
Statement of change request:	“search function” module had already been developed, and turn into the unit testing phase
Date:	20110501

*Major Outputs:* The new requirement change request is confirmed

*Exit Criteria:* < Control Change Report> and new <Requirement Document>

### 3. Requirement Tracing

CMMI requires that it should have the ability of tracing. Requirement tracing makes each tracing to trace the related design, code, and test case, and in the same time, product of every stage can trace back to the initial requirement.

*Purpose:*

To create and maintain consistency with the requirement, design, code, and test, ensure the product will meet the requirements of customer.

*Entry Criteria:* Requirements Document is commitment

*Major Inputs:* requirement document, < Requirements specification >, and stage products.

The main activities of requirement tracing:

1. Create and maintain requirements traceability matrix.
2. Check each requirement of requirement document is satisfied in follow-up products.
3. Check follow-up products is described in the requirement document.
4. When requirement is changed, you need to update requirement traceability matrix timely.

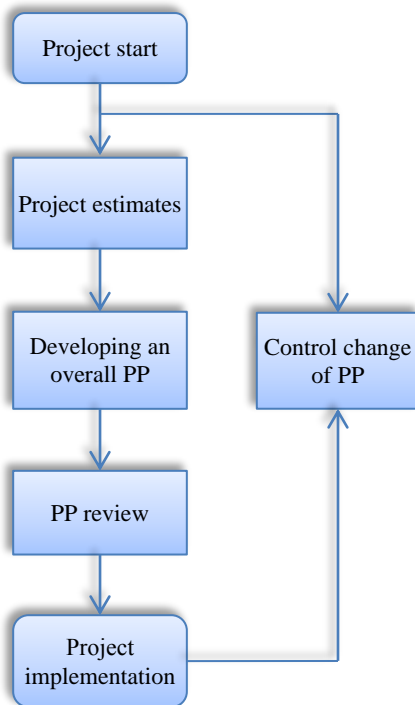
*Major Outputs:* <Requirement tracing report>

*Exit Criteria:* requirement traceability matrix of every stage is created, and deviation of the development activities has been eliminated

### 6.2.2. Project Planning (PP)

The purpose of Project Planning (PP) is to establish and maintain plans that define project activities [1]. The PP process area involves the following: developing the project plan, interacting with stakeholders appropriately, getting commitment to the plan, and maintaining the plan [1]. PP provides the baseline for implementing and controlling project activity. As any change in the requirements and agreement, inaccurate estimates and the whole process can change, and in the same time, PP needs to be modified too.

The process area in this framework has four main flows: project estimates, developing an overall PP, PP review, and control change of PP, their relationships and flows, as shown in Figure-23.



**Figure 23. Activities involved in PP**

### 1. Project estimates

Basis of PP is project estimates, as the accuracy of project estimates can directly affect validity of PP. However, in the beginning of project, understanding the product is superficial, more uncertainty, and it is difficult to make an accurate estimate. PP is in CMMI level-2, and CMMI request to do the continuous improvement in this process area.

In the estimates, the outsourcing company should use their own data and experience. Paying attention to own accumulation of historical data can help them to make reliable estimates.

The Product range of software outsourcing project is identified basically by client, so, the important contents of project estimates are product size, workload, and cost estimates. In the whole life cycle, lot of information evolved rapidly, the PP needs to be estimated and refined constantly.

*Purpose:* Project estimation includes product size, workload, and cost, etc. in order to provide reliable basis for developing PP.

*Entry Criteria:* Approved by senior leadership, project start.

*Major Inputs:* <Project Commission>, the requirement document of client, historical experience data.

The main activities of project estimates:

- (1) **The project manager establishes the project estimates team.** Project estimates team will collect material about the project commission, requirement document of client, and historical experience data, etc.

- (2) **To establish project scope:** creating top-level work breakdown structure to estimate project scope, such as: task description, WBS, etc.
- (3) **To establish work product and estimation value of the task properties,** such as: Technical solutions, size and complexity of task, work product, estimation model and property estimation.
- (4) **To define project lift cycle:** Tailoring useless process as the requirement of client, and defining project life cycle in order to limit the scope of the plan.
- (5) **To determine the outcome and cost estimates:** Based on estimation principle to estimate workload and cost of work product and task. Such as: estimation principle, project workload estimation, and project cost estimation.

*Major Outputs:* <Project Estimate>.

*Exit Criteria:* < Project Estimate> is approved by senior leadership.

### 2. Developing an overall PP

In the overall PP phase, it not only the project development plan that is included, but also project management plan as well. The PP is the guideline of project, which need to be reviewed clearly.

*Purpose:* Decide the task partitioning, resource allocation, and schedules, which can provide the basis for project activities and project monitoring. Help to make a consensus promise, implement or support PP with project stakeholders.

*Entry Criteria:* Finish the project estimates.

*Major Inputs:* <Project Commission>, <Project Estimate>, and relevant requirement documents of client.

The main activities in developing an overall PP:

- (1) **To plan all the work product of this outsourcing project:** Project manager and team will plan the work product of project, decide target value of project, and write the relevant work product table.
- (2) **To create budget and schedule plan:** Sometimes, the client will provide the general schedule, if no; the project manager should make a schedule following the contract, and then, submit the schedule to the superior and client. In the same time, project manager creates the budget plan.
- (3) **To decide project risk:** Decide and do analysis on project risks, probability of risks occurrence and risks impact and risk priorities, etc.
- (4) **To plan data management:** Plan how to manage the project data. Create requirement and rule, in order to ensure privacy and security of data. Establish machine processed of data store and data access. Then, decide what data can be confirmed, collected, and released.
- (5) **To define the software, hardware resource of project:** To decide time of use, range of use, access, usages, and the number of demand.
- (6) **Needed knowledge and skills plan:** To plan the positional requirements of project, and mark the needed knowledge, skill, and information need to be got from outside. Then, noting the difference of number and skill between requirement and staff. In the



same time, you can evaluate effective knowledge and skills.

- (7) **Stakeholder involvement plan:** To plan the entire project stakeholder and activity content, time, role, and responsibility which they will take part in.

*Major Outputs:* <Project Plan >, < Project Responsibility Allocation Table >, < Project Schedule >, <Project Milestone Plan>, etc.

*Exit Criteria:* The entire outputs documents are finished and approved.

### 3. PP Review

*Purpose:* Superior will review the project plan, and ensure the plan can be implemented in the project.

*Entry Criteria:* Finish the relevant documents of project plan

*Major Inputs:* All relevant documents of project plan

The main activities of PP review:

- (1) **To review PP and understand commitment of the project.**
- (2) **Organizations use the strict methods to review the entire project plan.** Project team records the review object, the staff involved in the review, problems found, and importance of the problems followed by the review results. Project team will modify the project plan, and coordination between the project plan and available resource.
- (3) **To get project plan commitment:** When the project plan is approved, project manager should explain the plan to project team members, each member will perform their related duties, and note the all the organization commitment, include the provisional and complete commitment, and sign it.

