2008-12

Measurement of software project management effectiveness

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MONTEREY, CALIFORNIA

DISSERTATION

MEASUREMENT OF SOFTWARE PROJECT MANAGEMENT EFFECTIVENESS

by

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December 2008

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2008	**3. REPORT TYPE AND DATES COVERED** Dissertation	
4. TITLE AND SUBTITLE: Measurement of Software Project Management Effectiveness			**5. FUNDING NUMBERS**
6. AUTHOR(S) Kadir Alpaslan Demir			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; Distribution is unlimited.			**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

Evaluating, monitoring, and improving the effectiveness of project management can contribute to successful acquisition of software systems. In this dissertation, we introduce a quantitative metric for gauging the effectiveness of managing a software-development project. The metric may be used to evaluate and monitor project management effectiveness in software projects by project managers, technical managers, executive managers, project team leaders and various experts in the project organization. It also has the potential to be used to quantify the effectiveness improvement efforts on project management areas. The metric is validated by conducting survey studies on software projects from public and private sectors. A statistical analysis of sixteen surveys on software projects, spanning small to large development projects, indicated that there is a strong positive correlation with software project success ratings provided by study participants and project management effectiveness measurements. Other contributions of this research include identification of approaches for measuring project management effectiveness of software projects, establishment of theories on project management and on project management effectiveness measurement, and the introduction and validation of a framework for software project management.

14. SUBJECT TERMS Type Keywords Here Project Management, Software Project Management, Project Management Effectiveness, Software Project Management Effectiveness, Software Metrics, Software Project Management Effectiveness Metric, Theory of Project Management, Software Project Management Measurement, Software Project Management Framework, Theory of Software Project Management, Project Management Metrics			**15. NUMBER OF PAGES** 428
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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MEASUREMENT OF SOFTWARE PROJECT MANAGEMENT EFFECTIVENESS

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DOCTOR OF PHILOSOPHY IN SOFTWARE ENGINEERING

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ABSTRACT

Evaluating, monitoring, and improving the effectiveness of project management can contribute to successful acquisition of software systems. In this dissertation, we introduce a quantitative metric for gauging the effectiveness of managing a software-development project. The metric may be used to evaluate and monitor project management effectiveness in software projects by project managers, technical managers, executive managers, project team leaders and various experts in the project organization. It also has the potential to be used to quantify the effectiveness improvement efforts on project management areas. The metric is validated by conducting survey studies on software projects from public and private sectors. A statistical analysis of sixteen surveys on software projects, spanning small to large development projects, indicated that there is a strong positive correlation with software project success ratings provided by study participants and project management effectiveness measurements. Other contributions of this research include identification of approaches for measuring project management effectiveness of software projects, establishment of theories on project management and on project management effectiveness measurement, and the introduction and validation of a framework for software project management.

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EXECUTIVE SUMMARY

Achieving high effectiveness in project management helps to ensure a successful outcome from the project. Currently, the software engineering body of knowledge lacks adequate tools that will help to quantify the project management effectiveness in software projects. Furthermore, the ability to assess or measure the status is essential to conduct any formal process improvement effort. In this dissertation, a software project management effectiveness metric is introduced. This metric provides a standard quantitative measure of project management effectiveness from project start to project delivery. It will help managers in software project development organizations to evaluate, monitor and improve project management effectiveness. Simply, this metric will guide project stakeholders to achieve better project outcomes, such as completing the project on time, within budget, with required functionality and with creation of value for project stakeholders.

Twenty survey studies on software projects are conducted to investigate the applicability and limitations of the metric. In addition, survey studies provided the necessary empirical evidence required for the validation of the metric. Pearson product moment correlation analysis on the data gathered from survey studies showed that there is a strong positive correlation with software project success ratings provided by study participants from survey studies and project management effectiveness measurements. The result of the analysis on the data set indicates that half of the variation in software project success may be explained by the project management effectiveness metric. This and other results based on the analysis conducted on the data set shows that the proposed software project management effectiveness measurement is sound.

The measurement of software project management effectiveness involves the use of two new tools developed within this research. The software project management evaluation instrument (SPMEI) is used to gather project data. Basically, this instrument is a data collection tool to gather project data related to fifteen project management areas. They are communication, teamwork, leadership, organizational commitment, project

manager, stakeholder involvement, staffing and hiring, requirements management, project planning and estimation, project monitoring and control, scope management, configuration management, quality engineering, risk assessment, and risk control. The instrument is comprehensive. A member of the project organization who has broad knowledge on all aspects of the project management fills out this questionnaire-based instrument. Then the data gathered with the instrument is fed into the software project management evaluation model (SPMEM). This model is used to measure the effectiveness based on the data gathered with the instrument. Responses to questions in the instrument are assigned with specific scores. The evaluation model simply combines these scores in a systematic way as it is hypothesized. SPMEM produces a score for each project management area and these scores are then used to compute a project management effectiveness (PME) score based on a scale from 0 to 10. A score of 0 indicates the least effective project management while a score of 10 indicates the most effective project management. A high PME score indicates a high probability of project success while a low PME score indicates a low probability of project success.

This doctoral research includes other contributions to the software engineering body of knowledge. At the beginning of the research, approaches for measuring the project management effectiveness in software projects are identified. This identification guided the selection of a suitable measurement approach. There are four ways to assess or measure the project management effectiveness. They are subjective evaluation, questionnaire-based measurement, metrics-based measurement, and model-based measurement. The chosen approach was the questionnaire-based measurement since this approach has shown promise in an earlier study while two other approaches, metrics-based measurement and model-based measurement, have not been used before. The other approach, subjective evaluation, was used by study participants to rate the success of their projects. The identification of approaches for measuring project management effectiveness will help researchers to develop other metrics in their future studies.

Project management discipline suffers from the lack of a theory of project management. This important issue has been raised by various scholars in recent years. These scholars indicated that not having a theory of project management poses challenges for advancing the body of knowledge. This research was also challenged due to the lack of a project management theory that lays the foundation for the development of a project management effectiveness metric. During the early phases of this research, the necessity for the development of a theory of project management became clear. Therefore a simple, yet powerful, theory of project management was developed. Simplicity is important because project management is complex by nature and development of the metric would be more challenging if the theory could not simplify the concepts. This theory aided the metric development process by providing a solid foundation to build upon. The core concepts in the theory of project management are activities and entities. A project is simply the result of a project management function that takes various activities and entities as its inputs. The ideal goal of project management is to find the right and efficient combination of necessary activities and entities to reach the desired outcome. Identification of activities and entities and arrangement of these activities and entities in an appropriate order while dealing with constraints are the tools to bring the project to life. The main task in the development of the software project management evaluation instrument was the identification of activities and entities used in software projects.

A theory of project management effectiveness measurement is developed based on the theory of project management and the core concepts identified with it. The theory of project management effectiveness measurement simply states that it is possible to measure project management effectiveness via measuring the effectiveness of activities and entities in software projects.

The development of another theory from the theory of project management and the successful results achieved in this research provides evidence for the validity of the proposed theory of project management.

Software project management is broad and complex by nature. The theory of project management lays the foundation for further advancement. Furthermore, it helps us to overcome the challenges of dealing with this complexity by enabling us to understand project management in terms of core concepts with a simpler view. It is essential to identify the boundaries as well. A software project management framework was developed in this research for two purposes. One of the purposes is to identify the boundaries of project management and necessary project management areas to be included in the effectiveness measurement. The other one is to categorize project management areas with respect to main areas. The main project management areas are people, process, product and risk. Each section in SPMEI corresponds to a project management area in the framework. Each project management area is categorized under one of the main areas. The first letters of these main areas are used in naming the framework. As a result, it is named as 3PR framework. This framework guided the development of the metric by helping the identification of what to include in the measurement. The 3PR framework is simple and modifiable. Therefore, it served well during the development of the metric. This framework is validated via a survey of software practitioners around the world. In addition, this validation survey helped to identify importance weightings for each main project management area. These weights are used in the development of the software project management evaluation model to compute the effectiveness score.

In this research, the development of software project management effectiveness metric required the accomplishment of a set of related studies, mainly because either such studies do not exist in prior literature or the existing literature are found to be inadequate.

The findings of the analysis conducted on the data gathered from survey studies indicates that the software project management effectiveness metric proposed in this research is sound, valid and applicable to be used in software projects.

ACKNOWLEDGMENTS

I would like to dedicate this work to all the people trying to make this world a better place to live for all others. This has been a long, exciting, joyful and demanding journey. Many people helped me in this journey. I will not able to mention all these people here. They know themselves. I want to thank them all anonymously.

First, I thank my family. I would not able to finish this journey if I did not have their constant and incredible support. Dad, Mom, Aslı, Selim, Cengiz. I love you so much.

I would like to thank my committee members, Dr. Osmundson, Dr. Michael, Mr. Langford, Dr. Shing, and Dr. Auguston, for their guidance and support. I learned a lot from them. I also want to thank Dr. Peter J. Denning for coaching and inspiring me. I thank Dr. Douglas J. Fouts with all my heart for believing in me. All my professors, whom I take courses from, are good teachers. They taught me well. I am very lucky to learn from the best.

I thank my friends, Musa, Serdar, Sefa, Çağlar, and Mert for their support. I thank to my big brothers and sisters, Ufuk and Serap Canöz, Mehmet and Ayşegül Gümüş. Their support for my success is undeniable. They always believed in me. I am blessed to have them as my friends.

I thank Martin Machniak and Mary Grossman for their help. Mr. Capers Jones has been an inspiration to me. I thank him for sharing his vast experience and knowledge. I appreciate Dr. Peter Chow's selfless mentoring. I also thank Kimberly Wiefling and SDForum Engineering Leadership Special Interest Group. I learned a lot from the meetings of this special interest group formed by incredible practitioners.

I thank Vishant and Neşe Shahnawaz, Dr Nafiz and Nilgün Arıca for their support and friendship. I also thank Vehbi, Sebahat, Çare and Ogün Meriçligil for their love.

Finally, I thank to a very special person, Seda. Without her support, encouragement, and inspiration, this research would not have been successfully completed.

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I. INTRODUCTION

A. BACKGROUND

The term “software crisis” was coined in 1968 at a NATO working group meeting on software engineering. At the time, the term referred to the inability of the government defense organizations of NATO countries to procure software-intensive systems on schedule, within budget, and with the desired level of functionality and dependability. The discipline known as software engineering is relatively new in relation to its sister engineering disciplines, but the pace of the evolution of software engineering into a mature engineering discipline needs to pick up because the lion’s share of the functionality in most systems produced today is implemented in software.

A report by the U.S. General Accounting Office (GAO) (1979) states that of the government software development projects analyzed:

- more than 50% had cost overruns;
- more than 60% had schedule overruns;
- more than 45% of the delivered software could not be used;
- more than 29% of the software contracted for was never delivered; and
- more than 19% of the software had to be reworked.

The Standish Group Report (1995) found that, on average, approximately 16% of software projects were completed on time and within budget. In addition, the projects completed contained only approximately 42% of the originally proposed features and functions. These two reports indicate that the situation has not changed.

The 1987, the Defense Science Board reported that:

> After two decades of largely unfulfilled promises about productivity and quality gains from applying new software methodologies and technologies, industry and government organizations are realizing that their fundamental problem is the inability to manage the software processes.

The U.S. DoD responded to this and various statements in similar reports by sponsoring the creation of the Software Engineering Institute (SEI) at the Carnegie Mellon University. SEI was tasked with finding ways to improve the software engineering processes used by the DoD and its contractors. One of the improvements developed by SEI is the Capability Maturity Model (CMM), which is now in use throughout the DoD. The CMM serves as a means to identify key practices to improve organizations' software development processes and propose models to encompass systematic advancements in various aspects of the process. The SEI specialized the original model to address software (SW-CMM), management of human-resources (P-CMM), systems engineering (SE-CMM), integrated product development (IPD-CMM), and software acquisition (SA-CMM). These models, except for SA-CMM, are now part of the Capability Maturity Model Integration (CMMI).

The Algorithmic Constructive Cost Model (COCOMO), developed in 1981, is one of the earliest and most widely used software project cost-estimation models (Boehm, 1981). The model is primarily used for developing predictions based on basic, intermediate, and detailed COCOMO; each level provides a different degree of rigor. Basic COCOMO is only useful when a quick, early, rough estimate is required. Intermediate COCOMO produces better results. Intermediate and detailed COCOMO take into account attributes of the software product, computer hardware, development personnel, and the project. Detailed COCOMO is more rigorous and describes the software as a module-subsystem-system hierarchy. In this model, software development is estimated by phase. However, neither of these models takes into account project management quality. Boehm, developer of these models, indicates that poor management can increase software costs more rapidly than any other factor. Furthermore, when estimating cost with COCOMO, there is an assumption built into the model that the project will be well-managed. Boehm also points out that management quality ratings are not easy to determine.

The first version of COCOMO II was released to the public in 1997. A few other versions with improvements were made available in subsequent years. COCOMO II was developed in response to the increasing difficulties in cost estimations with COCOMO 81 and COCOMO 87. Accidental advancements in the field such as development of new life cycle models, COTS and other reuse approaches, object oriented approaches, etc., were the reason for such difficulties (Brooks, 1995). COCOMO II has three submodels called Applications Composition, Early Design, and Post-architecture models (Boehm et al., 2000). It is crucial to state that COCOMO II recognizes the importance of maturity in cost, effort and schedule estimation. The model has a parameter called "process maturity" as an exponent scale factor. Process maturity affects the estimated effort exponentially (Boehm et al., 1995).

Development of CMMI and COCOMO models are two important studies in the field of software project management. These studies may be complemented with the introduction of a well-established software project management effectiveness metric. Such a metric would complement the CMMI and existing metrics, possibly contributing to further improvements in the software development processes and their applications in the development of software-intensive systems. The metric may be used as an input in software cost estimation models for better estimates.

B. CONTRIBUTIONS OF THIS RESEARCH

There is limited scientific work that addresses theories and foundations in software project management. The bulk of the work related to this area is based on experience reports with limited empirical studies.

This study expands the body of knowledge by laying new foundations and an introduction of a metric to evaluate the project management effectiveness in software projects. The contributions are listed below:

1. Introduction of a theory of project management.
2. Introduction of a theory of project management effectiveness measurement.
3. Identification of approaches for measuring project management effectiveness.
4. Introduction of a software project management framework.

5. Development of a self-evaluation instrument for software project management.
6. Development of a metric for software project management effectiveness.

Quality research enables us to ask new questions while providing answers to the old ones. These questions help us to improve the field. This research helps us to ask new questions in the field of software project management.

C. OVERVIEW OF THE DISSERTATION

This dissertation consists of ten chapters. Chapter I includes the introduction of the research. In the introduction section, statement and significance of the problem, the research hypothesis, the research overview, the assumptions and applicability of the metric, and the key definition are presented.

Chapter II discusses the related work. In this chapter, discussion of project success, project success and failure factors, the role of project management in achieving project success, measurement of project success, and software project management effectiveness are presented.

In Chapter III, the approaches for measuring the management effectiveness of software projects are outlined. Four different approaches are discussed with examples from prior research studies. The contribution in this chapter is the guidance for future researchers in the selection of metric development approaches.

Chapter IV introduces a theory of project management. This theory builds the necessary foundation for the development of the metric. In addition, a theoretical foundation for measurement of project management effectiveness is presented.

A framework for software project management is introduced in Chapter V. Related frameworks from various standards and software project management literature are discussed. The project management areas in the framework are explained.

In Chapter VI, the results from a survey study on software project management are presented. The goal of this survey study was to validate the framework introduced in the previous chapter. The results of the survey supported the validation of the framework.

In Chapter VII, the software project management evaluation instrument (SPMEI) and the evaluation model are explained. The overall structure, important characteristics, and the development of the instrument are discussed.

The analysis of the survey studies on software projects can be found in Chapter VIII. Each study is discussed briefly. The data analysis from these studies is also presented here.

The findings of this research are presented in Chapter IX, while conclusions and future work are discussed in the tenth and final chapter of the dissertation.

D. STATEMENT OF THE PROBLEM

Brooks (1995) points out in his well-known book that there are essential and accidental difficulties of software engineering. The accidental difficulties are timely problems of the field; they are solved with major breakthroughs and solutions, leading to increases in software development productivity. However, they are not inherent in the essence of software. According to Brooks, essential difficulties are inherent to the nature of software and they are complexity, conformity, changeability, and invisibility. If that is the case, no matter how much automation is acquired, software project development will continue to be a human-intensive task. Effective software project management is an important factor in the success of a software development project.