*Major Outputs:* Relevant documents of project plan.

*Exit Criteria:* Relevant documents of project plan have been reviewed and verified.

### 4. Control change of PP

As the change of requirement and commitment, corrective measures, client changes, the overall plan will change too and sometimes repeatedly revised.

*Purpose:* It is to adjust the original plan for adapting to the new requirement of project, and control change of PP.

*Entry Criteria:* The project key aspect has the change, such as:

- Significant changes in customer requirement
- Product schedule and cost of PP exceed deviation
- Follow original model, the quality of product cannot achieve expectation
- Project team have the major adjustments, such as: cut down the staff, adjusting mechanism

*Major Inputs:* The original relevant documents of project plan

The main activities involved in control change of PP:

- (1) **Submission of project changes:** Project manager submits the project with the change request, and explains the reasons, content, and impact of changes.
- (2) **Change approval:** The leader agrees with change request, project manager begins to modify the PP. Project manager should explain the new plan to the project team members, and get the new commitments.

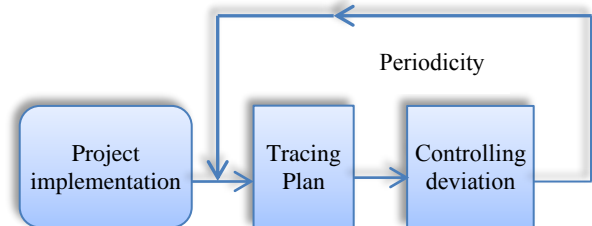
*Major Outputs:* <Project Change Request>, and the new <Project Plan>

*Exit Criteria:* Change Request and new plans are approved.

### 6.2.3. Project Monitoring and Control (PMC)

Through trace and action the parameters of schedule of project plan, workload, and cost, etc. PMC provides the understanding to the project progress, and can implement the corrective action when the performance of project serious deviate from the project plan, in order to ensure to achieve the goals of project. The corrective actions may include: revise the original plan, create the new agreement, and take additional activities under the current plan, etc.

In the CMMI model, the PMC include monitoring of the project against plan and manage corrective action to closure. In this model, the PMC is divided into two phases, as shown in Figure-24



**Figure 24. Activities involved in PMC**

#### 1. Tracing plan

*Purpose:* Regularly tracking the actual progress of the project, and make the documentation and report to the superiors and client.

*Entry Criteria:* <Project Plan> and other relevant documents have been finished.

*Major Inputs:* <Project Plan> and other relevant documents.

The main activities of tracing plan:

- (1) **Monitor project planning parameters:** The parameters of project plan include: work product, properties of the task, cost, workload, and schedule. Monitoring includes: measure actual value of the project planning parameters in order to compare the estimates of plan, Identify whether there are deviations. The main task for software outsourcing project is to focus on schedule, quality, scale, cost, and among them quality and

schedule should be seriously considered.

- (2) **Monitor commitments:** Formal review commitment (Including internal or external), Determine the unmet and serious risk commitment, keep record of the commitments to be reviewed.
- (3) **Monitor project risks:** Regularly review the risk records of current state and environment. This should be done via weekly meeting or other method. It is important to review risk in regular intervals in order to identify and discover new risks. Record the risk status, its severity and probability status and notify the relevant staff and communicate with them according to the situation of risk. In last appoint the staff to do risk mitigation and take appropriate actions, to trace the risk and resolve it.
- (4) **Monitor data management:** Based on project plan, regularly review data management activities, identify and record important problem and their impact, and also record the result of data management which has already been reviewed.
- (5) **Monitor stakeholder involvement:** Regularly trace the participation of stakeholders, the situation of review with project-related personnel, and documentation of the assessment results. This is done to Identify and record the important problem and their impact and also to record the activities and time the related personnel take part in. if someone in the project team exit appropriate actions should be taken in advance.
- (6) **Conduct progress reviews:** In the weekly and monthly meetings, inform related personal about their related activities and current state of work product so they should understand. Keeping records about different plans and actual data will be help in determining the deviation status of reviewed project progress and plan. In the same time, project manager need to record the time, cost and management results for each activity including management work, existing problems and solutions, the actual progress of solution, and regularly report this to the superiors.
- (7) **Conduct milestone reviews:** Project schedule, should be reviewed in order to set important and meaningful point, commitments, plans, status, and risks and goals to be achieved. To describe progress of targets in different milestone, superiors, client, and project team members, will review completion status of milestones in meetings, and it's to be decided whether to enter the next phase? A milestone is as a summary of the work phase; the project team can implement an activity of analysis and sum up of experience and lessons.

*Major Outputs:* < Project tracking and monitoring data tables>, and < Project Progress Report>, etc.

*Exit Criteria:* Project task, cost, relevant resource, and data of product are controlled.

## 2. Controlling deviation

*Purpose:* Analysis of tracking data, when the actual progress of the project and plan has a significant deviation, take appropriate corrective actions timely, when necessary, do the re-plan.

*Entry Criteria:* The actual progress of the project and plan has a significant deviation

*Major Inputs:* < Project tracking and monitoring data tables>, and < Project Progress Report>, etc.

The main activities of controlling deviation:

### (1) Analyze issues:

Project manager acts according to the project tracking data, and compares with the plan, and objectively assesses whether there is significant deviation, if deviation is noticed, project manager should analysis the reason and tag in the relevant document.

### (2) Take correction action:

Project manager should inform the status of deviation to the relevant staff, and submit them to the superiors in order to implement the corrective measures after the deviation review. It is necessary to record the actions used in identifying the problems and solving it. This record should reach to the related staff and communicate in order to coordinate internal and external change of commitments.

### (3) Manage corrective action:

Monitor corrective actions which are to be implemented, analyze result of corrective actions, to determine their validity, and keep on doing that until the deviation is totally eliminated. All the controlling deviation process and result should be recorded in the relevant document.

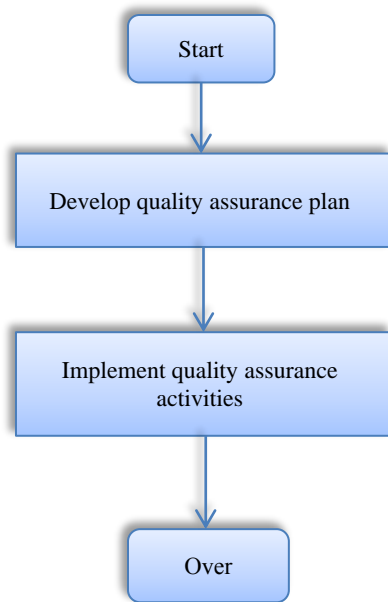
*Major Outputs:* <Corrective Action Report >

*Exit Criteria:* The deviation has been eliminated

## 6.2.4. Process and Product Quality Assurance (PPQA)

The purpose of PPQA is to provide appropriate monitoring of the process and product for the management department, and let development process to be transparent. PPQA involves the examination and verification of software product, and relevant activities, in order to verify consistency between them and the process, standards used, which can provide results to examine and verify by project manager and other relevant managers (client manager).

In the framework, there are two important processes in the PPQA process area: Develop quality assurance plan and implement quality assurance activities, as shows in the Figure-25.



**Figure 25. Activities involved in PPQA**

### 1. Develop quality assurance plan

*Purpose:* Develop the plan about inspecting and improving Process and Product Quality Assurance.

*Entry Criteria:* <Project Plan> has been finished.

*Major Inputs:* <Project Plan>

The main activities of develop quality assurance plan:

- (1) **To develop the quality assurance plan:** Develop the quality assurance plan about the specific process and product; follow the schedule according to the project plan and understanding of background and quality requirements of the project. In the quality assurance plan, the organization needs to identify and check related process and work product, in addition, they also needs to plan the time and staff, and chose the applicable process descriptions, standards, procedures.
- (2) **To review quality assurance plan:** Quality assurance plan should be reviewed with other plans in the same time. Relevant staff (such as project manager and quality assurance manager) should participate in the review and ensure the consistency between project plan and quality assurance plan to ensure that quality assurance plan can meet the requirement of client and outsourcing company. Sometimes, project team needs to review the plan with client and external experts (peer review).

*Major Outputs:* <Quality Assurance Plan>

*Exit Criteria:* <Quality Assurance Plan> has been developed, and passes the review

### 2. Implement quality assurance activities

*Purpose:* Objectively inspect “work process” and “work product” of project development team meet the established norms, and promote quality improvement.

*Entry Criteria:* implement quality assurance activities follow the <Quality Assurance Plan>.

*Major Inputs:* <Quality Assurance Plan>, <Outsourcing Project Checklist>.

The main activities to implement quality assurance:

- (1) **To inspect the process and product:** for the process, follow the checklist and talk with the relevant project team members. The quality assurance engineer inspects whether the actual process of project implementation meet established norms. For the product, quality assurance engineer implements inspection of full or sample of formally products that obtained from configuration management system. In the process of inspection, if there is non-standard item quality assurance engineer should analyze the causes and negotiate improvement method with relevant project team members. At a pinch, quality assurance engineer can implement the quality assurance activities with client and external experts.
- (2) **To record inspection results:** Quality assurance staff should faithfully record the results of quality inspection and lessons learned.
- (3) **To notify inspection results:** Quality assurance engineer checks and records the results of quality inspection and lessons learned, and notifies the results to all the project member and relevant staffs.
- (4) **To trace problem:** Quality assurance engineer traces the solving process of problem, and records the status of problem until the problem is solved.

*Major Outputs:* <Quality Assurance Report>, <Problem Tracing Table of Quality Assurance >, etc.

*Exit Criteria:* All identified quality problems have been satisfactorily solved.

### 6.2.5. Configuration Management (CM)

Software development process generate lot of information, such as: documents for requirements analysis & design specification, source code, user manual, test case, test result, and other related technical documentation (contracts, plans, reports, etc.). The change in various aspects of software development process is inevitable. When facing large and volatile information, it is very important to organize and coordinate using a structured manner during the whole development process. This well-structured information repository can help in managing changes made to the project, track the project and control the activities.

SCM (Software Configuration Management) process area is the key to manage all these issues. SCM is proposed for solving these questions, by providing set of management methods, action principles, and it also contains important quality assurance activities throughout the software development process[42][43]. In the CMMI, defined goals of CM are “Establish and maintain

the integrity of work products”, however, in the model, it does not provide specific guidance for the implementation of CM and achieving this goal. It just provides definitions and tasks for staff to imply with some simple methods. This makes it difficult to improve software process and implement CM when using this model. It is thus necessary to define structure of CM and do related tailoring for combining characteristics of outsourcing accordingly.

In the outsourcing enterprise, the main contents of SCM have configuration items, baseline management, control changes, version control, and access control, and the supporting process involved are configuration plans, configuration management records, configuration audits, and configuration reports, This can be seen in Figure-26

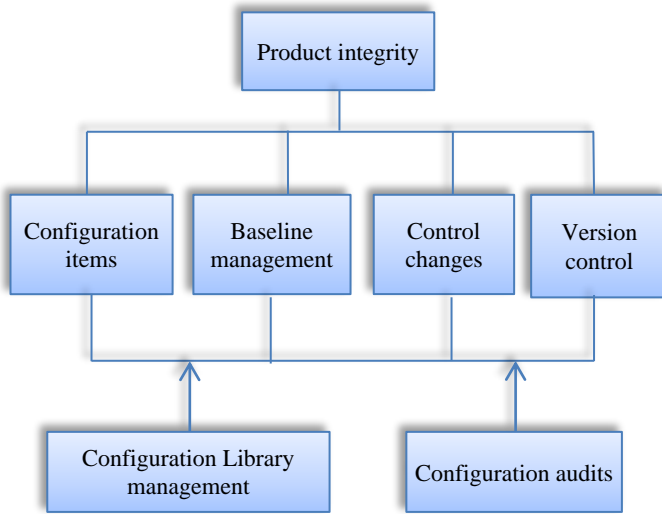


Figure 26. The content of SCM

### 1. Establish baselines

In the CM, “baseline” is a state which is controlled by review if the changes are made in the configuration items at different point of project Life Cycle. The baseline should be set right after the requirements have been approved, so if there is need to make some changes after the baseline that should be analyzed and reviewed. Each baseline is the starting and reference point of next stage development. Baseline defines one version of configuration items. Baseline is created in specified milestones, and maintains the synchronization with milestones of project [43].

*Purpose:* To create and maintain the baseline used in marking product.

*Entry Criteria:* document of CM and PP have been finished.

*Major Inputs:* < Configuration Management plan> and < Project Plan >

The main activities involves in establishing a baseline:

- (1) **Configuration items:** In the CM, “configuration” and “Configuration items” are the key concepts. “Configuration” is specified clearly in the technical

documents. It provides support data of software operating, and other elements to ensure software consistency, relative to the hardware kinds of configuration, “configuration” of software includes more content and have volatility. Table-9 lists common configuration items.