Without the use of metrics, software engineering processes will continue to be ad hoc processes at best. The SEI recognized this fact and incorporated a rating system to describe the maturity of an organization, from CMM level-one as ad hoc to level-five as optimizing. In order to comply with CMM level-four, organizations have to collect metrics related to software development processes. CMM level-five necessitates continuous effort on gathering these metrics and applying the metrics to continuously improve the process.

Currently, the software engineering field lacks a well-founded software project management metric. Such a metric could enable software project managers to measure the project management effectiveness, identify problematic areas during projects, identify challenged areas in completed projects (e.g., postmortem analysis), and shed light on forthcoming ones.

E. SIGNIFICANCE OF THE PROBLEM

In 2000, the Defense Science Board published a report on the subject of software process, stating that:

> … [the] DSB Task Force observed that requirements and management are the hardest part of the software task and advocated the use of revolutionary practices. This is still true today.

Furthermore, in the major findings and recommendations section of the same report, that the DSB concluded that “In general, the technical issues, although difficult at times, were not the determining factor. Disciplined execution was.”

DeMarco and Lister state in their recognized book about productive projects and teams: “For overwhelming majority of the bankrupt projects we studied, there was not a single technological issue to explain the failure.” Furthermore, “the major problems of our work are not so much technological as sociological in nature” (DeMarco & Lister, 1987; DeMarco & Lister, 1999).

Robertson and Robertson (2005) start one of the chapters named “Project Sociology” in their book with:

> In several decades of project experience, we have never seen a project fail for technical reasons. It has always been human failures that have caused otherwise good projects to grind to a halt.

These findings clearly point out that managing the software development process is still a fundamental problem within the defense community and the commercial world. However, little research has been devoted to this issue. In this dissertation, the goal is to develop and experiment with a project software management metric to measure the effectiveness of software project management.

The benefits of gathering metrics have been advocated by many researchers and practitioners in the field. Putnam and Myers (2003) explain how to use the metrics in software projects and how they are related with each other. They clearly emphasize that metrics provide and enable:

- dependable estimates of project effort, schedule, and reliability;
- control of the project during its course;
- ability to re-plan an errant project along the way;
- master-planning the assignment of resources to all projects within the organization;
- monitoring process improvement from year to year.

Having a software project management metric will complement the current set of metrics and provide us with a broader understanding of software development dynamics.

The ten most important success factors are identified in an IT project by The Standish Group's CHAOS study (1994). In 2000, the ratings of the factors are updated by The Standish Group (2000). According to the new rating, the factors, executive support and experienced project manager, were rated first and third with a success factor of 18 and 14 out of 100 respectively. A software project management metric will provide a project management evaluation that can be used by project managers to better manage software development efforts.

Finally, Peter W. G. Morris (Pinto, 1998) states that:

> One of the major areas of project management development over the next few years, I believe, will be establishing and refining interindustry metrics for quantifying performance improvements. Much of this work will be IT related.

Martha Gray (1999) discusses the state of software metrics and emphasizes the immaturity of software metrology and its fundamentals. She points out the importance of having measures for software and IT industry. This study will be an addition to the set of metrics and it will form a basis for discussion over the measurement of project management effectiveness in software projects.

F. RESEARCH HYPOTHESIS

There is only one hypothesis in this research:

- The success of a software project positively correlates to its project management effectiveness.

The success rating of the project will be provided by the survey study participants. They will assess the success of a project based on their perspectives. They will rate the project success on a 0 to 10 scale, with 0 being complete failure and 10 being complete success. The software project management effectiveness (PME) will be acquired using the software project management evaluation instrument and model. The PME metric will be on a scale from 0 to 10.

The testing of the hypothesis will be conducted by analyzing the Pearson product-moment correlation coefficient (PMCC) between these two measures.

G. RESEARCH OVERVIEW

1. Research Questions

We believe that it is possible to develop a software project management effectiveness metric. This metric should be meaningful enough that it provides insights on the quality of the project management. The measure should also be able to distinguish between the projects following certain expected best practices and others lacking some of these practices.

The following questions will be addressed with this research:

1. What are the most important project management areas?
2. What are the possible approaches for measuring the project management effectiveness?
3. Is it possible to develop a simple theory of project management and measurement of project management effectiveness?

4. Is it possible to develop a software project management metric that measures the project management effectiveness in a software project?

5. Will this metric be sound, meaningful and applicable?

Soundness of the metric is that software practitioners respond positively when applying the metric. To get some idea regarding the soundness, we can simply ask them if they find the metric sound during its application. Further analysis can be conducted by identifying and responding to validity concerns. Meaningfulness of the metric is that it yields different results for the project management in which one of them clearly lacks certain best practices. Applicability of the metric is that the measurement is practical.

Answering the fifth research question in detail requires substantial research that expands beyond the scope of this dissertation. However, some evidence can be provided as to whether such qualities are captured to a certain level with the metric. It is important to address these qualities in a metric development effort.

2. Research Strategy

The objective of this research is to develop a software project management effectiveness metric. The literature on the subject is limited and mostly consists of rough models such as Pinto and Slevin (1987) and Wohlin and von Mayrhauser (2001) for project success.

Identification of crucial and common aspects for software project management is the first step for this research. Second, this identification will help us to develop a framework to work on. The validation of the framework is necessary to ensure the soundness of the metric. A survey of software practitioners will be conducted for the validation as a third step. Then, using the framework and its components, a measurement tool will be developed. Finally, data will be collected from real-world software projects and the results will be analyzed.

Any meaningful measurement instrument should be able to distinguish two different entities based on the goal of the measurement. In addition, it is imperative to be able to substantiate one measure with another measure. Therefore, in this research, two different measures will be used. These two types of scores will be analyzed for positive correlation. The data analysis from survey studies will help us to determine the soundness, meaningfulness and applicability of the software project management effectiveness metric (PME). The framework of the research is shown in Figure 1.

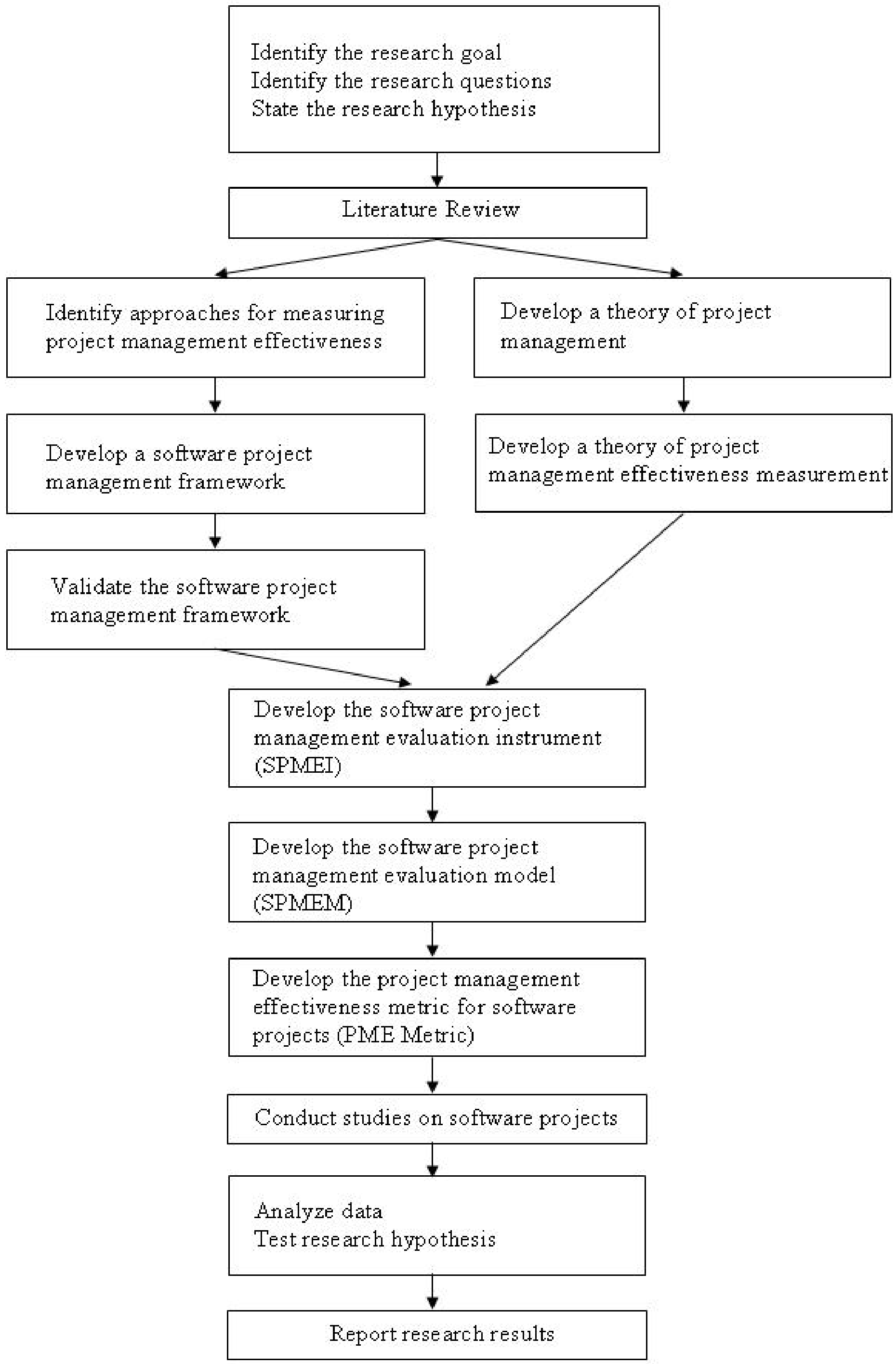

Figure 1. Research Framework

3. Research Scope

The scope of the research includes:

- A background analysis and literature review.
- Development of a viable framework for software project management.
- Validation of the framework through a survey study.
- Identification of significant aspects of software project management.
- Development of a metric that measures the project management effectiveness in software projects.
- Validation of the metric through studies on software projects.

H. ASSUMPTIONS AND APPLICABILITY

It is important to state the assumptions and applicability of the measurement activity clearly. Therefore, assumptions and applicability of the metric are provided below.

1. Assumptions

Assumption 1. A software project development requires at least an informal process that involves certain activities.

Assumption 2. Software project management requires certain concepts, entities, roles and functions to exist within the software project team and the rest of the stakeholders.

Assumption 3. Small size maintenance projects require different management techniques than software development projects. Therefore, the metric may not be reliable for small software maintenance projects.

Assumption 4. There exists at least one person who has insight over a broad aspect of project management and the metric instrument is to be used by such a person.

2. Applicability

Applicability 1. The metric instrument is designed to be applicable to software or software intensive projects. It is not applicable to projects in which only a very small portion of the project involves software development.

Applicability 2. The metric is applicable to canceled projects on the condition that at least some requirements development activities are conducted.

Applicability 3. The instrument measures the project management effectiveness from the project start to the customer delivery time or the time it is canceled. The project start time is defined (for the purpose of this metric) as the time after the business decision is made to go ahead with the project. Therefore, the soundness and quality of the business decision is not included in this measurement. Because the metric instrument evaluates the management effectiveness during the development, the business decision is not considered a part of the development for the purpose of this study. The quality assessment of the business decision may require different metrics.

The measure of project management effectiveness may be high even though the customer never uses the deliverables of the project due to various reasons. The assessment of customer satisfaction after delivery is not included in the measurement.

Applicability 4. The metric is not designed to evaluate the effectiveness of small software maintenance projects.

Applicability 5. The metric is not applicable to very small software development efforts in which certain management roles and functions are not distinctively identifiable. These projects generally include a very small team of developers.

Applicability 6. The metric instrument should be used by a project manager, an executive manager or a project team member who has broad insight into all management aspects of the project.

I. KEY DEFINITIONS: PROJECT, SOFTWARE PROJECT, PROJECT MANAGEMENT, AND SOFTWARE PROJECT MANAGEMENT

First of all, we have to define what a project is and discuss if the definition applies to software projects. There are various definitions of projects in the literature. One of the best is offered by Tuman (1988):

> A project is an organization of people dedicated to a specific purpose or objective. Projects generally involve large, expensive, unique, or high risk undertakings which have to be completed by a certain date, for a certain amount of money, within some expected level of performance. At a minimum, all projects need to have well defined objectives and sufficient resources to carry out all the required tasks.

Some of the recognized researches on various aspects of projects are reported by Jeffrey K. Pinto and Dennis P. Slevin dating back to the 1980s. Pinto and Slevin (1988) defined the characteristics of projects as follows:

- A defined beginning and end (specified time to completion).
- A specific, preordained goal or set of goals (performance expectations).
- A series of complex or interrelated activities.
- A limited budget.

All of these project characteristics also apply to software projects without exception. An addition to these characteristic is as follows:

The project emphasis must be on software or a mix of software and hardware.

The definition of a software project for the purpose of this dissertation is as follows:

> *A software project is an undertaking in which the emphasis is a piece of software or a mix of software and hardware and it involves a series of complex or interrelated activities to achieve a specific, preordained goal or set of goals. The software project has a limited budget, a defined beginning and an end.*

Munns and Bjeirmi (1996) state that the distinction between the project and project management is less than precise. Definitions for these two terms are also provided and their definition of a project is quite similar with the given definition above. The definition of project management is given by Munns and Bjerimi (1996) is:

> …project management can be defined as the process of controlling the achievement of the project objectives. Utilizing the existing organizational structures and resources, it seeks to manage the project by applying a collection of tools and techniques, without adversely disturbing the routine operation of the company.
>
> The functions of project management include:

- Defining what needs to be done in order to achieve project goals.
- Establishing the boundaries and extent of work.
- Determining, planning, estimating and allocating the resources required.
- Planning and implementing the work.
- Monitoring the progress of work.
- Managing risk, adjusting and accommodating deviations from the plan.

The definitions of project and project management may seem to overlap in many aspects. Both are oriented towards the accomplishment of the project. However, Munns and Bjeirmi (1996) point out an important difference between these two. While the scope of a project is long-term, the scope of project management is short-term. The expected benefits from a project may be financial, technical or marketing-oriented. All of these benefits tend to be long-term in nature. For example, in order to determine the return on investment from the project, a certain point of time must be reached after the project is successfully in place. If the return on investment is computed just after the project implementation, it is unlikely to reflect the correct figure. Also, the project success factors and the perception of project success change over time (Pinto and Slevin, 1988; Pinto and Prescott, 1988; Pinto and Mantel, 1990; Fortune and White, 2006). On the other hand, project management is oriented towards planning and control. The basic concerns are on-time delivery, expenditures within budget expectations, and achieving the necessary expected performance. All these are short-term goals in the life cycle of a project. After the project delivery for use, project management tasks are either completed or significantly reduced. Thus, project management success should be measured upon project delivery when most project management tasks are completed. Software project management refers to the project management when the project emphasis is on software or a mix of software and hardware.

II. RELATED WORK

The research on success and effectiveness of project management has been the interest of various researchers in the past. However, most of the research completed was not specifically targeted to the software development field. The projects analyzed in these studies included projects from diverse fields such as construction, manufacturing, environmental, etc. It has been recognized that managing software projects is different in many aspects (Brooks, 1995). However, it is possible to extract similarities that can help us to conduct studies on software project management effectiveness.

A. DISCUSSION OF PROJECT SUCCESS

First, it is important to emphasize that project success is not the same as project management success (Cooke-Davies, 2004c).

Defining project success is not an easy task. According to Griffin and Page (1996), it is multifaceted and difficult to measure. Even though many studies have been conducted on identification of project success factors, project failure factors or related areas, the criteria for success have not been well-established. Pinto and Slevin (1998, p. 379) state that "success" and "failure," like beauty, are in the eyes of the beholder. There is a significant risk of mislabeling projects as success or failure when there are no universally agreed criteria. Pinto and Slevin argued the need for a working definition of project success. The three conventional criteria of project success present challenges. These conventional criteria are:

- Time (completing the project within the scheduled time frame).
- Cost (completing the project within its budget limits).
- Performance (completing the project with achieving its intended mission and specifications).

Pinto and Rouhiainen (1998) state that these criteria do not work in the modern business world. The tremendous competition in this modern business world requires a customer-oriented focus. Therefore, customer satisfaction should be a criterion in the evaluation of project success.