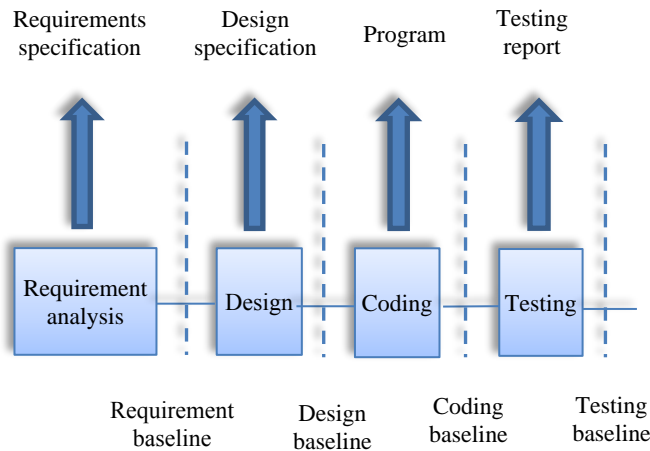
Table 9. Common configuration items of Software Configuration Management

classification	characteristic	Example
Environmental	Environment of software development	Operation system, editor, database, test case, etc.
Definition	Maintenance requirement analysis and product when definition phase is finished.	Requirements specification, project development plan, design standards, and acceptance test plan.
Design	Product of design phase is finished.	Program specification, database design, interface design, coding standards.
Coding	Product of coding and unit testing are finished.	Source code, unit testing and result.
Testing	Product after system testing is finished.	System testing data and result.
Maintenance	Product when maintenance starts.	The above Configuration items that need to be changed.

- (2) **Creating configuration management system:** To create and maintain configuration management system, and change management system which is to be used in control work product.

- (3) **Baseline management:** The first baseline includes software requirement passed appraisal, so call it as “requirement baseline”, by establishing such a baseline, controlled system requirement will become the starting point for further software development, and the requirement changes are initialized and evaluated formally. Controlled requirement also is the functional assessment base on software.

Every baseline has to accept strict control of CM, any modification to them will strictly follow the process of change control request, when a software development phase is finished, the last baseline add the modified contents, and form next baseline, and this is the process of “baseline management”. Figure-27 shows the diagram of baseline for software configuration management.



**Figure 27. The baseline of software configuration**

*Major Outputs:* <Identification of Configuration Items>, <Configuration Management System>, <Baseline>.

*Exit Criteria:* The entire outputs documents are finished.

## 2. Control changes

Change is very common in the outsourcing project. When the client proposes the change request, then, outsourcing company needs to do the control changes for modification of requirement.

*Purpose:* It is easy to trace and manage changes, to avoid confusion in the work.

*Entry Criteria:* Configuration management system and change request data have been created, and running.

*Major Inputs:* <Configuration Items Change Request>

Two main activities of control changes:

- (1) **Change tracking:** To analysis the requirement changes requested by client and impacts of current version of the software. The goals of analysis is to define what program and document need to be changed, estimate impacts of changes on cost and schedule, and report to project leader.
- (2) **Control tracking:** When the change of requirement is approved by project leader, CM staff has to make the appropriate changes for the program and document to make an analysis point.

*Major Outputs:* <Change Request>, <Latest Record of Configuration Items >

*Exit Criteria:* Activity is finished

## 3. Establish integrity

*Purpose:* Create and maintain integrity of baseline

*Entry Criteria:* <Configuration Management Plan> has been worked out, Configuration management system has been created, and configuration items start to running, change request data has been created.

*Major Inputs:* <Configuration Management Plan>

The main activities to establish Integrity:

- (1) **Version control:** Version control is basic requirement of SCM; it ensures the recovery of any version for any semi-finished product at any time. Version management will record contents of libraries and files, which can ensure traceability of product, and provide lots of helps for code debugging, clearing bug, and in the same time, version management supports parallel development and maintenance, so, which lays the first stone for collaborative development.

Main activities of version control:

- When finding a program that have problem and need to modify, first of all, organization needs log the problem content and the part of the program to the alter file.
  - To inform the related people who will modify the part of program.
  - After finished the modification, let tester do the testing work. Tester saves the program of modification and no-modification firstly, and records content, time of modification, stores locations, etc. it is easy to search them in the future.
- (2) **Configuration Library management:** To decide structure of CLM (Configuration Library management) is important foundation of CM activities. There are two commonly used forms of organization to build library: configuration items type and task. General, building a database by task is better for outsourcing company. Because in the outsourcing company, which uses a wide range of development tools, the development model mainly uses linear development. Routine of CLM is some business works, and it is mainly to keep the security of CL (Configuration Library):
    - Regular backups to CL
    - Clearly useless files and versions
    - Detect and improve performance of CL
  - (3) **Configuration audits:** The main function of configuration is as an additional part of control change, the goal is to ensure validity of SCM, and avoid any confusion.

*Major Outputs:* <Latest Record of Configuration Items >, <Status of Configuration Items >, < Configuration Audit Results >

*Exit Criteria:* CL is kept in the archives, all audit results meet the requirements, and until the end of the project.



### 6.2.6. Risk management (RSKM)

Risk usually is events of beyond the control of planners. In the development plan, it usually has a corresponding target, but there will always be some unforeseen events, the existence of these events will affect to achieve the ultimate goal [44]. The risk of software project means that the damage and loss of software development process and software product cause itself. In the project management, what needs to take care is what risk can lead to the failure of software project? Requirement changes, technology, staff, or other elements related to project. If project already have the risk, the point is how to solve and how to avoid in the future. The purpose of RSKM is to identify potential problems before they occur, and minimize the impact of risk.

#### RSKM activity

Usually, RM does the activities around risk assessment and risk control. When the risk management as part of a separate to do processing, need to clarify the relationship between it and the project process.

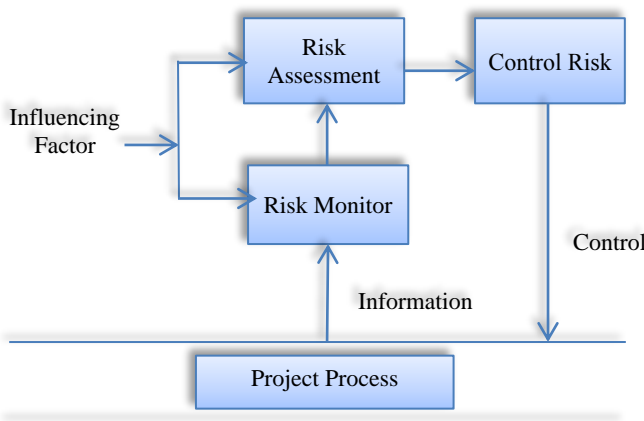


Figure 28. Activities involved RSKM and project process

Figure-28 shows the relationship between RSKM and project process. Project execution and other correlative factor acquire risk information, and then manage risk after risk is distinguished, in the same time; management activity affects the project process, in order to minimize the adverse consequences of risk.

#### 1. Prepare for risk management

*Purpose:* Prepare for the implementation of risk management activities

*Entry Criteria:* < Project Plan> has been finished.

*Major Inputs:* < Project Plan>

The main activities of prepare for risk management:

##### (1) Follow the < Project Plan> to decide risk resource and types:

In the outsourcing project, there are three kinds of most common risks:

- a) Time: Project cannot be submitted on time
- b) Function and quality: Project cannot achieve all of the features planned, or poor quality of the

products submitted

- c) Cost: cost of the project is much higher than budget.
- (2) *Define factors of analysis and classification risk*, the parameters is used to control risk management activities.
- (3) *The strategy of creating and maintaining risk management*  
A good RSKM strategy should meet the following conditions:
  - a) To plan RSKM in project development, and try to avoid the risk.
  - b) To designate risk managers, and monitor risk factors.
  - c) To establish risk items and risk management plan.
  - d) To establish the risk feedback channels.
  - e) To check risk occurrence possibility regularly.

*Major Outputs:* risk resource and types have been defined, and decided the strategy of risk management.

*Exit Criteria:* < Risk Source List > and <Project Risk Management Strategy>, etc.

#### 2. Risk Assessment

*Purpose:* identify and analysis risk to decide relative importance

*Entry Criteria:* < Risk Source List > and <Project Risk Management Strategy> have been finished.

*Major Inputs:* < Risk Source List > and <Project Risk Management Strategy>

The main activities of risk assessment:

##### (1) Risk identification

Risk identification is the first step of risk assessment to identify risk of known and predictable of project, the common method is to build "Risk checklist items", the checklist items list the entire possible questions related to each risk factor, which can let risk manager focus on identifying common, known, and predictable risk, such as: requirement risk, management risk, and technology risk. You need to constantly update checklist items from project start to before project over, this can make the project staff to keep waking consciousness of risk management, constantly solve risk and identify new risk, which can make project to be smooth.

##### (2) Risk quantification and ranking

The different occurrence of risk is difference, and the impacts of project is difference too, so you have to distinguish various risks, and to understand what risk can be ignored, and what risk have to be controlled, so, this need risk quantification method to measure risk, and present risk ranking, organization can use the size of risk exposure to measure them. There are two factors to decide risk exposure value: one is probability of risk occurrence, the other one is degree of risk impact on the project.

- a) Probability of risk occurrence  
To establish the probability of risk occurrence follow different project. For example, Table-10 divides probability of risk occurrence into five levels.

**Table 10. Probability of five level risks**

Probability of Risk Occurrence	Value Range
Highest	0.8-1.0
Higher	0.5-0.8
Middle	0.5
Lower	0.2-0.5
Lowest	0.0-0.2

- b) Degree of risk impact on the project:  
Degree of impact is to need to be measured. In here, we can do the level divided, and assignment, for example, Table-11 divides degree of risk impact into seven levels.

**Table 11. The effect of seven level risks**

Level of Impact	Value Range
Dangerous	1.0
Highest	0.8-1.0
Higher	0.5-0.8
Middle	0.5
Lower	0.2-0.5
Lowest	0.0-0.2
No	0.0

- c) Calculation of risk exposure value:  
Risk exposure value is not only related to probability of risk occurrence, but degree of risk impact as well, the computing formula is:  
 $RE(R) = Prob(R) * Loss(R)$   
RE(R): risk exposure value  
Prob(R): probability of risk occurrence  
Loss(R): Loss of Degree of impact

*Major Outputs:* identify existence risk and priority level of risk.  
*Exit Criteria:* <Risk List>

### 3. Risk control

Risk control can eliminate potential threats and risks through risk monitor and risk aversion. In the whole project, the risk management is continuous and repeating, after eliminates some risk, the new risk will out. So, during project implementing, project management staffs have to make a standard to measure project progress state.

*Purpose:* The risk is processed and reduced to reduce negative impact

*Entry Criteria:* <Risk List> has been finished  
*Major Inputs:* <Risk List>

The main activities of risk control:

- (1) **Risk monitor:** as it is difficult to forecast the effect of progress to the project, so the risk monitor is an

important task in the project implementation. Risk monitor is to monitor the change of project product, progress of the project process, and project environment. General, as the project progresses, the risks will be more, the task of risk monitor will be bigger and more complex in the time, propose the solution and method will be more needs.

- (2) **Risk aversion:** when the risk is monitored, and which exceed threshold or risk possibility is high, then, you should use appropriate method to do the risk aversion, organization can start the work from nature of the risk, change probability of risk occurrence, and change effect of risk occurrence. The tactics of risk aversion include prevention, transfer, avoidance, and acceptance.
- (3) **Ex-post control-risk management report:** regardless of the progress of the project, you have to arrange, gather and analysis the RSKM plan, activity, and result, and then, fix them into RSKM.

*Major Outputs:* <Risk Management plan>, <Risk Status List>, etc.

*Exit Criteria:* <Risk Management Plan>, <Risk Status List> have been finished

## 6.3. Discussion

Software outsourcing industry is growing rapidly, thus facing many challenges which are in many ways different from in-house development. Outsourcing projects help in cutting the cost, but at the same time it is difficult for outsourcing companies to do project management, configuration management, requirement management and risk management consistently an precisely due to lack of resources and weak organizational structure. Among many challenges faced by Software outsourcing companies one of them is an efficient development process and its continuous improvement throughout the life cycle of the projects.

This research has provided a process improvement framework for software outsourcing companies in order to overcome the challenges they face in improving their development process. One of the major challenges faced by outsourcing companies is shortage of competent managers for the middle and senior management. Another important issue faced by outsourcing companies is lack of resources including human resource, tools and technology as it comes with cost. Many Outsourcing companies are low budget companies and they don't have enough tools and resources to implement the process improvement methods effectively and efficiently. These challenges often create a big communication gap between clients and outsourcing companies. This Communication gap leads to problems in configuration management of the project, managing and controlling the changes in the requirement, and controlling the quality of the projects. The outsourcing project teams cannot grasp the quality indicators of work product, and thus the final quality verification of the product evaluated by most of the clients is with unsatisfactory remarks. These challenges require that outsourcing companies should focus on improving the Quality assurance capabilities and improve their management skills through an effective process.

### 7. CONCLUSION

To overcome these challenges a framework is designed that can be used by outsourcing companies for process improvement, This framework will help them in facing the major challenges in the area of project management, requirement management, configuration management, risk management, quality assurance and project monitoring and control through an effective process. The framework will focus on key process areas identified for outsourcing projects and will help in building quality products in short span of time, confidently and securely.

The data collected in this research was from various software outsourcing companies via their websites, research papers and case studies performed in outsourcing environment. The CMMI provides lot of information about software outsourcing. We tried to contact many outsourcing companies about their process improvement techniques and methods but all of them were reluctant in sharing their business goals. The results collected in this research are totally based on the case studies performed on outsourcing projects. In our thesis project, we use the CMMI to improve the project process, and get results. The results are never tested in real software organization or any projects so the outcome of the results may vary in different outsourcing environment. The results of this research provide a basic framework for outsourcing companies but it does not investigate the current environment of outsourcing companies and process improvement methods used by them, so outsourcing companies should align themselves according to SPIMO methods first in order to start a process improvement.