Glass (1999) points out the need for a new theory of project success. Different stakeholders may have different concerns. This is inevitable. One of the key challenges of any project management is to align the goals and address the concerns of the stakeholders. Linberg (1999) showed that the definition of success for software practitioners is quite different from the conventional criteria. Software practitioners may classify a project as a success even though it is late, or perhaps over budget. They are more concerned with the quality and functionality of the product. Also, they may even view a cancelled project as a success due to the lessons learned from the project. Agarwal and Rathod (2006) investigated the notion of software project success for different stakeholders. They examined project success in the views of programmers/developers, project managers, and customer account managers. Procaccino (2002, et al., 2005) developed a quantitative model for early assessment of software development success in the practitioner's perspective.

Griffin and Page (1996) suggest that the most appropriate set of success measures should be derived from the project strategy. For example, the success criteria for a product development that opens up a new market should be different than the criteria for the development of a product that is extending a product line. They relate the product development success to the company's innovation strategy.

Cooke-Davies (2004a) examines the issue with a broader view. His view beautifully clarifies some challenged research areas. He provides a definition of success at different levels. His questions for each level help us to focus on the heart of the matter. According to him, there are three levels of success:

- Level 1. Project Management Success – was the project done right?

  At this level, the measures of success are the traditional project success criteria. The job of project management is about managing time, cost and quality. The project management's job should start after the decision about the business case has been concluded by upper management. Therefore, the question "was the project done right?" really suggests what the measure of success at this level is. The focus of this study is the first level of success which is project management success.

- Level 2. Project Success – was the right project done?

  This level of success is about choosing the right problem to solve.

- Level 3. Consistent Project Success – were the right projects done right, time after time?

  This level of success is about organizational success. In order to reach organizational success, organizations have to complete projects successfully over and over.

B. PROJECT SUCCESS FACTORS

This dissertation focuses on software project management effectiveness, evaluation, and the development of a metric. The literature on the subject is quite limited. However, it is possible to draw similarities from researches on project management and project success. These studies mostly focus on the broad aspects of projects. A brief overview of selected studies on project success will be provided next.

A significant part of literature on project management is the identification of critical factors for project success or successful project implementation. Most of them are theoretically based and only some fraction of them is empirically-supported. One of the earliest attempts was conducted by Pinto and Slevin (1987). They identified critical success factors felt to be predictive of successful project management. Ten factors were discovered after an empirical study. Some of these factors are also mentioned in other theoretical research (Martin, 1976; Locke, 1984; Cleland and King, 1983; Sayles and Chandler, 1971; Baker, Murphy & Fisher, 1983; DeCotiis and Dyer, 1979). The ten factors are:

Project Mission: Having clearly defined goals was rated as one of the most important factors. This factor is supported with many research works (Martin, 1976; Locke, 1984; Cleland and King, 1983; Baker, Murphy & Fisher, 1983; Pinto and Kharbanda, 1995).

Top Management Support: This factor is considered as a key enabler in many studies for successful project implementation. It is considered of great importance in determining the ultimate success or failure of projects (Schultz and Slevin, 1975). Top management support includes aspects such as allocation of sufficient resources including financial, manpower, time, etc. The degree of management support will lead to considerable variations in the acceptance of the project by stakeholders (Manley, 1975). Two important studies of The Standish Group (1994, 2000) discovered that top management support in IT projects is among the first two success factors.

Project Schedule/Plan: This factor refers to all planning and scheduling activities including contingency plans in case the project is off schedule. It also includes risk management issues related to budget and manpower. This factor may be categorized under different names or divided into some other factors in other studies.

Client Consultation: In Pinto and Slevin (1987), the client refers to anyone who will ultimately be making use of the project as either a customer outside the company or a department within the organization. Manley (1975) found that client involvement to the project creates significant variations in their support to the project. Like the project schedule/plan factor, client consultation can be found in many research works under different names. For software engineering research, the meaning is close to consideration of the stakeholders' interests. Under The Standish Group (1994, 2000), the factor partially exists as user involvement.

Personnel Issues: The fifth factor was personnel issues including recruitment, selection, and training. Some research suggests that the right people for the right job is an enabler for successful project implementation (O'Connell, 2002). For example, Hammond (1979) included people as a variable to his contingency model of the implementation process. Also, the importance of project manager skills is emphasized in some studies (Sayles and Chandler, 1971; Baker, Murphy & Fisher, 1983; Belasi and Tukul, 1996; Verner and Evanco, 2005).

Technical Tasks: This factor refers to the necessity of having personnel with the necessary technical skills and having the adequate technology to perform their tasks.

Client Acceptance: Client acceptance refers to the final stage of the implementation process. Even though client consultation is managed well during the project development, client acceptance is another step to be managed just like other stages. A study was conducted by Bean and Radnor (1979) to examine intermediaries between the parties of the project.

Monitoring and Feedback: This is the eighth factor Pinto and Slevin identified. Monitoring and feedback refers to overseeing the schedule, budget and performance, and taking corrective action when plans are deviating. Souder (1975) emphasizes the importance of constant monitoring from a budgeting perspective. With metrics, monitoring and feedback will be based on facts. Putnam and Myers (2003) suggest the use of metrics to manage projects. Reel (1999) also emphasizes that keeping track of progress during software development and post-mortem analysis are crucial for success.

Communication: Having proper and adequate communication channels in place between stakeholders is extremely essential for successful project implementation. This factor works as a catalyst for many other factors such as advertisement of project mission, top management support, client consultation, personnel issues, client acceptance, etc.

Trouble-shooting: The last factor listed in the Pinto and Slevin (1987) study is trouble-shooting. The term actually refers to risk management activities in today's literature. The importance of risk management is broadly recognized today.

The study also recognizes the necessity of an empirically based model of the project implementation process and a measurement instrument to quantify the success of a project implementation. Such a model can be formulated as follows (Pinto and Slevin, 1987):

$$S = f(x_1, x_2, \ldots, x_n),$$

where S is project success, and x_i is the critical success factor i.

In this simplified model, it is assumed that independent variable success factor x_i relates positively to project success. The study only identifies the critical success factors; however, it doesn't measure the strength of their relationship with project success.

Pinto and Slevin conducted empirical research on project implementation. They identified the critical success factors and even proposed a simple measurement model based on critical factors. The importance of this research is that the factors identified are more comprehensive than most other studies (Martin, 1976; Locke, 1984; Sayles and Chandler, 1971; Morris and Hough, 1987; Reel, 1999). This study partially relates to this research by proposing a measurement model. Different types of projects require different project management practices (Cooke-Davies, 2004b). Thus, different factors may be descriptive of project success in different projects. In addition, the focus in this dissertation is on project management success, which can be considered as a factor in project success (Munns and Bjeirmi, 1996; Wohlin and Mayrhauser, 2001).

Jiang et al. (1996) produced a list of thirteen critical success factors in 1996. The factors identified were almost identical to those identified by Pinto and Slevin. Competent project manger, competent project team members, and sufficient resource allocation may be thought as the addition to the previous list. The study ends with an important conclusion stating that information system users and professionals are surprisingly similar in their importance rankings of success factors. It is also important to note that the success factors haven't changed dramatically over time.

Gemuenden and Lecher (1997) conducted an empirical study on identifying critical success factors based on a large data set (448 projects). Their goal was to identify a limited number of factors. They have identified eight success factors explaining approximately 59% of variance in project success. These factors are top management, project leader, project team, participation, information/communication, planning/control, conflicts, and goal changes. They rely on the participants' view while determining whether a project is successful or not.

The critical success factors in software projects are reported by Reel (1999). However, the factors are rather experience-oriented as opposed to being the result of an empirical study. His list was comprised of five essential factors to managing a successful project:

Start on the right foot: Field (1997) provided ten signs of information systems project failures, of which at least seven are determined at the start of the project, such as project managers don't understand users' needs, the project's scope is ill-defined, etc. By resolving such issues, we can improve the success chance of the projects. Building the right team, ensuring that there are enough resources for the project, providing the highly productive environment and the necessary tools, and involving users and customers are all part of starting on the right foot. Most of these issues can be found under different factors in Pinto and Slevin (1987).

Maintain momentum: Starting on the right foot provides momentum for the project team. However, it is crucial to maintain the momentum for the duration of the project. There are three issues that need attention under this title: attrition, quality and management. Reel (1999) points out the attrition problem in the software industry and states that it can be disastrous for a mid-stream software project. Brooks' famous law, "adding manpower to a late software project makes it later," explains why it can be a disaster. Quality must be incorporated throughout the development process. It is not possible to go back and add quality. Reel (1999) recommends managing the product more than the personnel. The observation he had was that project leaders often avoid confronting individuals and merely fix a problem by setting arbitrary rules.

Track progress: There is an important difference between civil engineering projects and software projects. The progress of a construction project can easily be observed; however, due to the intangible aspect of software projects, it is hard to observe the status of a software project. But this doesn't eliminate the necessity of tracking progress during software development. There are methods to accomplish it, and we have to get the most out of them.

Make smart decisions: Some key decisions about the projects determine whether the project will be successful or not. For example, designing a networking protocol and building a communication tool may cost much more than buying a commercial-off-the-shelf tool. At best, buying a commercial-off-the-shelf product may cost a fortune; however, it may also be the decision that saves the project. Good project leaders are the ones that can make the smart choices.

Institutionalize post-mortem analyses: Without figuring out what happened during a project, it is inevitable to repeat the same mistakes over and over again. The difference between CMMI level-1 and other CMMI levels are institutionalization (CMMI, 2002). CMMI level-1 is named as Initial which is a rating when organizations can not be rated with higher levels. CMMI level-2 is a rating given to organizations when the existence of certain processes and practices only warrant for this level. CMMI level 3, 4 and 5 focuses on improvement of the process, and improvement can only be achieved by collecting and analyzing project data. Process improvement movement inspired by Dr. Deming validates the benefit of measuring a process and improving it (Aguayo, 1990).

The factors identified in this study overlap some of the factors listed earlier (Pinto and Slevin, 1987). So, it is imperative to say that there are commonalities between success of any other types of projects and software projects. However, when software projects and other types of projects are compared, the likelihood of having an unsuccessful result in a software project is quite high. This suggests that there are some critical factors creating this huge variation in the success of software projects. The clues Reel (1999) provides us are:

- Managing complexity of a software development project.
- Attrition in the software industry.
- Quick technological trend shifts and making smart decisions.
- The issue of adding overall quality to software.

Reel's report relates to this dissertation by identifying factors for managing software projects. Nonetheless, this report was not supported by an empirical study. In addition, he does not bring up the issue of effectiveness measurement.

C. COMPREHENSIVE LIST AND COMPARISON OF PROJECT SUCCESS FACTORS

Fortune and White (2006) conducted a recent study which includes a comprehensive literature search on critical project success factors. The goal of the study was to frame project critical success factors by a systems model. In the study, they reviewed 63 publications and extracted 26 different factors. The factors found are listed in decreasing order of frequency of occurrence (the numbers in parenthesis are the counts of occurrence in different publications) (Fortune and White, 2006):

- Support from senior management (39)
- Clear realistic objectives (31)
- Strong/detailed plan kept up to date (29)
- Good communication/feedback (27)
- User/client involvement (24)
- Skilled/suitably qualified/sufficient staff/team (20)
- Effective change management (19)
- Competent project manager (19)
- Strong business case/sound basis for project (16)
- Sufficient/well allocated resources (16)
- Good leadership (15)
- Proven/familiar technology (14)
- Realistic schedule (14)
- Risks addressed/assessed/managed (13)
- Project sponsor/champion (12)
- Effective monitoring/control (12)
- Adequate budget (11)
- Organizational adaptation/culture/structure (10)
- Good performance by suppliers/contractors/consultants (10)
- Planned close down/review/acceptance of possible failure (9)
- Training provision (7)

- Political stability (6)
- Correct choice/past experience of project management (6)
- Environmental influences (6)
- Learning from past experience (5)
- Project size (large)/ level of complexity (high)/ number of people involved (too many)/ duration (over 3 years) (4)
- Different viewpoints (3).

The three most cited factors are found in more than 80% of the publications. However, only 17% of the publications cite all three of them (Fortune and White, 2006). There is a lack of consensus on the factors. The lack of consensus on the factors influencing project success was also identified by Wateridge (1995). Fortune and White criticize the critical success factors approach. One of the two criticisms they had is that the inter-relationships between factors are also as important as the factors themselves, which may also be the reason on the variations of factors identified by different researchers. The other one is viewing the project implementation as a static process. However, project implementation is a dynamic phenomenon and different factors have varying importance on different levels and stages. Pinto and Mantel (1990) showed that the critical factors associated with success and failure varies during the project life cycle. While mission, top management support, and schedule/plans have significance during the strategic stage, factors such as client consultation, personnel, technical tasks and others are important in the tactical stage.

Fortune and White (2006) propose a new solution for analysis and predicting the outcomes of the projects. The solution consists of a system model approach. The model is known as Formal System Model (FSM) and it is developed by Bignell and Fortune (1984). The Formal System Model consists of a decision-making subsystem, a performance-monitoring subsystem and subcomponents and components that carry out transformations. The model also describes the interactions between subcomponents and environment. Fortune and White (2006) mapped all the critical success factors identified in the literature to concepts in the Formal System Model. Then, the model is experimented on two projects. Since all the factors are mapped, they analyzed the projects with the FSM and showed that the model is capable of predicting the outcomes of the projects.

The study conducted by Fortune and White (2006) relates to this research by trying to predict the outcomes of projects in two simple measures: success or failure. This evaluation can also be considered as a binary measurement. However, this measurement has limited capabilities to determine how successful the project is.

D. PROJECT FAILURE FACTORS

Another line of research is about failure factors in projects. One well-known study known as the CHAOS study was conducted by The Standish Group (1994). The study includes both success and failure factors. The failure factors were divided in two as project challenged factors and project impaired factors. Project challenged factors are the ones that reduces the effectiveness of the project. Lack of user input, incomplete requirements and specifications, changing requirements and specifications are the first three factors in the list. Project impaired factors are the ones that cause cancellation of projects. The list includes incomplete requirements, lack of user involvement, lack of resources, unrealistic expectations, lack of executive support, changing requirements and specifications, lack of planning, project no longer needed, lack of information technology management and technology illiteracy (The Standish Group, 1994). This study is simply a report of the statistics gathered from a large database of projects. It does not contain detailed research and explanations on the reasons of successes and failures of software projects. Another report, generated by the same Standish Group in 2000, is similar to the first report and contains updated statistics.

At first, failure factors may be simply thought as the lack of success factors. However, this common belief is not true. In the literature, there are differences in success and failure factors. For example, Pinto and Mantel (1990) list different factors for success and failure at different stages of project implementation.

E. THE ROLE OF PROJECT MANAGEMENT IN ACHIEVING PROJECT SUCCESS

The terms project and project management are generally confused with each other. The goal in both endeavors is project success. Even though these two terms significantly overlap, there is an important distinction. Understanding this distinction and the role of project management in achieving project success will help us to focus our research efforts in the right direction. Munns and Bjeirmi (1996) explained the distinction and the overlap in these two terms.

The distinction of these terms lies in their scope in the life cycle of a project. The goals in a project are towards long-term benefits such as return on investment, productivity increase due to the use of project, etc. However, project management is generally concerned about short-term goals such as on-time delivery, meeting performance standards, project development within budget expectations, etc. After the deployment of the project, the project management functions are generally no longer needed or reduced to minimum just for maintenance of the project. Having this clear distinction about the scope of both concepts makes it possible to discuss the distinction between project success and project management success. A developed model of project success is shown below in Figure 2. The model briefly depicts the success measures from different perspectives.

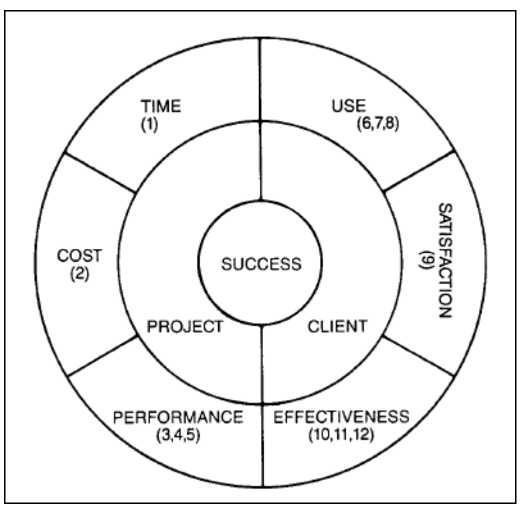

Figure 2. A Model of Project Success [From (Pinto and Slevin, 1988)]

Since project success is oriented towards long-term goals, important parameters within the goals will be return on investment, profitability, competition and marketability (Munns and Bjeirmi, 1996). As shown earlier, the list of critical success factors is long. Different researchers identified different factors to be of importance. There are two main reasons for such differences. First, success is about perception. Stakeholders may have different perceptions of success. For example, learning experience from technical challenges or a comfortable working environment may constitute a success for practitioners (Procaccino, 2002; Procaccino et al., 2005; Glass, 1999). Client and development teams have different concerns relating to success (Pinto and Slevin, 1988). Only some of the success parameters are in control of the project development team (Munns and Bjeirmi, 1996). There are factors related to the external environment such as political, economical, social and technological environments, competitors, sub-contractors, etc., (Belasi and Tukul, 1996). All these factors create the differences in perception from some stakeholder's perspective. Which parties are interested in which part of project life cycle is given below in Figure 3.