#### 6.4. Summary of Chapter

The SPIMO-Model is primarily aimed for software process improvement in outsourcing companies. It consists of specific goals and specific activities involved in different process area. These specific goals and specific activities are based on CMMI. The model also contains the key activities which are explained in section 6.2. The key process areas are mapped with certain problems in order to identify the possible hurdles in outsourcing projects. The key activities explain the implementation procedures which are required to be performed in order to improve a process.

The key activities explained by SPIMO-MODEL focus on improving process area by implementing them in a flow. In each process areas, to achieve the specific goals, organization have to implement the corresponding specific practices which should follow the activities explained by SPIMO-MODLE. The activity flow organizes specific goals into an activity flow. If the activities are implemented in right direction the SPIMO-MODEL will help in process improvement. These activities will lead project teams in understanding the overall flow of the activities and will provide step by step procedure in order to practically implement those activities. The purpose, entry criteria, major inputs, exit criteria and implementation of the main activities is the main job which a project team has to do.

The main objective with the thesis was to produce a software process improvement model that was tailored for outsourcing organizations. The aim with this model is that it should provide the key activities which should provide a way to plan and implement these activities. It should make it possible for outsourcing companies to identify their key process areas, identify their specific goals and activities related to achieve those specific goals.

The model should be based on the result of review literature from CMMI and case studies in outsourcing. For this study an extensive review literature was made to review and to find out the importance of different SPI activities from an outsourcing company point of view. The review was mainly based on CMMI. Key activities were included as implementation part with the purpose to make it complete and cover activities not included in CMMI.

The model is totally based on CMMI specific goals and specific practices. In order to interpret CMMI for outsourcing a well structure approach is required in order to start a process improvement inside a process area. The approach used in this master thesis is Problem-Goal-Question-Metric. This approach will focus on key problems exists in a process areas and measures to improve the process will enable staff to structure process improvement activities. This approach will help identifying the existing problems in a process area, specifying the requirements and providing effective measures in order to resolve the issues.

A conclusion made from the result of review literature is, that all the process areas explained by CMMI are not required for process improvement in outsourcing. By mapping the goals explained by CMMI and problems of outsourcing identified from reviewing case studies shows that six process areas are of most concern for process improvement in outsourcing projects.

The problems in outsourcing are identified by analyzing the life cycle of outsourcing projects and the relevant case studies. The problems are then mapped with the process areas according to their working environment. The main problems found in outsourcing are,

- Managing the requirements.
- Reaching End users.
- Incomplete lifecycle.
- Project Estimation Issues.
- Controlling the progress.
- Right of quality assurance is incomplete.
- Degree of autonomy, controllability of projects is not comprehensive.
- Risk assessment.

The following six process areas were found more important than others. If the key activities related to these process areas are explained with proper criteria it could lead organization in delivering high quality products in given time with high quality. The performance of outsourcing companies will increase by implementing key activities in these process areas.

- CONFIGURATION MANAGEMENT
- PROJECT MONITORING AND CONTROL
- PROJECT PLANNING
- PROJECT AND PRODUCT QUALITY ASSURANCE
- REQUIREMENT MANAGEMENT
- RISK MANAGEMENT

The reason for this is that CMMI focuses on process improvement throughout the whole organizational setup and process involved in software outsourcing less in number. On the other hand it is the authors' experience that outsourcing companies tend to work with specific activities required for the development of the product without focusing on improving them.

The SPIMO-Model is primarily aimed for software process improvement in outsourcing organization. It consists of Related Process areas, specific goals linked with every process areas and the specific activities involved to achieve those goals. These process areas, specific goals and specific activities are based on CMMI. The model provide a section of key activities which provide the guidelines to outsourcing companies in implementing the practices in order to achieve better results and at the same time improving the process.

One of the strengths of SPIM-MODEL is its structure that allows outsourcing companies to focus on most important process areas and vital activities related to them. The benefits of adapting this model is the key activities which act as implementation guidelines with specific criteria's to meet at the end of each process area.

It is important to point out that the proposed model has not been tested in a real outsourcing environment and can therefore not be said that it's working as expected. However the authors' expectations and belief in the SPIMO-Model are very high.

## 7.1. Future Work

### *Implementation of the model*

The aim with this Master thesis was to produce a software process improvement model for software outsourcing organizations. Yet there was no time to implement the model in a real organization. One of the interesting works could be practically implement the model in an organization. Preforming case studies in each process areas would be interesting. To investigate how model works and how model effects can be studied using case studies. Another aspect would be trying to practically implement the key activities inside an organization.

### *Improving the model*

SPIMO-MODEL was based on CMMI practices and specific goals, one interesting thing would be involvement of other process improvement models. Another important thing would be getting feedback from the outsourcing companies to improve the model.

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## APPENDIX A: Key process areas defined by CMMI

This section contains the process areas and their abbreviations as defined by CMMI.

<b>Process Area name</b>	<b>abbreviation</b>
Causal Analysis and Resolution	CAR
Configuration Management	CM
Decision Analysis and Resolution	DAR
Integrated Project Management + IPPD	IPM+IPPD
Measurement and Analysis	MA
Organizational Innovation and Deployment	OID
Organizational process Definition + IPPD	OPD+IPPD
Organizational process Focus	OPF
Organizational process Performance	OPP
Organization Training	OT
Production Integration	PI
Project Monitoring and Control	PMC
Project Planning	PP
Process and product quality Assurance	PPQA
Quantitative project Management	QPM
Requirements Development	RD
Requirements Management	REQM
Risk Management	RSKM
Supplier Agreement Management	SAM
Technical Solution	TS
Validation	VAL
Verification	VER

## APPENDIX B: Generic goals, generic practices and sub practices identified by CMMI

This section contains all the Generic goals, Generic practices and Sub practices for the Key Process Areas.

Generic Goals	Generic Practice	Sub Practices
<p>GG1: Achieve Specific Goals</p> <p>The specific goals of this process area are supported by the process by finalizing the product from initial stage to the final stage.</p>	<p>GP1: Perform Specific Practice.</p> <p>The purpose of this specific practice is to produce the products and deliver the service.</p>	
<p>GG2: Institutionalize a Managed Process</p> <p>The Process is repeatedly performed as a managed process.</p>	<p>GP 2.1: Establish an organizational policy.</p> <p>The purpose of this GP is providing details about expected outcome from a process.</p>	
	<p>GP 2.2 Plan the Process</p>	<p>Define the Document of plan.</p> <p>2. Define and document the process description.</p> <p>3. Review the plan with relevant stakeholders and get their agreement.</p> <p>4. Revise the plan as necessary.</p>
	<p>GP 2.3 Provide Resources</p>	
	<p>GP 2.4 Assign Responsibility</p>	<p>1. Assign authority and responsibility for performing the overall and specific tasks of process.</p> <p>2. Confirming people assigned this authority understand it and accept it.</p>
	<p>GP 2.5 Train People</p>	
	<p>GP 2.6 Control Work Products</p>	
	<p>GP 2.7 Identify and Involve Relevant Stakeholders.</p> <p>Stakeholders are involved normally in planning, decision making, communication, coordination, reviews, requirement definitions and appraisals.</p>	<p>1. Identify and plan the involvement of stakeholder's relevant to the process.</p> <p>2. Share identifications with project planners.</p> <p>3. Involve relevant stakeholders according to the plan.</p>
	<p>GP 2.8 Monitor and Control the Process</p>	<p>1. Evaluate actual progress and performance of work products and services.</p> <p>2. Review results against the plan for performing the process.</p> <p>3. Review activities, status, and results of the process and identify issues.</p> <p>4. Identify and evaluate the effects of significant deviations from the plan for performing the process.</p> <p>5. Identify problems in the plan</p> <p>6. Take corrective action when requirements and objectives are not being satisfied,</p> <p>7. Track corrective action to closure.</p>
	<p>GP 2.9 Objectively Evaluate Adherence</p> <p>The purpose of this generic practice is to provide assurance that process and work product is implemented as</p>	