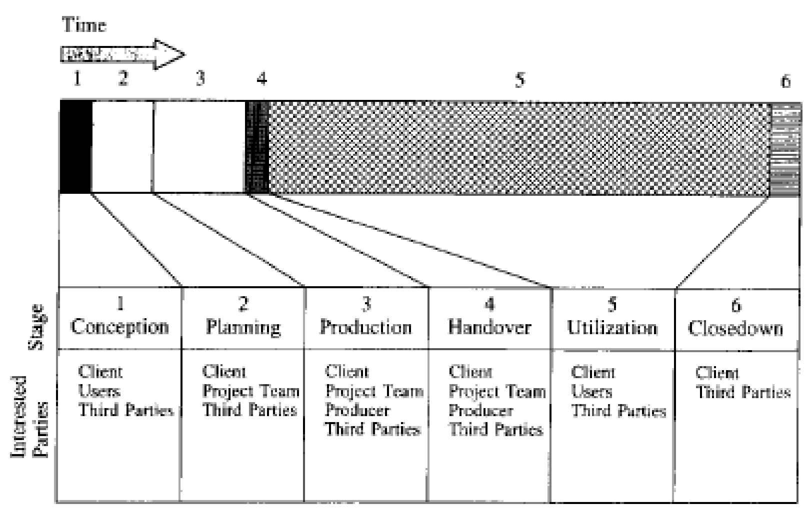

Figure 3. The Stages of Project Life Cycle and Associated Parties to Each Stage [From (Munns and Bjeirmi, 1996)]

Another reason for the variance is that project success and project success factors change over time (Pinto and Slevin, 1988; Pinto and Prescott, 1988). Project success should be thought of as a dynamic entity rather than a static entity (Fortune and White, 2006). Figure 4 shows the assessment of project success over time. During early stages of the projects, internal factors influence the project more than external factors, therefore they are more important. Also, success measurement is easier. The percentage of completed project work at a given stage can be a measure of success during project development. For example, after installation, if profitability is the measure of success, it is subject to an economical environment which may fluctuate over time. Therefore, it is important to know when to measure success in a project life cycle and from what perspective. In Figure 4, the top line shows how the result of project success assessment changes over time depending on the factors affecting it. Up until installation, the success assessment function is linear and it is mostly affected by internal factors. In simple words, the success may be measured by the amount of work accomplished. After installation, the success assessment is mostly affected by external factors. The assessment of success is complex and can fluctuate rapidly, especially from the perspective of users and customers. After installation, new bugs in software applications may be found by the system users. The frustration due to bugs in the system changes the perception of the user, causing the user to perceive the product as a failure. Maintenance and bug fixes on the system replace the negative perception of the users with a positive perception again. This cycle continues until the end of the life cycle of the application.

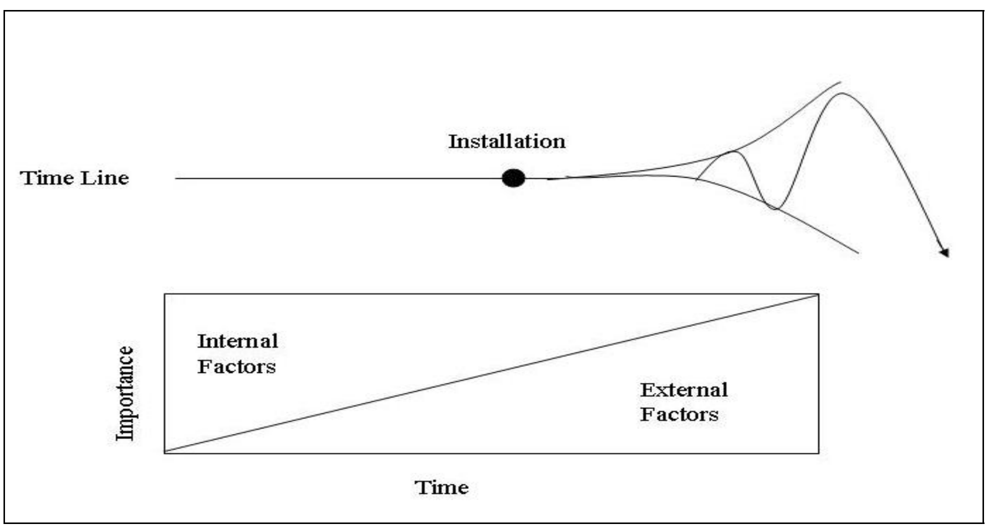

Figure 4. Assessment of Project Success over Time [After (Pinto and Slevin, 1988)]

The obvious success measures for project management are completion of the project in time, within budget, adequate quality standards, and meeting the project goal. Project management success is a part of project success. However, it is possible to achieve success in a project even though project management fails, or vice versa (Wit, 1988). Thus, we have to differentiate the measurement of project success from project management success. The scopes of project management success and project success are provided in Figure 5. In order to conduct a successful measurement, we have to measure concepts within their scope.

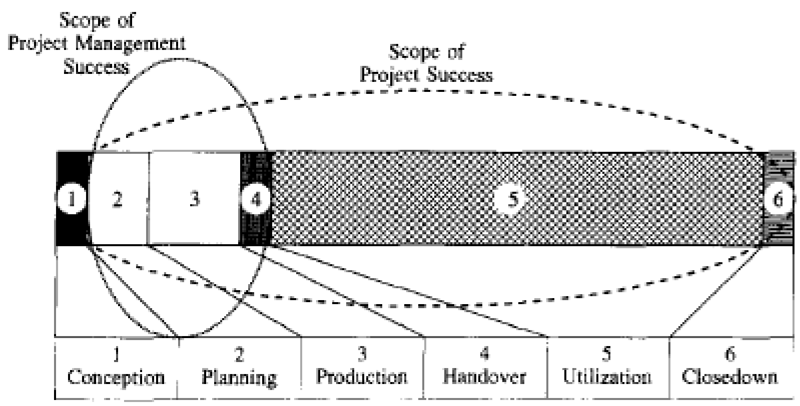

Figure 5. The Scope of Success within Project Life Cycle [From (Munns and Bjeirmi, 1996)]

F. MEASUREMENT OF PROJECT SUCCESS

One of the early attempts to define and measure project performance is provided by DeCotiies and Dyer (1979). The study was aimed to conceptualize and measure the dimensions of project performance and their determinants. It was conducted in a high technology matrix organization in an effort to increase effectiveness of project groups. A questionnaire was developed in order to identify the dimensions of project performance. The study identified and defined five distinct performance dimensions:

Manufacturability and business performance: Extent to which the product is manufacturable, and finished in time to make a timely market entry and result in a favorable financial return.

Technical performance: Extent to which the project generates the needed technical data and critical technical specifications are met.

Efficiency: Extent to which the project operates efficiently in terms of costs, time, and productivity.

Personal growth experience: Extent to which the project provides those involved an interesting, challenging, and professionally developing experience.

Technological innovativeness: Extent to which the project results in significant technological advances.

DeCotiis and Dyer (1979) selected manufacturability and business performance as their ultimate project success criterion. Technical performance and efficiency were selected as major contributors to project success and technological innovativeness as a minor contributor. Professional growth experience would be a supplementary success criterion if other performance dimensions are rated high. Projects are measured in each of these dimensions.

Every project performance dimension is measured with project performance determinants. These determinants of project performance include management support, inter-organizational relations, sponsor relations, transfer management, panning and stability of specifications and designs, clarity of project leader role, project member's skills and cooperation, communication and decision-making, and personal utilization, planning and scheduling, control procedures, and leadership.

The study included the results of a stepwise regression model to identify the most important determinants for each dimension. For example, the most descriptive determinants for manufacturability and business performance are transfer management, planning and scheduling, lack of inter-organizational relations, and lack of clarity of project leader's role. Other dimensions may be investigated with a different set of determinants. The study ends with a model of determinants of project performance.

DeCotiis and Dyer (1979) reached an important conclusion stating "the identification of these distinct dimensions of project performance illustrates that a project can be both successful and unsuccessful at the same time." For example, a project may be innovative from a technological perspective; however, it may not be a success when the perspective is manufacturability and business performance.

DeCotiis and Dyer's (1979) study is important in terms of stating the complexity of analyzing project success. However, the model developed within the study is only a broad framework. How the model can be applied to different types of projects or whether the model needs modification for a specific type of project are some of the questions left outside of the study. DeCotiis and Dyer's study relates to this research by stating the fact that measuring project performance is multidimensional. While Decotiis and Dyer's study is focused on project success, this dissertation is focused on project management success. Both of these terms have several overlapping factors, but they refer to different concepts. In addition, in this research the emphasis is on software, unlike in Decotiis and Dyer's study.

Slevin and Pinto (1986) developed and tested a generalized project success measure called Project Implementation Profile (PIP). PIP includes a questionnaire derived from critical success factors identified by the same authors (1987). The questionnaire is applied to project managers and uses a 5-point Likert scale. PIP contains the perspective of both the client and project implementation. The measure includes two subscales as project and client score and another overall score. These scores can then be compared according to a score ranking of completed projects database of 418 projects. If a project is below the 50^{th} percentile in any factor, the project manager should devote extra attention to it. A table of the percentile scores for project implementation profile is given in Appendix A. The PIP measurement is a viable method to measure project success. However, its scope is beyond project management, which is the emphasis of this dissertation.

After releasing their well-known report, the Standish Group (1995) also developed a simple measurement technique for project success. The Standish Group used the ten success criteria from their earlier report and weighted each factor based on a survey of IT managers. Careful analysis of factors will reveal that all factors are related to project management. With regard to the discussion presented earlier about the distinction between project and project management, this simple measure is in fact a software project management metric. The measurement is called the success potential chart. There is a weight associated with every factor in the success potential chart with the total weight in the chart equaling 100. Every factor is divided into five smaller questions. For example, the most important factor, user involvement, consists of the following questions:

- Do I have the right user(s)?
- Did I involve the user(s) early and often?
- Do I have a quality user(s) relationship?
- Do I make involvement easy?
- Did I find out what the user(s) needs are?

For each question with a yes answer, 3.8 points should be added to the success potential score. Other factors have different weights and the same procedure is followed throughout the assessment to calculate the success potential for a project. The chart can be found in Appendix I.

The measurement developed by the Standish Group is hardly scientifically grounded. Even though the factors are a result of an empirical study, the same weight for the questions within the factors raises validity concerns. However, it is a simple measure and it can still differentiate a successful project management from a failed one.

G. MEASUREMENT OF SOFTWARE PROJECT MANAGEMENT EFFECTIVENESS

As pointed out earlier, project management success is not the same as project success (Cooke-Davies, 2004c).

O'Connell has published a series of books on how to run successful projects. In his latest book (O'Connell, 2002), he presents his experiences on a method called

Structured Project Management. The method relies on a ten-step progress approach embedded with a measurement of project success. The measure is called Project Success Indicator (PSI). The ten steps are (O'Connell, 2002):

1. Visualize the goal; set your eyes on the prize;
2. Make a list of things to be done;
3. There must be one leader;
4. Assign people to jobs;
5. Manage expectations, allow a margin for error, have a fallback position;
6. Use an appropriate leadership style;
7. Know what's going on;
8. Tell people what's going on;
9. Repeat Steps 1-8 until step 10; and finally
10. The prize.

In every step, there are sub-steps helping management to accomplish the project. There are scores assigned to every step in the measure. For example, the first two steps are assigned 20 out of 100. The last two steps correspond to a score of 0. The highest score is 100. As a general guideline, the project success indicator (PSI) should not be below 60, and the first two steps are the most important ones. O'Connell (2002) also explains how the scoring should be in his book.

The structured project management approach seems to be a viable solution for many software projects. PSI is also designed to assist the approach. PSI can be considered as a software project management metric. However, PSI is purely based on the general guidelines on the structured project management and mostly subjective on the scoring. The information PSI provides is limited in many terms. For example, when the project has only one leader, the project gets 10 points on the scoring. However, the scoring has no means to measure the effectiveness of the leader and the leadership. O'Connell does not explicitly claim that PSI is a metric. In addition, PSI does not have the ability to assess the project management success with precision. On the other hand, PSI is proactive and can be used as an indicator during development to determine whether the project management is becoming a success or not.

Osmundson et al. (2003) introduced a metric called the quality management metric (QMM). The metric considers four important areas of project development: requirements management, estimation/planning management, people management, and risk management. These areas within software projects are investigated by conducting surveys on project managers and developers. The survey reveals a quantitative analysis of the project which can be used for improving further software developments. The QMM metric is developed by Machniak (1999). Three programs are used to validate the proposed metric. The validation is extended by Grossman (2000) by applying the metric to ten more Department of Defense software projects.

These initial studies showed potential that a project management metric can be developed. The studies compared the QMM metric and the observed program success evaluated by the program managers and developers. Such comparison was the base for the validation of the QMM. The results indicated that QMM showed a strong positive correlation with the QMM percentage score and the overall program score. There are mainly two issues with these successful studies. First, the number of samples in these studies is limited. Overall, thirteen software programs are analyzed in these studies. More programs are needed to be analyzed to fully understand the applicability of this metric.

Within the software programs investigated by Machniak and Grossman, there are only two programs involving twenty-four or twenty-five developers. All the other programs have smaller team size. This data set calls for additional research to reveal the scalability and applicability of QMM in large-scale projects.

In addition, the software development projects are all defense-related projects developed by military research centers. The expectation is that these centers generally follow specific guidelines set forth by the Department of Defense. Another concern is QMM's applicability or assessment success in a commercial environment in which practices are expected to differ at least in some ways.

H. SUMMARY

In this section, related work was presented. The related work presented here is a collection of literature from a variety of disciplines. Some of these disciplines are software project management, project management, organizational management, organizational behavior, and organizational sociology. Defining project success, identification of project success and failure factors, measurement of project success, and measurement of project management quality studies are all related to this research.

The most notable research related to this study is the development of a quality management metric. The metric proposed in this research and QMM both intend to measure the same concept, which is software project management quality or effectiveness. QMM achieved a remarkable success in capturing the essentials of project management and measuring its quality.

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III. APPROACHES FOR MEASURING PROJECT MANAGEMENT EFFECTIVENESS IN SOFTWARE PROJECTS

A. INTRODUCTION

There are various studies reporting the success and failure rates of software projects (GAO, 1979; The Standish Group, 1995; El Emam and Koru, 2008). Even with the lowest failure rates reported, software projects are significantly failing when compared to projects in other fields. In (Slevin, Cleland and Pinto, 2002), current project management issues in leading project-based industries are listed. Among nine industries, only in the software industry column overruns and poor performance are explicitly listed as issues, among others. The average software project is likely to be six to twelve months behind schedule and 50 to 100 percent over budget (Yourdon, 2004). One would expect that the record in software projects should have been much better with all the advancements in technical aspects of software engineering. However, relying merely on technological advances to achieve better outcomes in software projects may be misleading. Significant advances in software project management field to achieve better results in software projects are also required. Therefore, proposals and discussions for applicable and viable theories, models, tools and practices in software project management are important steps in achieving better project outcomes.

Ineffective software project management is among the main reasons for the failures in software projects (Jones, 2004). In addition, effective project management is a determinant in the success of the software projects (Jones, 2004). DeMarco and Lister (1999) state, “for overwhelming majority of the bankrupt projects we studied, there was not a single technological issue to explain the failure.” Robertson and Robertson (2005) emphasize that, “in several decades of project experience, we have never seen a project fail for technical reasons. It has always been human failures that have caused otherwise good projects grind to a halt.” Various other studies, researchers and practitioners report similar issues regarding the importance of software project management in the success and failure of software projects (Weinberg, 1994; Defense Science Board, 2000).

According to Boehm, poor management can increase software costs more rapidly than any other factor. COCOMO, a method for software project cost and effort estimation developed by Barry Boehm and his colleagues, does not include project management as a factor (Boehm, 1981). Therefore, in COCOMO II, the estimation model incorporates some project management related factors such as PCON (personnel continuity) and PMAT (process maturity) (Boehm et al., 2000). We believe, in order to keep the rate of the software cost overruns and schedule slippages down, that measuring and therefore improving the quality of project management areas is an enabler. In addition, such project management metrics can be incorporated to cost estimation techniques yielding better estimates.

According to Morris (1998), "one of the major areas of project management development over the next years, I believe, will be establishing and refining inter-industry metrics for quantifying performance improvements. Much of this work will be IT-related." Hyvari (2006) investigates the effectiveness of project management based on four different factors. The factors are organizational structures, technical competency, leadership ability, and the characteristics of an effective project manager. He does not state the reasoning for the selection of these factors and whether this is a complete list or not.

Project management is a complex endeavor and the development of a metric for project management effectiveness is clearly not an easy task. However, measurement and evaluation of management effectiveness in software projects opens up many opportunities for improvement. In this section, we introduce four approaches for measuring the quality of software project management. We further discuss each approach and present examples of the existing implementations. The significance of the section is guidance for the development of project management effectiveness metrics.

B. SUCCESS PYRAMID

Project management success is not the same as project success (Cooke-Davies, 2002). Even though most practitioners would emphasize that software project success is closely related to project management quality or success, there is no established empirical evidence for such a relation in the software project management literature. Related empirical studies in the software engineering field or even in the project management literature are quite limited. This is no coincidence. There are some reasons for this.

First, even though there are many studies in the area of project success factors, there is no established criteria for project success. Pinto and Slevin state that words like success and failure are in the eyes of the beholder. They also emphasize the risk of mislabeling projects as success instead of failure or vice versa without a well-established set of project success criteria (Pinto and Slevin, 1998, p. 379). For example, Proccacino (2005) investigated how various practitioners view project success. His study adds and introduces another view to existing project success criteria. White (2006) criticizes the lack of suitable measures of successful projects. Simply, we still don't have a universally-accepted definition for project success. How then can we relate project success to project management success when there is no clear definition for project success?

Second, there is no theory for project management that has found recognition (Smyth and Morris, 2007; Pollack, 2007). In 2006, Turner (2006, pp. 1-3), editor of the International Journal of Project Management, wrote a series of editorials. In these editorials, he states that project management has still not been accepted as an academic discipline. He concludes that one of the reasons for this is the lack of a theory for project management. In that and following editorials, he provides a normative theory of project management (Turner, 2006, pp. 1-3, 93-95, 187-189). In 2007, Sauer and Reich wrote a response. While they promote the idea of having a normative theory for project management, they expressed the need for a theory that helps us to understand the conditions, constraints, and drivers leading to functional and dysfunctional behaviors (Sauer and Reich, 2007). Therefore, we can influence such behavior to reach intended results. While theories shape a discipline, they also guide researchers to investigate the phenomenon. As a result, our ability to develop quality criteria for project management is limited.

Finally, the fields of software engineering and project management are quite young when compared to other fields. Research works related to foundations of disciplines take time to build up. Reliable empirical studies require the existence of a certain amount of fundamental research. Therefore, our ability to conduct empirical research in the field of software project management is limited.

Defining project success is not an easy task. It is multifaceted and difficult to measure (Griffin and Page, 1996). The three conventional project success criteria are time, cost, and performance. Pinto and Rouhiainen (1998) state that these criteria don't work in the modern business world. The tremendous competition in this modern business world requires a customer-oriented focus. Therefore, customer satisfaction is another key criterion. Glass (1999) points out the need for a new theory of project success. Different stakeholders may have different concerns. This is inevitable. One of the key challenges of any project management is to align the goals and addressing the concerns of the stakeholders. Linberg (1999) showed that the definition of success for software practitioners is quite different from the conventional criteria. Software practitioners may classify a project as a success even though it is late or even over budget. They are more concerned with the quality and functionality of the product. In addition, they may even view a cancelled project as a success due to the lessons learned and the challenge in the project. Agarwal and Rathod (2006) investigated the notion of software project success for different stakeholders. They examined project success in the views of programmers/developers, project managers, and customer account managers. Procaccino (2002, et al., 2005) developed a quantitative model for early assessment of software development success in the practitioner's perspective. Cooke-Davies (2004a, 2004d) examines the issue with a broader view. His view clarifies some challenged research areas beautifully. He provides a definition of success at different levels. His questions for each level help us to focus on the big picture. According to Cooke-Davies, there are three levels of success:

- *Level 1: Project Management Success: Was the project done right?*
- *Level 2: Project Success: Was the right project done?*
- *Level 3: Consistent Project Success: Were the right projects done right, time after time?*

These levels are shown in a pyramid in Figure 6. The figure implicitly implies that the success of each level depends on the success of the previous level. Even though this is the fact in most cases, it does not apply in all cases. The figure has the merit of providing an overall view of what success means at each level. It is possible to achieve a successful project even when the management fails or vice versa (Munns and Bjeirmi, 1996). For example, even though the management has done a good job in completing the project within budget, on time and with the expected quality, the product may never find its share in a competitive market. Then the fault lies on the executive management (or project sponsor) with the decision to undertake such a project delivering a product that cannot find its place in a competitive market. In that case, the assumption is that the project management team is handed the project proposal and they are to deliver a project.

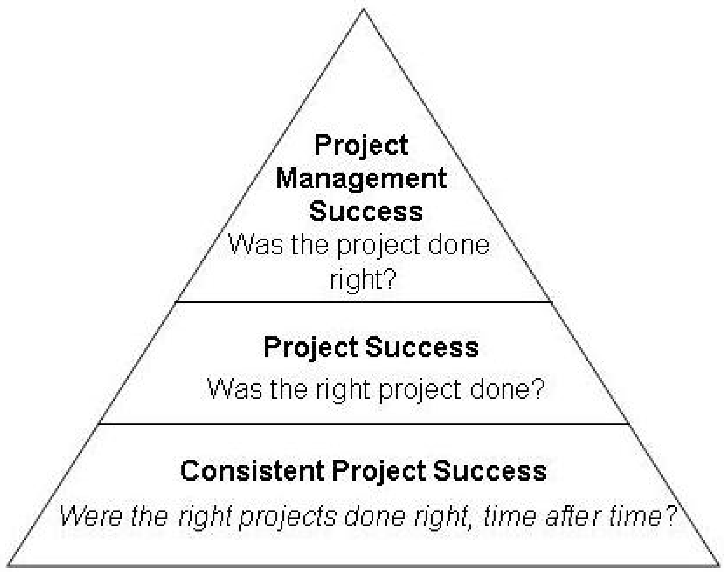

Figure 6. Success Pyramid

Munns and Bjermi (1996) provide a good discussion regarding the role of project management in achieving project success. They discuss that project management success suggests a shorter term while project success has a longer term. This is consistent with Cookie-Davies's view of success at different levels. As a result, the developed framework for success at different levels is presented in Figure 7.

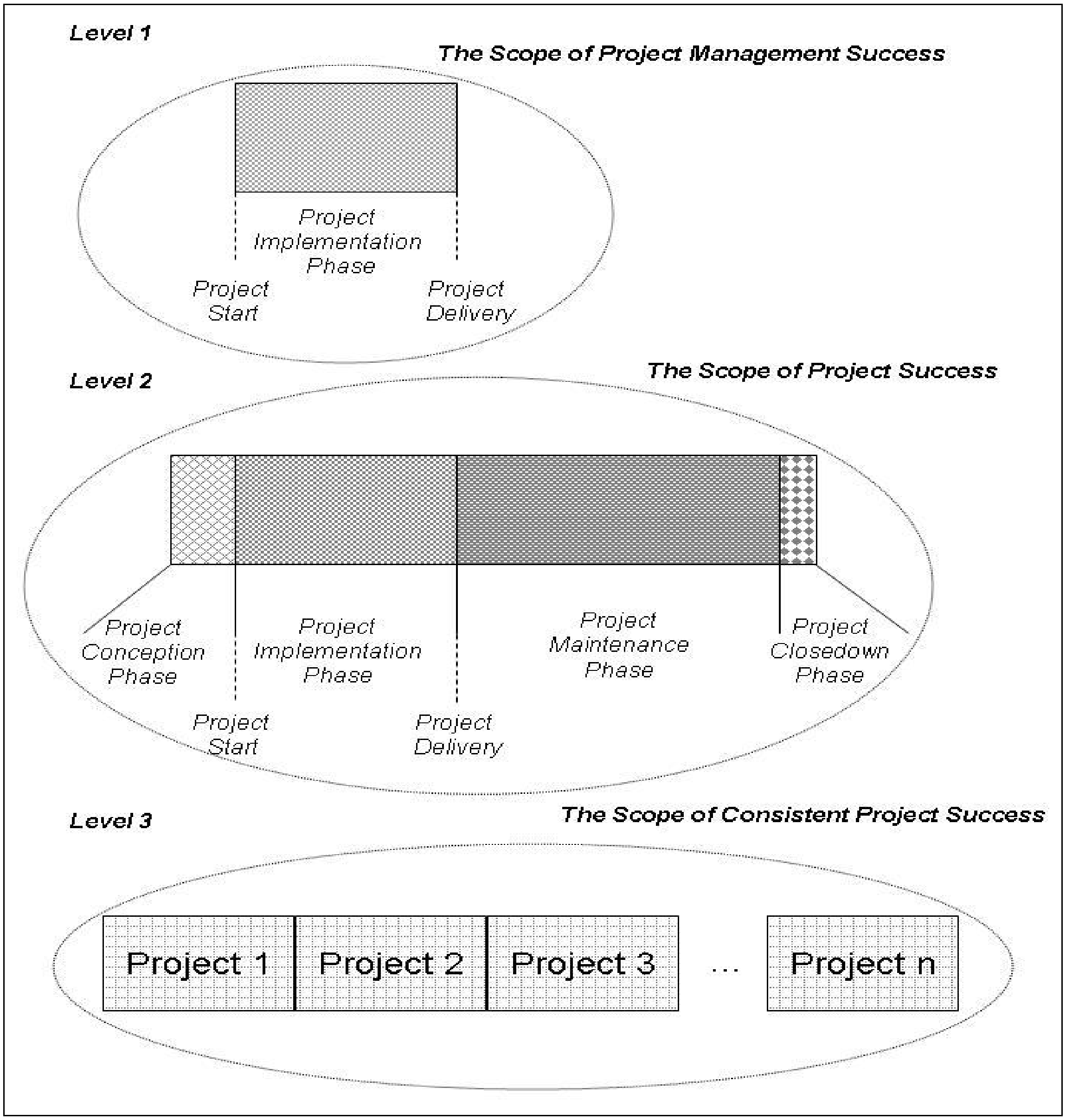

Figure 7. The Scope of Success at Different Levels

C. DISCUSSION OF APPROACHES

To our knowledge, this study is the first attempt to provide a framework for measuring the effectiveness of software project management. Related measurement studies in the project management literature are almost non-existent. The management literature focuses on organizational effectiveness that is remotely related to project management effectiveness.

We have identified four different approaches that can be used in the development of methods to measure the effectiveness of software project management. Figure 8 shows these four approaches and corresponding metric types. Each of these approaches is discussed in the following sections.

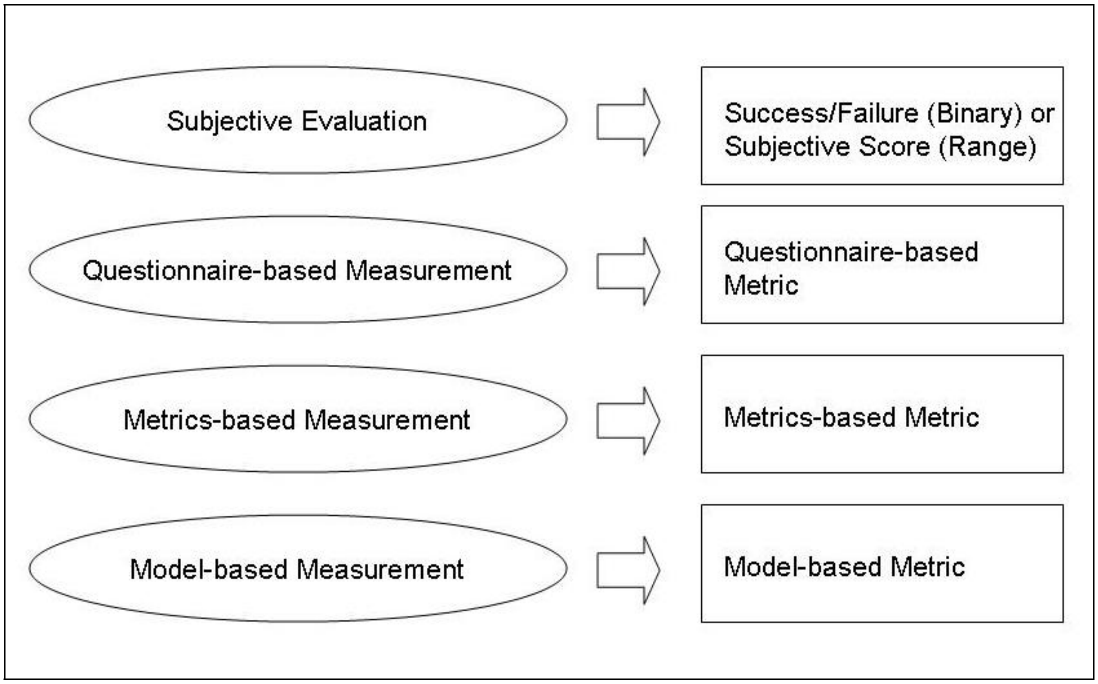

Figure 8. Four Approaches for Software Project Management Effectiveness Measurement

1. Subjective Evaluation

In this approach, the project participant's perception is used in the evaluation of the project management. This participant may be the project manager, the technical manager, or the developers. Since it is based on the perception of the participant, this is a subjective evaluation. In this approach, the project participant is simply asked to categorize the project as a success/failure or rate the project based on a scale. This approach is the simplest one and used in some studies. For example, Osmundson et al. (2003) requested the project managers and project developers rate the project's success based on a scale from 0 to 10 in their study. In another study, Verner and Evanco (2005) investigated the project management practices leading to success in in-house software development. They analyzed forty-two successful and unsuccessful projects based on the senior software practitioners' categorization of their projects. In his doctoral dissertation, Procaccino (2002) used the same approach and his study is based on the view of software practitioners. Gemuenden and Lechler (1997) conducted an empirical analysis on 448 projects to determine critical success factors. Their study relies on the participants' view as to whether the project is a success or not.

It is important to point out that even though such an approach is subjective, it is hard to disregard the validity (to some extent) of the project participant's perception. The practitioners have a sense of what the best practices are and if those are followed or not. However, as Pinto and Slevin (1998, p. 357) pointed out that there is a significant risk of mislabeling a project as a success or failure without a well-established set of success criteria. This risk is more significant when the study compares the successful and failure projects based on the subjective evaluation approach. Because when the project is in fact a failure and the participant mislabels it as a success, then this evaluation skews both results such as boosting the success rate and decreasing the failure rate.

Another important consideration is that the measures resulting from this approach do not provide any insight on how to improve the management of the project. Just labeling a software project as a success or a failure without understanding the causes of it has limited use for practitioners and researchers.

2. Questionnaire-based Measurement

In this approach, the measurement of management effectiveness is based on the evaluation of responses to a questionnaire. Questionnaire-based evaluations are common in management and organizational sociology study areas (for example (Brown, 2003; (Baugh and Roberts, 1994; Paul and Anantharaman, 2003; Kinlaw, 1998; Muller, 2003)). This is because abstract concepts such as teamwork, organizational commitment, communication, leadership, etc. are hard to quantitatively analyze. This approach has been used in the development of a quality management metric for software development (Osmundson et al., 2003).

In the study by Osmundson et al. (2003), a questionnaire was developed to investigate which best management practices are followed to what extend in a software project. Then, based on the responses to the questions, the quality of the project management is measured. They also compared the resulting metric (QMM) with a metric gathered via subjective evaluation discussed in the previous section. The questionnaire investigates four important areas of software project management. They are requirements management, project planning and estimation, risk management, and people management (Machniak, 1999). People management is further divided into four areas: human resources, leadership, communication, and technical competency of the program manager. The complete questionnaire instrument included 457 questions. The QMM metric is based on a scale from 0 to 10, with 0 being the lowest quality score, and 10 being the highest quality score. The importance of the QMM study is the focus on the development of a metric for the quality or effectiveness of project management in software projects.