	planned.	
	GP 2.10 Review Status with Higher Level Management The purpose of this practice is to provide insight to higher management inside a process.	
GG 3 Institutionalize a Defined Process	GP 3.1 Establish a Defined Process. The purpose of this practice is to define a process tailored from organization set of standard process.	1. Selection of standard process covering process areas and required for project and organizational functions. 2. Establish the defined process by tailoring the selected processes according to guidelines tailored by organization. 3. Ensure that the organization's process objectives are appropriately addressed in the defined process. 4. Document and record the define process and tailoring, and revise it accordingly.
	GP 3.2 Collect Process Related Experiences	1. Store process and product measures in measurement repository, submit the documentation and lesson learned in organization process asset library and propose improvements to the process assets of organization.

Generic Practice	Process Area Elaboration	Example Work products
GP1: Perform Specific Practice. The purpose of this specific practice is to produce the products and deliver the service.		
GP 2.1: Establish an organizational policy. The purpose of this GP is providing details about expected outcome from a process.	CM Elaboration: <i>Maintaining baselines keep tracks and records and control changes in the products under development.</i>	
GP 2.2 Plan the Process	CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration <i>Plans for all these process area in can be included in Project Plan.</i>	Description of Process Standards and requirements Specific objectives to achieve results Dependencies among process Assigning responsibility Training for supporting process Controlling of work products Involving relevant stakeholders Activities to do Monitoring and Controlling of the process
GP 2.3 Provide Resources	CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration <i>Providing the Resources to perform tasks</i>	Database Management tools Tracking Systems Experienced estimators, Schedulers Evaluation tools Traceability tools Risk mitigation tools
GP 2.4 Assign Responsibility	PPQA Elaboration <i>Assigning responsibility to people to perform process and product quality assurance independently.</i>	
GP 2.5 Train People	CM Elaboration PMC Elaboration PP Elaboration	<b>CM Elaboration</b> Roles, responsibilities of configuration management staff, Configuration management standards, procedures, and methods.

	PPQA Elaboration REQM Elaboration RSKM Elaboration	<b>PMC Elaboration</b> Monitoring and control Risk and Data management Application Domain <b>PP Elaboration</b> Estimating, Budgeting, Negotiating Risk and data management, planning and scheduling <b>PPQA Elaboration</b> Quality assurance objectives, process descriptions, standards, procedures, methods, and tools <b>REQM Elaboration</b> Requirements management and configuration management tools training for negotiation and resolving conflicts. <b>RSKM Elaboration</b> Risk management including risk identification, evaluation, monitoring and mitigation.
GP 2.6 Control Work Products	CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration	<b>CM Elaboration</b> Access list and Manage change request <b>PMC Elaboration</b> Project schedules with status <b>PP Elaboration</b> Project plan, DB management plan, WBS, involvement of stakeholders <b>PPQA Elaboration</b> Evaluation of logs and reports <b>REQM Elaboration</b> Requirements traceability matrix <b>RSKM Elaboration</b> Risk management strategy and mitigation plans.
GP 2.7 Identify and Involve Relevant Stakeholders. Stakeholders are involved normally in planning, decision making, communication, coordination, reviews, requirement definitions and appraisals.	CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration	<b>CM Elaboration</b> The involvement includes establishing baselines, reviewing configuration, resolve issues, managing reports, analyzing results and configuration management. <b>PMC Elaboration</b> Reviewing commitments, risks, data management activities, project progress and managing actions taken to closure of project. <b>PP Elaboration</b> Establish estimates and reviewing all plans. <b>PPQA Elaboration</b> Establish criteria for [process evaluation and work products and resolving noncompliance issues. <b>REQM Elaboration</b> Resolving requirement engineering issues and identifying inconsistencies among the requirements, project plans and products. <b>RSKM Elaboration</b> Establish a free environment to discuss risk and review risk management plans strategy and reporting risk management status.
GP 2.8 Monitor and Control the Process	CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration	<b>CM Elaboration</b> Number of changes made to configuration items, schedule of audit activities <b>PMC Elaboration</b> Corrective actions taken both open and close, financial schedules, reviews performed and review schedules. <b>PP Elaboration</b> Revision to the plan cost, schedule and efforts. Schedule for development and maintenance. <b>PPQA Elaboration</b> Variance of objective process and work product evaluations and performed. Schedule for objective evaluations. <b>REQM Elaboration</b>



		<p>Number of change requirements and setting schedules analyzing and coordination of requirements.</p> <p><b>RSKM Elaboration</b> Number of risks identified, fixed, controlled and managed and schedules for risk analysis and risk mitigations.</p>
<p>GP 2.9 Objectively Evaluate Adherence The purpose of this generic practice is to provide assurance that process and work product is implemented as planned.</p>	<p>CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration</p>	<p><b>CM Elaboration</b> Establishing baseline and controlling changes.</p> <p><b>PMC Elaboration</b> Monitoring project performance and progress against project plan.</p> <p><b>PP Elaboration</b> Establish estimates, develop plan and achieve commitment as planned.</p> <p><b>PPQA Elaboration</b> Objectively evaluation process and work products and tracking noncompliance issues.</p> <p><b>REQM Elaboration</b> Managing requirement and aligning project plan, requirement and work products.</p> <p><b>RSKM Elaboration</b> Establishing risks management strategy, identifying risks and mitigating risks.</p>
<p>GP 2.10 Review Status with Higher Level Management The purpose of this practice is to provide insight to higher management inside a process.</p>	<p>REQM Elaboration Ensure to accomplish the commitment made on proposed changes by higher management.</p> <p>RSKM Elaboration Reviews of the project risks to take corrective actions by higher management.</p>	
<p>GP 3.1 Establish a Defined Process. The purpose of this practice is to define a process tailored from organization set of standard process.</p>		
<p>GP 3.2 Collect Process Related Experiences</p>	<p>CM Elaboration PMC Elaboration PP Elaboration PPQA Elaboration REQM Elaboration RSKM Elaboration</p>	<p><b>CM Elaboration</b> Status of configuration items and reporting containing results and change requests.</p> <p><b>PMC Elaboration</b> Record significant deviations, analyze it and take corrective measures.</p> <p><b>PP Elaboration</b> Structure of project data library and project attributes and their estimates and impact of risks.</p> <p><b>PPQA Elaboration</b> Evaluation logs, quality trends and reports about noncompliance and corrective actions and about cost of quality for the project.</p> <p><b>REQM Elaboration</b> Matrix for requirement traceability, number of unfunded requirements after changing and lesson learned in resolving lengthy requirements.</p> <p><b>RSKM Elaboration</b> Risk parameters Risk categories Risk status reports</p>