COCOMO II incorporates a process maturity factor (PMAT) as a scale factor to the effort estimate (Boehm et al., 2000). It is important to note that scale factors affect the effort estimate exponentially. In COCOMO II, this PMAT factor is determined using one of two methods (Clark, 2000). The first method is based on the SW-CMM rating of the organization when there is one. The second method is used when the organization does not have a SW-CMM rating. The second method uses another rating, Equivalent Process Maturity Level (EPML), which is based on the percentage of compliance for each key process area goal in SW-CMM model. This compliance is (EPML rating) evaluated via the responses to a questionnaire derived from eighteen key process areas.

3. Metrics-based Measurement

Another approach for measuring the effectiveness of software project management is via the use of other software metrics. For example, metrics such as the number of defects over time, software complexity, requirements stability, staff turnover rate, etc. can be used as inputs for a metrics model for a software project management effectiveness metric. This type of measurement is in fact an indirect measurement. When complex attributes are measured in terms of simpler sub-attributes, this measurement is indirect (Fenton, 1997). Many effort predictions use several levels of indirect measurement (Fenton, 1997). Erdogmus (2007) presents a cost-effectiveness indicator for software development. He uses base measures such as nominal output, production effort, rework effort, issue count, and staffing profile to derive a breakeven multiple as an indicator aggregating productivity, quality, and staffing needs. This is a good example for this approach in a different context. Wohlin and Maryhauser (2001) provide a detailed method for assessing software project success using subjective evaluation factors.

To our knowledge, there has not been an attempt for the development of a metric for assessing the management effectiveness of software projects using this approach. Therefore, we provide a metric model for such measurement to guide future research. The model is shown below:

$$SPMEM = Measurement\_function(\sum_{i=1}^{n} w_i m_i).$$

In the model above, m is a metric that has been found to relate to the metric for management quality, which is denoted by $SPMEM$. There can be n number of metrics. There may also be only one metric and in that case n equals 1. Examples of such metrics may include programmer productivity, defect reduction rate, certain earned value metrics (EVM), etc. w_i is the weight associated with a certain metric, m_i. Such weights may be required since different metrics may relate to the resulting management quality metric differently. Then these metrics are combined via a measurement function based on the hypothesized metric model.

A generic metric model was presented above. Development of a management effectiveness or quality metric for software projects using this approach requires significant research based on empirical studies.

4. Model-based Measurement

In this approach, the metrics for effectiveness or quality of management are derived from models of management of software projects. Currently, this approach is also conceptual and there are no examples implemented. There has not been any attempt to measure the management effectiveness of software projects based on a model of project management.

For quite some time, researchers have been focused on developing software development life-cycle methodologies. There are many examples of methodologies such as waterfall, spiral, win-win, rapid prototyping, agile development, SCRUM, etc. There is also a field called software process research within the software engineering discipline. Software process research started back in the 1980s through a series of workshops and events. Due to many software application failures, researchers focused on improving the software process. The assumption is that there is a direct correlation between the quality of the software process and the quality of the software application developed. A good example in the software process research is the development of the CMM series models. An area of software process research is software process modeling. There are a number of Process Modeling Languages (PMLs) developed (Fuggetta, 2000). Some examples are Process Interchange Format (PIF) (Grunninger et al., 1996; 1998), Process Specification Language (PSL) (Schlenoff, Knutilla and Ray, 1998), Unified Process Model (UPM) (Kruchten, 1999), Core Plan Representation (CPR) (Pease, 1998), Workflow Management Coalition Process Definition (WfMC) (1998), and Architecture of Integrated Information Systems (ARIS) (Scheer, 1999). A review of these PMLs can be found in (Breton and Bezivin, 2000).

In June 2005, Business Process Management Initiative (BPMI) and Object Management Group (OMG) merged their activities and formed the Business Modeling & Integration (BMI) Domain Task Force (DTF). They have developed various standard proposals for different views of process management, such as Business Motivation Model (BMM) specification (OMG, 2007a) and Business Process Definition Metamodel (BPDM) (OMG, 2007b). Even Gantt Charts and PERT (Program/Project Evaluation and Review Technique) and CPM (Critical Path Analysis) charts are process models, and the development of Gantt Charts dates back to 1910s. However, there is a significant difference between the PMLs mentioned above and the process models. While the process models (such as Gantt, PERT and CPM) got wide-acceptance in industry, as Fuggetta (2000) pointed out few (if any) of the proposed PMLs and related Process-centered Software Engineering Environments (PSEE) have been transferred into industrial practice. Fuggetta states that the goal should be to ease the adoption of PMLs.

Most of the PMLs are heavily technical and formal. The wide adoption of Gantt, PERT and CPM charts tell us what the practitioners would like to see in these types of process modeling languages: it is simplicity. Since these PMLs could not find their share in practicality, we do not have actual project data based on models developed with these languages. Viable effectiveness measurements for software project management require actual data from projects, which we do not have. Process models are developed for one specific purpose and they only focus on one aspect of project management. For example, PERT charts are used for prediction of the project schedule. However, managing software projects has many aspects.

As a result, Pinto stresses the importance of modeling the business, technical, financial, environmental, and other dimensions of the project before committing any significant sources or even before the go-ahead (Pinto and Slevin, 1998, p. 11). Jaafari (2004) provides a simplified highest-level representation of a project model and lists the ideal requirements for a project model. He stresses that we still have a long way to go in realizing such sophisticated modeling systems. We have developed a simple, visual and formal modeling language called PROMOL for modeling project management (Demir and Osmundson, 2008). This modeling tool achieves most of the ideal requirements listed by Jaafari. According to Demir and Osmundson (2008), as hypothesized, there are two core concepts in the heart of project management: activities and entities. These two concepts can be used in modeling project management. Then, the quality or effectiveness of these activities and entities in a project management model can be used as inputs for a metric model for effectiveness of project management. As a result, a high-level metric model may be formulated as follows:

$$SPMEM = Measurement\_function(\sum_{i=1}^{m} qa_i + \sum_{j=1}^{n} qe_j) .$$

In the metric model above, qa_i is the quality of an activity and qe_i is the quality of an entity. These activities and entities are components of a project management model. There can be m number of activities and n number of entities in the model that is of interest as inputs for the $SPMEM$ metric model. The measurement function is a function that combines the quality measures of activities and entities. This function is specific to the metric model and it is defined in the metric model. Different metric models may require quite different measurement functions. It is important to emphasize that there can be a number of variations of this high-level model. Examples of these variations may be where a model is including only activities, including only entities, or basing the metric model to a specific life-cycle development model and deriving the activities and entities from this life-cycle development model.

The success of the model-based measurement will be highly dependent on the representation capability of the project management model. When these project management models are far from satisfactory, then the resulting metric will likely be unsatisfactory.

D. CONCLUSIONS

According to Evans, Abela and Beltz (2002), the first characteristic of dysfunctional software projects is the failure to apply essential project management practices. This is derived from 841 risk events in 280 software projects. 480 out of 841 risk events (57%) in software projects are due to not applying essential project management practices. Jones (2004) reports that an analysis of 250 software projects between 1995 and 2004 reveals six major areas effective in successful projects and inadequate in failing projects. They are project planning, project cost estimating, project measurements, project milestone tracking, project change management, and project quality control. All of these areas are related to software project management. These studies clearly show the importance of project management in achieving software project success. Therefore, project management metrics are the key to rationally focus and substantiate the management improvement efforts.

It is important to note the recognized work by Basili and Rombaugh (1988) on the Goal/Question/Metric (mostly known as GQM) approach for development of software metrics. They provide an overall approach on how to develop metrics. First, it is very important to define the goal of the measurement activity. This sets up the context for the measurement. Second, we have to find the right questions for identifying the metrics that are going to be used in the measurement effort. Third, we have to choose or develop the right metrics for achieving the goal. The GQM approach is completely applicable to all the approaches presented here. The goal referred in GQM is already defined via the context, and that is measuring the project management effectiveness of a software project. The presented four approaches help us to refine and ask the right questions. The examples and high-level models presented in the previous sections guide us in identifying and combining the necessary metrics.

In this doctoral research, two approaches are employed and the results from these approaches are compared with each other. These are the subjective evaluation and questionnaire based measurement approach. Both of these approaches have examples in the literature. Therefore, their applicability has found recognition by other researchers as well. This is the main reason for the selection of these approaches. According to the literature review conducted by the author, metrics-based and model-based measurement approaches have not yet been implemented explicitly for evaluating software project management effectiveness. Earned value management (EVM) metrics are used to monitor project performance. EVM metrics may be used with reservations for assessing project management effectiveness purposes. For example, a low cost performance indicator (CPI=Earned Value/Actual Cost) may indicate problems related to project management; however, it may also indicate a problem with project cost and effort estimations. Therefore, EVM metrics are limited in practice for this purpose.

IV. INTRODUCTION OF A THEORY OF PROJECT MANAGEMENT

A. INTRODUCTION

Even though project management has been a recognized practice and discipline for many years, it still lacks an explicit theory of project management and sufficient theoretical foundation (Shenhar, 1998; Turner, 1999; Koskela, 2002; Engwall, 2003; Smyth and Morris, 2007; Pollack, 2007; Jugdew, 2008). Turner (2006, pp. 1-3), the editor for the International Journal of Project Management, wrote three editorial articles in 2006. In his first editorial, he clearly stated that "… there is not yet a theory of project management." Therefore, in these editorials, through a series of premises, corollaries and lemmas, he built a structured theory of project management. During the process, he identified a number of inherent properties of project management. Turner's project management theory helps us to outline a framework for project management discipline. The theory helps us to derive study areas for the discipline. Turner's theory identifies the domain, defines the key elements and constructs, and explains the relations among such constructs. Some of the premises, corollaries and lemmas he provides are as follows (Turner, 2006, pp. 1-3):

- Premise 1. A project is a temporary organization to which resources are assigned to do work to bring about beneficial change. (The resources may be human, material, or financial).
- Corollary 1. Project Contract Management and Procurement Management are inherent properties of project management.
- Corollary 2. Information Management is an inherent property of project management.
- Lemma 1. A project consumes resources, particularly financial resources.
- Lemma 2. A project produces an output or deliverable, a new facility or asset.

- <u>Lemma 3</u>. The reason the owner buys the asset is to achieve a beneficial outcome.

For further discussion of the theory, refer to (Turner, 2006, pp. 1-3, 93-95, 187-189).

Sauer and Reich (2007) provided a response to Turner's theory of project management in with a guest editorial. While they are confirming the necessity of having a theory of project management, they also raise the question of "what kind of theory we need." They explain the normative nature of Turner's theory and its necessity. However, they also express that Turner's theory focuses on "what should be." Therefore, the theory doesn't explain the deviations from the norm, the effects of the deviations and how to correct them. Sauer and Reich emphasize the need for a theory helping us to understand the conditions and drivers leading to either functional, dysfunctional or both behaviors. Such theories can help us to define root causes and create a change for the desired outcome. A positive theory in nature can satisfy such need and complements normative theories.

Due to the normative nature of Turner's theory of project management, the theory does little to enable formal analysis of projects and project managements. It lacks the definitive power to statically and dynamically investigate the inner workings of a project. The development of a new project management theory aims to satisfy such a need. The benefits of this new theory include:

- It simplifies the project management complexities using basic concepts.
- It has explanatory power of any type of project. It is not restricted to any specific domain or type.
- While reducing the complexities to basic concepts, it helps us to formally define and analyze projects.
- It is extendable, and therefore lays a foundation for other theories to build upon.

The theory also guided us to develop a project management modeling language (Demir and Osmundson, 2008; Demir and Erguner, 2008). This modeling language is called PROMOL. The language is supported by a graphical representation to ease the understanding and the use. The applicability and scalability of PROMOL in modeling project management for software projects is analyzed in (Demir and Erguner, 2008; Erguner, 2008). While being extendable, the produced models can aid us in static and dynamic analysis of projects. It is possible to conduct behavior analysis and investigate project management best practices within projects. The modeling tool enables us to create project histories and databases to enable further research on project management. Overall, this new theory allows us to gain insights about projects and help the body of project management knowledge expand.

B. BASICS OF THE THEORY OF PROJECT MANAGEMENT

The theory is that a project is the result of a project management function, which is limited over a specific time. The inputs for this function are a limited number of activities and entities related to any part of the project. An activity is a named process, function, or task that occurs over limited time. An entity is something that has a distinct, separate existence, though it doesn't need to be a material existence.

It is important to note that a project is the sum output of all deliverables as well as the by-products that are not delivered to the customer. Examples of such by-products are patterns, architectures, methods, reusable components, etc. Notice that a project is whatever the project management function generates. However, the project may not be what the customer fully or partially wanted. Nonetheless, the project management function outputs a project or pieces of the project.

The project management function is uniquely described by activities and entities. Then the function combines and transforms them into the project. This function is different for every project, assuming that no two projects are the same. All stakeholders influence this function by negotiating for activities and entiies. Then the optimum for project success is achieved when the negotiations are pareto-efficient (Langford, 2009). Basically, this project management function may be viewed as an ontology of activities and entities when combined transformed into the project.

In this theory, project management is viewed as a function and the formulation of the project management function is given below:

$$P = PM(a_1(), a_2(), a_3(), ..., a_m(), e_1, e_2, e_3, ..., e_n).$$

In the equation above, *P* denotes the project and *PM* is the project management function that outputs the project. The inputs of the project management function are activities denoted by *a()*, and entities represented by *e*.

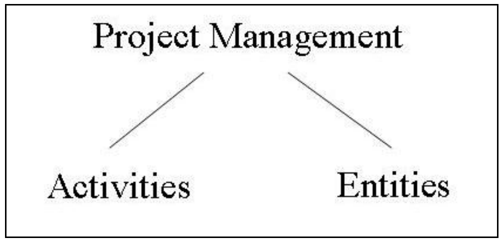

Figure 9. Activities and Entities.

Note that both activities and entities are not unlimited but limited. Therefore, there exists a way to formulate the project management function. Also, it is imperative to emphasize that activities and entities are distinctly identifiable.

Two important concepts lies in the heart of the theory as depicted in Figure 9: activities and entities. Examples of activities are requirements analysis, testing, stakeholder analysis, prototyping, staff meetings, code reviews, etc. Examples of entities are project manager, staff, teamwork, test cases, leadership, requirements, documentation, etc. Using these two important concepts, it is possible to define and explain any project with a management view emphasis.

C. DISCUSSION OF REPRESENTATIONAL THEORY OF MEASUREMENT AND ITS APPLICABILITY

1. Introduction

Sauer and Reich (2007) stated that having a positive theory would help us to understand project aberrations and improve in getting better results by identifying the root causes. Previously, a new theory of project management was introduced. However, by itself this theory is not sufficient to understand and measure certain phenomenon within the project. Therefore, we need an applicable theory of measurement that complements the theory of project management.

There are various definitions of measurement. In Stevens (1973), it is defined as "the matching of an aspect of one domain to an aspect of another." In Sydenham (1982), Fenton, 1994, and Fenton, 1997, it is defined as "measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined rules."

There are only a few theories of measurement introduced in the literature: classical, operational and representational theory of measurement (Sarle, 1997; Sydenham, 1982).

The classical theory of measurement assumes that there are only quantitative attributes or qualities that can be measured, and the classical approach only deals with discovering such measures and attributes. In addition, the classical theory of measurement assumes existence of a reality that is being measured. The classical theory of measurement found wide applicability in physics and related areas. However, it was not able to recognize measurement studies in social and behavioral sciences.

The operational theory of measurement deals with the definition and specification of precise measurement operations. On the other hand, it avoids the assumption of the existence of a reality that is being measured. Its concern is limited with the operational aspect of measurement.

The representational theory of measurement handles the limitations posed by both the classical and operational theory of measurement. In this theory, there exists a reality that is being measured and this reality may also be one that is not readily quantitative.

Representational theory of measurement (Pfanzagl, 1968; Krantz et al., 1968; Sydenham, 1982; Fenton, 1994) is found to be applicable. A brief discussion of representational theory is provided as it is pertinent to the study. It is a brief presentation taken from Sydenham (1982).

A representational theory of measurement requires four parts:

- An empirical relational system corresponding to a quality.
- A relational system based on a defined symbolism, generally it is numbers.
- A representation condition.
- A uniqueness condition.

2. Empirical Relational System

Let $q_1, q_2, ..., q_i, ...$ represent the individual manifestations of some quality and define Q as the set of all manifestations:

$$Q = \{q_1, q_2, ..., q_i, ...\} .$$

Define Ω as the set of all objects that we are interested in measuring:

$$\Omega = \{w_1, w_2, ..., w_i, ...\} .$$

There exists a set of R empirical relations $r_1, r_2, ..., r_i, ..., r_n$ on the defined set Q. Define R as:

$$R = \{r_1, r_2, ..., r_i, ..., r_n\} .$$

Then, the empirical relational system is represented as:

$$L = \langle Q, R \rangle .$$

3. Numerical Relational System

Define N as a class of numbers and P as a set of relations on N:

$$P = \{p_1, p_2, ..., p_i, ..., p_n\} .$$

So, a numerical relation system is represented as:

$$S = \langle N, P \rangle .$$

4. Representation Condition

The representation condition requires that there exists a correspondence between the set of quality manifestations and the set of numbers in such a way that the relations defined on the set of quality manifestations is preserved on the other set.

Formally, measurement M is defined as an empirical operation:

$$M : Q \to N ,$$

such that $L = \langle Q, R \rangle$ is mapped homomorphically (structure-preserving mapping) onto $S = \langle N, P \rangle$ by M and F. One-to-one mapping is denoted by F with domain R and range P:

$$F : R \to P .$$

Therefore, P_i is denoted as:

$$p_i = F(r_i); p_i \in P; r_i \in R ,$$

where p is an n-ary relation if and only if it is the image under F of an n-ary relation. A homomorphic mapping is that for all $r_i \in R$ and all $p_i \in P$ and $p_i = F(r_i)$,

$$r_i(q_1,...,q_i,...,q_n) \leftrightarrow p_i(M(q_1),...,M(q_i),...,M(q_n)) .$$

Measurement M is not a homomorphism (Sydenham, 1982) since, unlike F, M is not a one-to-one mapping. There can be mappings to the same number because there may be multiple but separate qualities corresponding to the same number.

As a result,

$$Y = \langle L, S, M, F \rangle ,$$

where Y constitutes a scale for $n_i = M(q_i)$. The image of q_i in N under M is called the measure of q_i on scale Y.

5. Uniqueness Condition

There may be multiple mappings for which the representation condition is valid. It is possible to have transformations from one scale to another as long as the representation condition is valid. The uniqueness condition defines the class of scale transformations to mappings for which the representation condition is valid (Sydenham, 1982).

D. DIRECT AND INDIRECT MEASUREMENT

There are two methods of measurement: direct and indirect. In Sydenham (1982), direct measurement is defined as the method "by which the value of a quantity to be measured is obtained directly, without the necessity for supplementary calculations based upon a functional relation between a quantity to be measured and other quantities actually measured." The key difference between the direct and indirect method is obtaining the measurement with or without the necessity of measuring other qualities. In Sydenham (1982), the indirect method is defined as the method "in which the parameter sought is gained by use of intermediate stages of different units which are linked in some positive manner." Examples of direct measurement in software engineering are source lines of code, duration of an activity such as testing, number of defects, and effort in number of man-hours or man-months. Examples of indirect measurement in software engineering are productivity defined such as number of lines of code over effort in man-month, requirements stability defined as number of requirements at start over total number of requirement at the time of measurement, etc.

Since our goal is to measure effectiveness of project management in a software project, the complexity of the concept required an indirect approach. The theory helps us measure certain properties of activities and entities. New concepts are also introduced.

Activities and entities as defined in the previous theory of project management have distinctly identifiable and quantifiable properties. There exists a way to quantify and measure these properties. There also exists a way to combine these measures and represent them as another measure of the same or different property provided that a measurement function is defined.

Using the previous theory of project management and assumptions provided above, it is possible to derive various project management metrics. For example, every activity may have a property called duration. Assuming a complete sequential model of the project, which fully orders the activities, simply adding the duration properties of the project activities will yield the duration of the project. Notice that the resulting type of the property is the same for this example.

Properties of activities and entities are denoted with a name followed by a dot after the activity or the entity. A quality exists for a property that relates the property to the quality. For an activity "a()", a property "pr" and a quality "q," the property of the activity corresponds to the quality as follows: "a().pr=q." For an entity "e," a property "pr" and a quality "q," the property of the entity corresponds to quality as follows: "e.pr=q."

Following the previous definitions, we can define a measurement function *"F"* for a property *"pr"* of an activity *"a()"* as follows:

$$q = F_{a().pr}\{a_1().pr_1, a_2().pr_2, ..., a_m().pr_m, e_1.pr_1, e_2.pr_2, ..., e_n.pr_n\}$$
$$q = a().pr,$$

where *"q"* is the quality that corresponds to the property *"pr"* of the activity *"a()"* and *"m"* and *"n"* are the identifiers for various activities and entities. Note the similarity of the formulation with the *PM* function formulated in the theory of the project management. Remember that *PM* is a specially defined type of activity in the theory.

We can similarly define a measurement function *"F"* for a property *"pr"* of an entity *"e"* as follows:

$$q = F_{e.pr}\{a_1().pr_1, a_2().pr_2, ..., a_m().pr_m, e_1.pr_1, e_2.pr_2, ..., e_n.pr_n\}$$
$$q = e.pr,$$

where q is the quality that corresponds to the property *"pr"* of the entity *"e."*

Note that these formulations represent the most general form in which the resulting quality is a combined measure of the different properties provided that the measurement function "F" is defined. The same formulation may also be applied when the properties of the activities and entities are the same:

$$q = F_{a().pr}\{a_1().pr, a_2().pr, ..., a_m().pr, e_1.pr, e_2.pr, ..., e_n.pr\}$$

$$q = F_{e.pr}\{a_1().pr, a_2().pr, ..., a_m().pr, e_1.pr, e_2.pr, ..., e_n.pr\},$$

where *"m"* and *"n"* are the identifiers for various activities and entities.

E. A THEORY OF PROJECT MANAGEMENT EFFECTIVENESS MEASUREMENT

The theory of project management effectiveness measurement lays the foundation for the development of the software project management effectiveness metric. Simply, we can assume that the effectiveness of software project management is the result of a measurement function in which the inputs are the effectiveness properties of activities and entities used as inputs in the project management function. In other words, when we measure the effectiveness of activities and entities in a project, we can also come up with the effectiveness of project management using a measurement function.

$$PM.eff = F_{PM.eff}\{a_1().eff, a_2().eff, ..., a_m().eff, e_1.eff, e_2.eff, ..., e_n.eff\}$$

where:

PM : The project management function for a specific project, *P*.

PM.eff : The effectiveness property of the project management function, *PM¸* for project *P*.

$F_{PM.eff}$: The measurement function defined for *PM.eff* when specific activity and entity inputs, $a_1().eff, a_2().eff, ..., a_m().eff, e_1.eff, e_2.eff, ..., e_n.eff$, are used.

$\{a_1(), a_2(), ..., a_m()\}$: The activities related to the project

$\{e_1, e_2, ..., e_n\}$: The entities related to the project.

V. DEVELOPMENT OF A FRAMEWORK FOR SOFTWARE PROJECT MANAGEMENT

A. INTRODUCTION TO 3PR FRAMEWORK

In order to guide the development of the software project management metric, it is essential to be able to frame the core areas of software project management. Therefore, a framework for software project management is developed. The framework is quite simple and intuitive. It is also modifiable to suit the need to focus different areas for different types of projects. First, a brief overview of different approaches to frame the project and software project managements will be presented.

Project Management Institute's (PMI, 2004) "Project Management Body of Knowledge Third Edition" (PMBOK Guide), identifies five project management processes groups:

1. Initiating Process Group.
2. Planning Process Group.
3. Executing Process Group.
4. Monitoring and Controlling Process Group.
5. Closing Process Group.

According to the PMBOK, these are not phases of a project and they may be repeated for each phase where appropriate. PMBOK also identifies and lists nine project management knowledge areas:

1. Project Integration Management.
2. Project Scope Management.
3. Project Time Management.
4. Project Cost Management.
5. Project Quality Management.
6. Project Human Resource Management.
7. Project Communications Management.
8. Project Risk Management.
9. Project Procurement Management.

PMBOK identifies forty-four project management processes used to achieve a project. Appendix E provides the mapping of the project management processes to the project management process groups and the knowledge areas. Even though this mapping may constitute a framework, it is arguably complex.

Capability Maturity Model Integration version 1.1 (CMMI) identifies the following process areas related to project management (CMMI, 2002):

- Project Planning.
- Project Monitoring and Control.
- Supplier Agreement and Management.
- Integrated Project Management for Integrated Product and Process Development (IPPD).
- Risk Management.
- Integrated Supplier Management.
- Quantitative Project Management.

CMMI version 1.1 prefers to divide the process areas into two process area groups: the basic project management process areas and the advanced project management areas. Project planning, project monitoring and control, supplier agreement and management are addressed as basic project management process areas. Integrated Project Management for IPPD, risk management, integrated supplier management and quantitative project management process areas are categorized as advanced project management areas. Figures 10 and 11 provide the interactions among these process areas for basic and advanced project management process areas respectively.

As it is observed in the Figures 10 and 11, the interactions among these process areas are not easily comprehensible, even though only certain important interactions are depicted in the figures. CMMI version 1.1 lists requirements management and requirements development under the title of engineering process area, and configuration management is listed under the title of support process area.

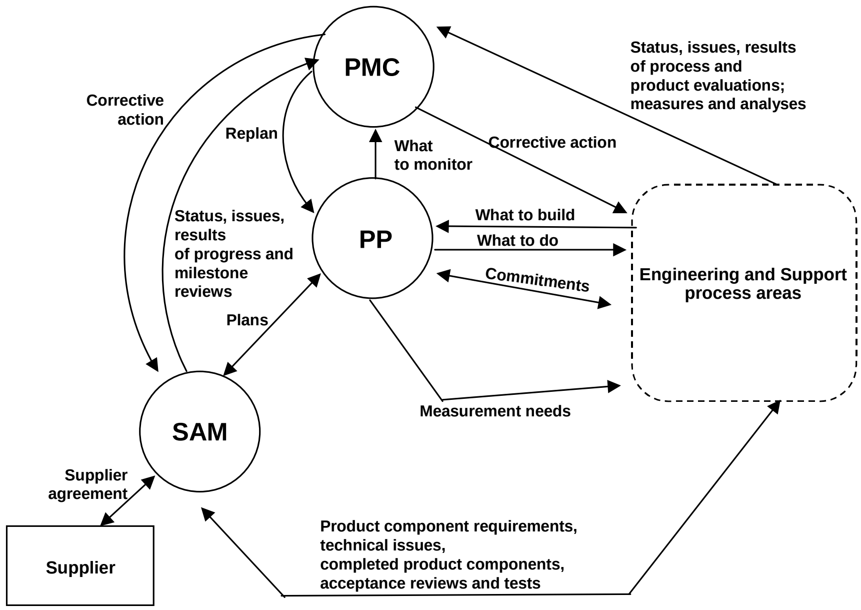

Figure 10. Basic Project Management Process Areas (Taken from (CMMI, 2002))

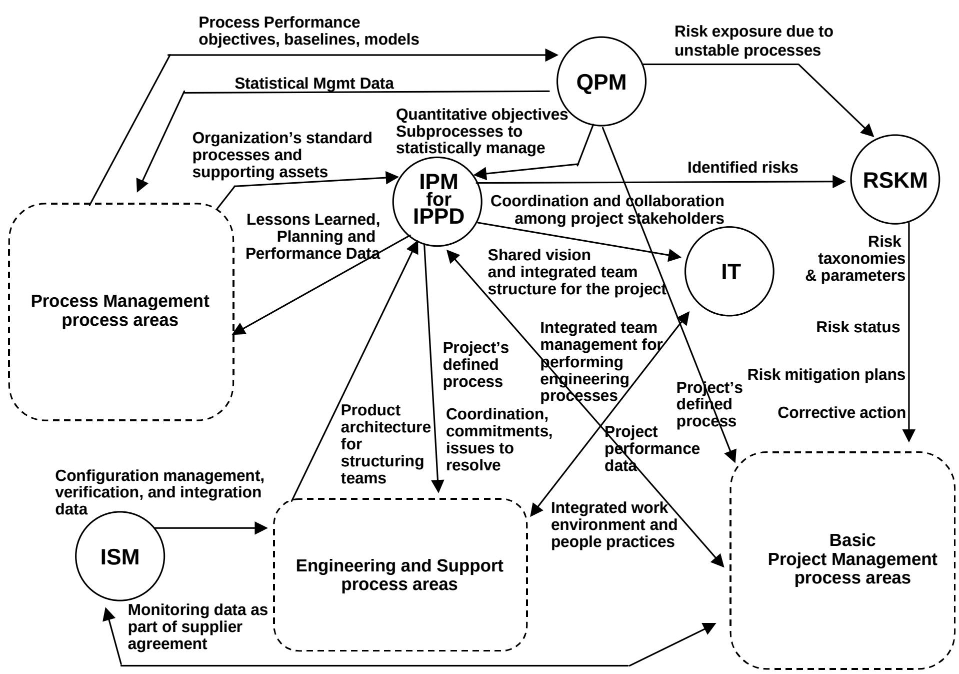

Figure 11. Advanced Project Management Process Areas (Taken from (CMMI, 2002))

The "Program Manager's Guide to Software Acquisition Best Practices Version 2.31" prepared for the Software Program Managers Network (SPMN) identifies nine principal best practices (SPMN, 1998):

1. Formal Risk Management.
2. Agreement over Interfaces.
3. Formal Inspections.
4. Metrics-based Scheduling and Management.
5. Binary Quality Gates at the Inch-Pebble Level.
6. Program-wide Visibility of Progress vs. Plan.
7. Defect Tracking Against Quality Gates.
8. Configuration Management.
9. People-Aware Management Accountability.

Also, the guide groups the best practices into seven proven management areas:

1. Risk Management.
2. Planning.
3. Program Visibility.
4. Program Control.
5. Engineering Practices and Culture.
6. Process Improvement
7. Solicitation and Contracting.

Every management area contains many best practices. For example, risk management has five best practices, planning has four, program visibility has four, and so on.

In (PMI, 2004; CMMI, 2002; and SPMN, 1998), process areas or best practices are categorized extensively. Developing a framework out of them is not an easy task.

Forsberg, Mooz and Cotterman (2005), developed an elegant visual model for project management. The model is called "the wheel and axle model," depicted in Figure 12. It accounts for many important areas of project management. The model is based on five essentials for every project (Forsberg et al., 2005):

- Organizational commitment.
- Communication.
- Teamwork.
- Project Cycle.
- Management Elements.