## APPENDIX C: Project plan

Task Name	Duration	Start	Finish	Resource Names
<b>Master Thesis</b>	<b>152 days</b>	<b>11/1/3</b>	<b>11/6/13</b>	<b>Zahoor,Zhou</b>
<b>Choosing a subject area</b>	<b>29 days</b>	<b>11/1/3</b>	<b>11/2/10</b>	<b>Zahoor,Zhou</b>
Defining Research Topic	3 days	11/1/3	11/1/5	Zahoor,Zhou
Reading previous research	5 days	11/1/6	11/1/12	Zahoor,Zhou
Writing Thesis Proposal	9 days	11/1/13	11/1/25	Zahoor,Zhou
Submission of Thesis proposal to Coordinator	2 days	11/1/26	11/1/27	Zahoor,Zhou
Research Topic Approval from Coordinator	1 day	11/1/28	11/1/28	Zahoor,Zhou
Looking for Company to sponsor our thesis	7 days	11/1/31	11/2/8	Zahoor,Zhou
Registering Master Thesis	1 day	11/2/9	11/2/9	Zahoor,Zhou
Thesis Registration approval	1 day	11/2/10	11/2/10	Zahoor,Zhou
Planning report	1 day	11/2/10	11/2/10	Zahoor,Zhou
<b>Research Plan</b>	<b>94 days</b>	<b>11/2/11</b>	<b>11/5/15</b>	<b>Zhou,Zahoor</b>
<b>Theoretical Framework</b>	<b>9 days</b>	<b>11/2/11</b>	<b>11/2/19</b>	<b>Zhou,Zahoor</b>
CMMI Model concepts	2 days	11/2/11	11/2/12	Zhou,Zahoor
Outsourcing concepts	2 days	11/2/13	11/2/14	Zhou,Zahoor
Software process concepts	2 days	11/2/15	11/2/16	Zhou,Zahoor
Project management methods	1 day	11/2/17	11/2/17	Zhou,Zahoor
Quality Control	2 days	11/2/18	11/2/19	Zhou,Zahoor
<b>Research Methodology</b>	<b>85 days</b>	<b>11/2/20</b>	<b>11/5/15</b>	<b>Zhou,Zahoor</b>
<b>Research phase</b>	<b>32 days</b>	<b>11/2/20</b>	<b>11/3/23</b>	<b>Zhou,Zahoor</b>
<b>Data collection</b>	<b>6 days</b>	<b>11/2/20</b>	<b>11/2/25</b>	<b>Zhou,Zahoor</b>
Collection of research paper for CMMI	2 days	11/2/20	11/2/21	Zhou
Collection of research in software process improvement and based on CMMI	2 days	11/2/20	11/2/21	Zahoor
Collection of research paper for software outsourcing and based on CMMI	2 days	11/2/22	11/2/23	Zhou
Collection of relevant articles, literatures, books, journals	2 days	11/2/22	11/2/23	Zahoor
Collection of relevant case studies for software outsourcing based on CMMI	2 days	11/2/24	11/2/25	Zhou,Zahoor
<b>Data Reading</b>	<b>26 days</b>	<b>11/2/26</b>	<b>11/3/23</b>	<b>Zhou,Zahoor</b>
Reading CMMI in detail	6 days	11/2/26	11/3/3	Zhou,Zahoor
Reading SPI in detail	4 days	11/3/4	11/3/7	Zhou,Zahoor
Reading Outsourcing in detail	4 days	11/3/8	11/3/11	Zhou,Zahoor
Reading Case Study	6 days	11/3/12	11/3/17	Zhou,Zahoor
Writing and explaining concept of CMMI	3 days	11/3/18	11/3/20	Zhou,Zahoor
Writing and explain concept of outsourcing	3 days	11/3/21	11/3/23	Zhou
Writing and explaining concepts of SPI	3 days	11/3/21	11/3/23	Zahoor
<b>Data Analysis phase</b>	<b>31 days</b>	<b>11/3/24</b>	<b>11/4/23</b>	<b>Zhou,Zahoor</b>
Analysis of CMMI Models	6 days	11/3/24	11/3/29	Zhou,Zahoor
Analysis of software process improvement based on CMMI	6 days	11/3/30	11/4/4	Zhou,Zahoor
Analysis of software outsourcing based on CMMI	6 days	11/4/5	11/4/10	Zhou,Zahoor
Analysis of case study and previous research work	6 days	11/4/11	11/4/16	Zhou,Zahoor
Writing Analysis results	7 days	11/4/17	11/4/23	Zhou,Zahoor
<b>Development Phase</b>	<b>22 days</b>	<b>11/4/24</b>	<b>11/5/15</b>	<b>Zhou,Zahoor</b>

Propose Best CMMI process areas for software outsourcing	7 days	11/4/24	11/4/30	Zhou,Zahoor
Model Designing	10 days	11/5/1	11/5/10	Zhou,Zahoor
Writing the research result	5 days	11/5/11	11/5/15	Zhou,Zahoor
<b>Result</b>	<b>5 days</b>	<b>11/5/16</b>	<b>11/5/20</b>	<b>Zhou,Zahoor</b>
Outcome and conclusion	5 days	11/5/16	11/5/20	Zhou,Zahoor
<b>Thesis Writing</b>	<b>10 days</b>	<b>11/5/27</b>	<b>11/6/5</b>	<b>Zhou,Zahoor</b>
Finalizing Thesis Report	10 days	11/5/27	11/6/5	Zhou,Zahoor
<b>Feedback</b>	<b>8 days</b>	<b>11/6/6</b>	<b>11/6/13</b>	<b>Zhou,Zahoor</b>
Submission Final Thesis report	1 day	11/6/6	11/6/6	Zhou,Zahoor
Rework after feedback	5 days	11/6/8	11/6/12	Zhou,Zahoor
<b>Presentation</b>	<b>1 day</b>	<b>11/6/13</b>	<b>11/6/13</b>	<b>Zhou,Zahoor</b>