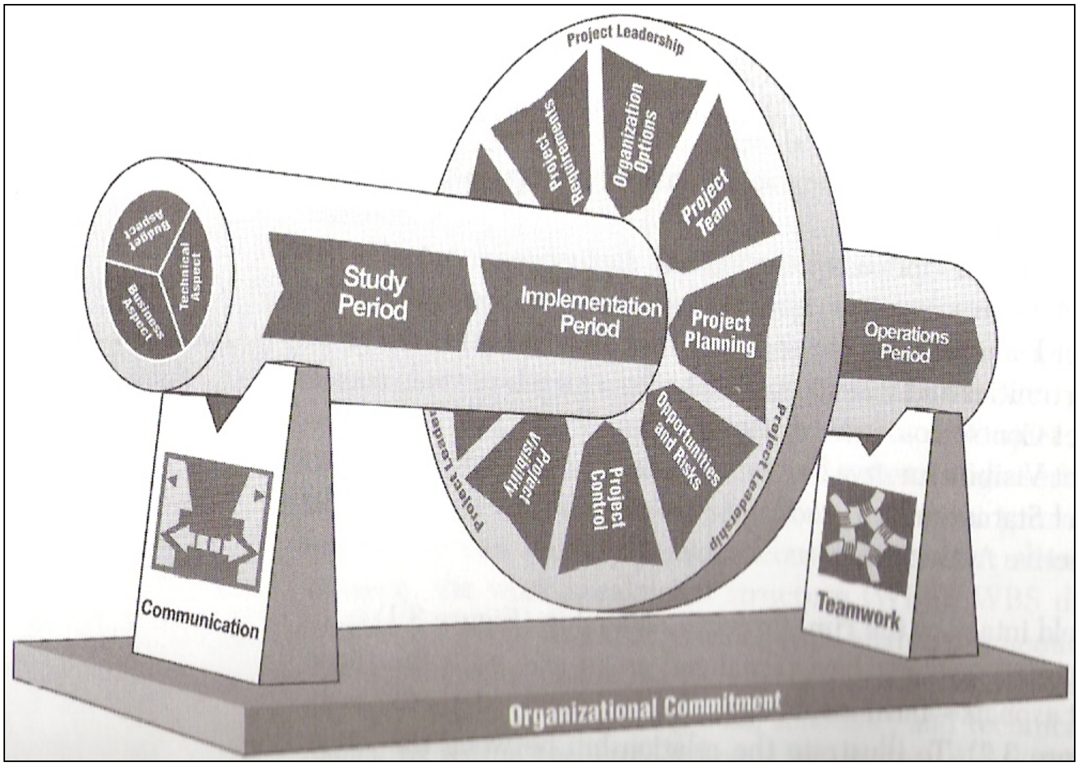

Figure 12. The Wheel and Axle Model [From (Forsberg et al., 2005)]

The visual model has sequential and situational practices. The phases of the project cycle are sequential and the management elements are situational. The management elements are applied throughout the project cycle. They are homogeneous in this aspect. The project cycle portrayed as an axle is shown in Figure 13. The ten management elements are presented as a wheel in Figure 14

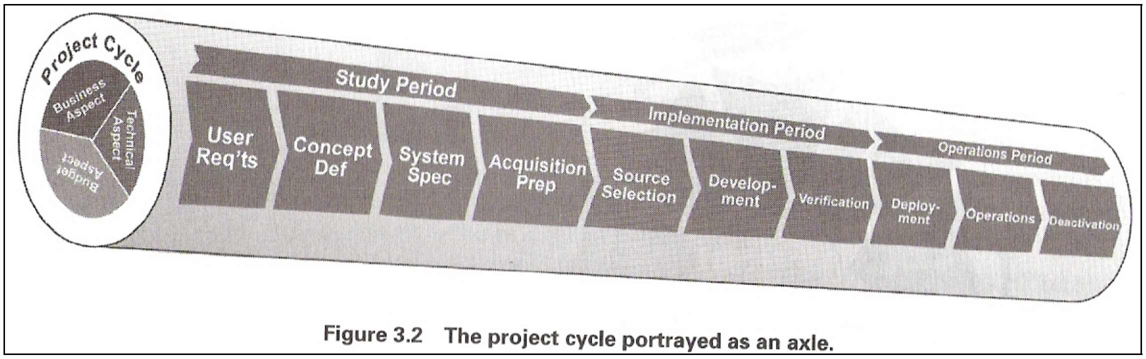

Figure 13. The Project Cycle Portrayed as an Axle [From (Forsberg et al., 2005)]

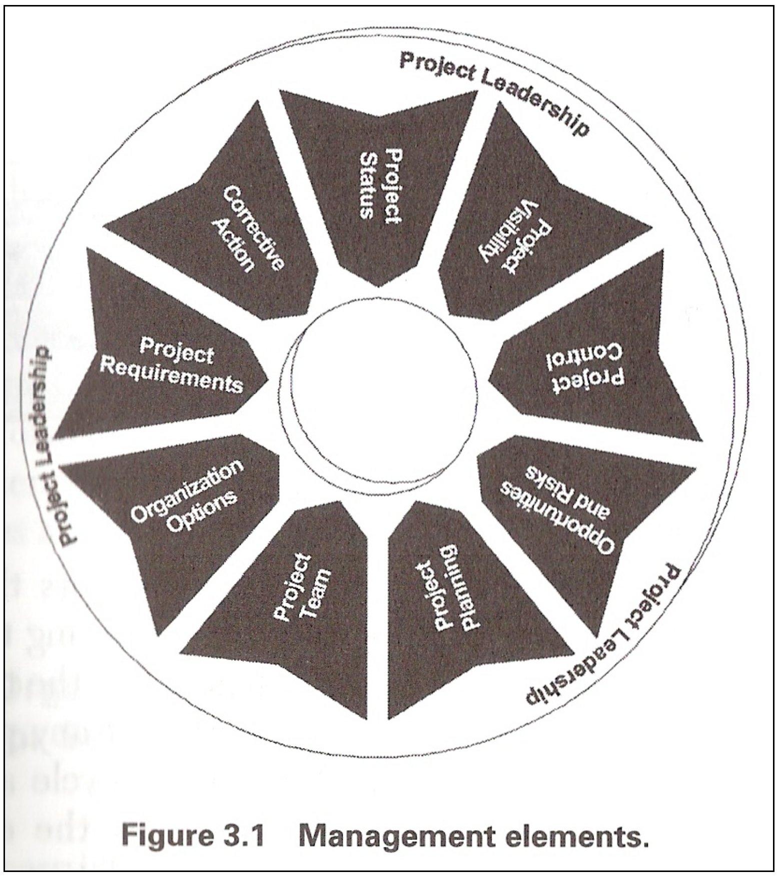

Figure 14. Management Elements [From (Forsberg et al., 2005)]

The project cycle has three periods: study, implementation, and operations. The project also has business, budget and technical aspects managed throughout the cycle. The management elements are depicted as the spokes of a wheel and they are:

- Project Requirements.
- Organizational Options.
- Project Team.
- Project Planning.
- Opportunities and Risks.
- Project Control.
- Project Visibility.
- Project Status.
- Corrective action.

The tenth management element is project leadership and it is depicted as the rim that holds the spokes, which are the previously listed nine items. The model helps us to understand various important elements and aspects of project management. It also helps us to visualize the interactions among the elements to a certain level. However, the model also indicates that interactions among elements and processes can easily get complex.

Philips (2000) identifies three key perspectives for software project management: people, business, and process. He emphasizes that having these perspectives won't make a project successful, but it will help to go a long way to making success possible. He promotes four basic principles that need to be applied with discipline and perseverance:

1. Balance people, process and product.
2. Promote visibility.
3. Organize by using configuration management tools properly.
4. Use standards judiciously.

Philips highlights that all undertakings include the 3Ps: people, process and product. In successful undertakings, these 3Ps are managed in harmony. Figure 15 provides Philip's mindmap for software project management.

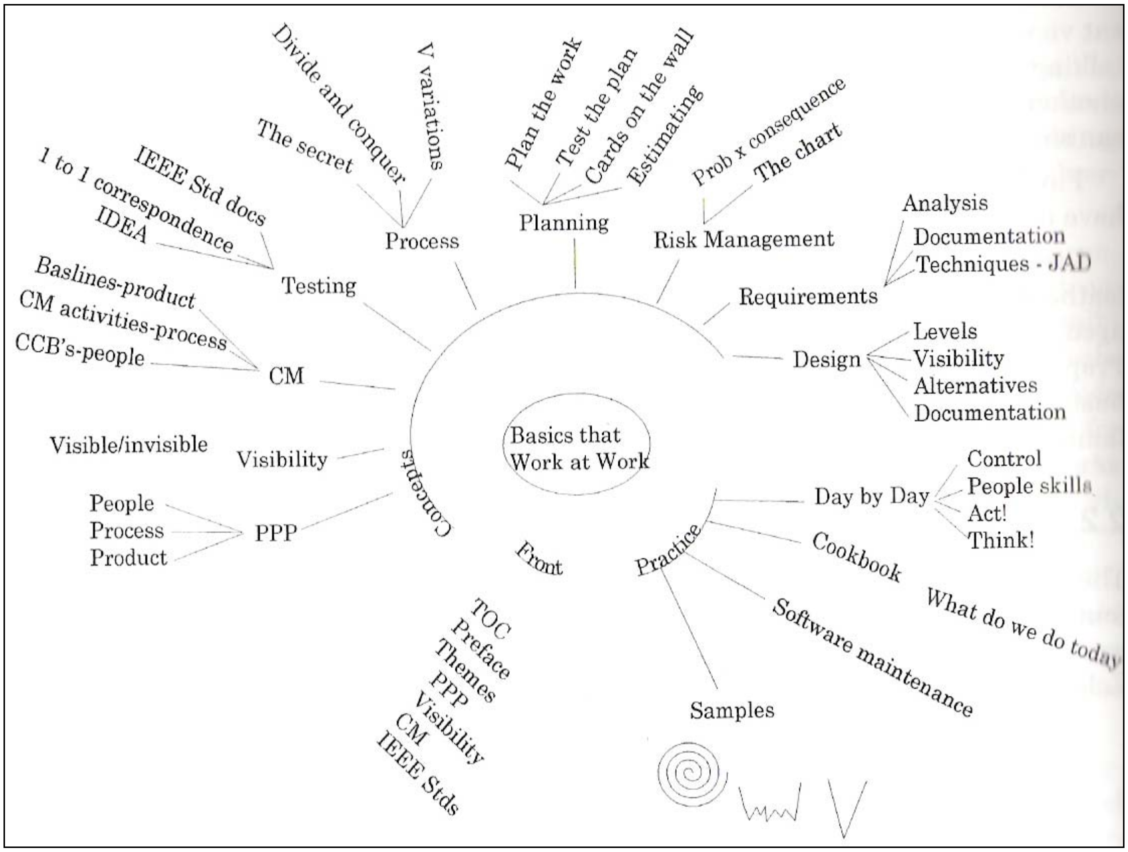

Figure 15. A Mindmap for Software Project Management [From (Philips, 2000)]

The Software Quality Institute's Body of Knowledge for Software Project Management (SQI BOK) lists thirty-four competencies. This list of essential competencies is employed by the most successful software project managers. These competencies are categorized into three parts: Product, Project and People (Futrell, Shafer and Safer, 2002).

<u>Product Development Techniques</u>

1. Assessing Processes.
2. Awareness of process standards.
3. Defining the product.
4. Evaluating alternative processes.
5. Managing requirements.
6. Managing subcontractors.
7. Performing the initial assessment.

8. Selecting methods and tools.
9. Tailoring processes.
10. Tracking product quality.
11. Understanding development activities.

Project Management Skills

12. Building a work breakdown structure.
13. Documenting plans.
14. Estimating cost.
15. Estimating effort.
16. Managing risks.
17. Monitoring development.
18. Scheduling.
19. Selecting metrics.
20. Selecting project management tools.
21. Tracking processes.
22. Tracking project progress.

People Management Skills

23. Appraising performance.
24. Handling intellectual property.
25. Holding effective meetings.
26. Interaction and communication.
27. Leadership.
28. Managing change.
29. Negotiating successfully.
30. Planning careers.
31. Presenting effectively.
32. Recruiting.
33. Selecting a team.
34. Teambuilding.

Wiegers (1996) identifies five dimensions of a software project:

- Staff.
- Features.
- Quality.
- Cost.
- Schedule.

Throughout a software project, the listed five dimensions have to be managed. Figure 16 shows these dimensions. These dimensions are somewhat dependent on each other; the relations among them are nonlinear and complex most of the time. The dimensions may be assigned roles on a project: a driver, a constraint, or a degree of freedom (Wiegers, 1996). The driver of a project is the key objective. There may also be multiple drivers. However, if all dimensions are assumed to be drivers, there is no point in having different roles. A constraint is the limiting factor for the project. The constraint has to be outside of the project manager's control. For example, a fixed cost price, where negotiation with the customer is not an option, is the constraint. When the team size is fixed and the manager is not allowed to hire new team members or detach team members from the project organization, then staff is the constraint. The rest of the dimensions that are not drivers or constraints become the degrees of freedom. When the project manager has control over adding or not including features, then the feature dimension is a degree of freedom.

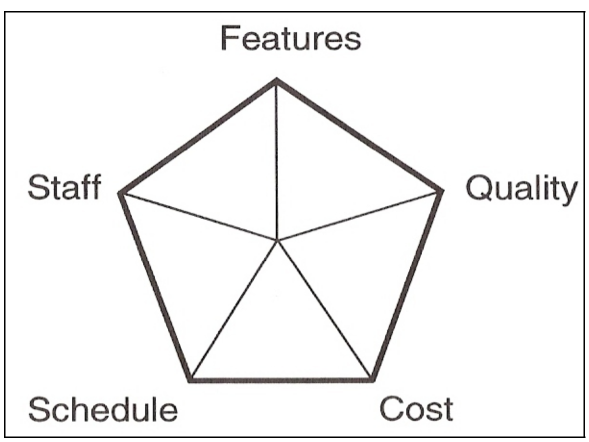

Figure 16. The Five Dimensions of a Project [From (Wiegers, 1996)]

Figure 16 presents the dimensions on a kiviat diagram. Kiviat diagrams are useful when multiple item evaluations are presented on a single diagram. A kiviat diagram is a polygon, which has the same number of sides as the number of variables. Each axis represents a data category and different scales and data types can be used. However, in this case, the same scale will be used. The dimensions are categorized with respect to the flexibility the project manager has over the dimension. The flexibility of the dimension is plotted on an axis of the kiviat diagram. The scale on a dimension goes from zero flexibility to highest flexibility (0 to 10). The closer the plot is to the center, the less flexibility there is for that dimension. So, for a complete constraint such as having a fixed number of team members, the plot on the staff axis would be the closest to the center. Figure 17 shows the flexibility diagram of a quality-driven application. The plot on the quality axis is closest to the center. As the diagram shows, the project manager has some flexibility over features and cost while having considerable flexibility over staff and schedule.

Understanding the driver, the constraint and degrees of freedom in a project and plotting them on a kiviat diagram helps us in critical decision making as well as with prioritization.

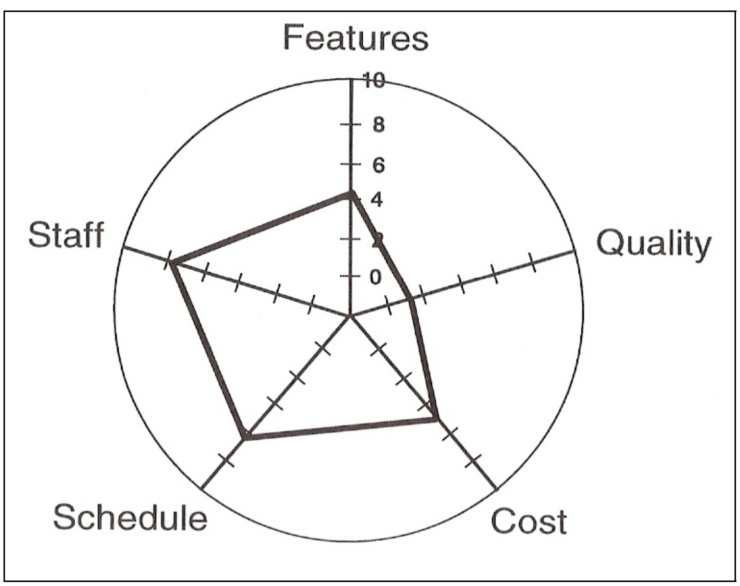

Figure 17. Flexibility Diagram of a Quality-Driven Application [From (Wiegers, 1996)]

According to Bach (1995), all managers are faced with the 3Ps while developing software. These 3Ps are people, problem and process. He questions whether the 3Ps should be given equal weight and whether one should be given more focus than others. Bach emphasizes that the people aspect of software development should be given more focus than it is currently given. He criticized CMM for focusing too much on process rather than people at the time (1994). One year later in 1995, the first version of the People Capability Maturity Model (P-CMM) (Curtis et al., 1995) was released based on the work by Humphrey (1989). Later the work was called Personal Software Process (Humphrey, 1996; 1997).

Kulpa (2007) reports an interesting graphic from a CMM introduction class. The graphic presents the foundations for an organization and referenced them as quality leverage points. The graphic consists of a three-legged stool figure. In the graphic, the stool represents the organization. The legs of the stool are people, process and technology. She points out the reasons to use People-CMM in her article (Kulpa, 2007). Figure 18 presents the graphic mentioned.

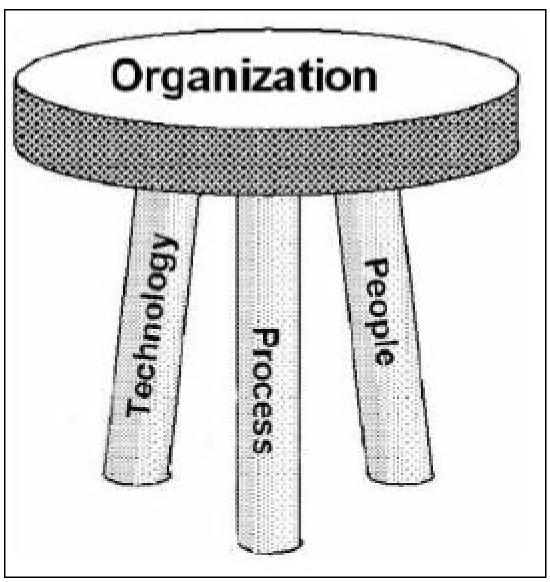

Figure 18. Quality Leverage Points [From (Kulpa, 2007)]

Some of the frameworks, models, perspectives, standards and guidelines for project management are sampled above. Most of these are complex in nature and arguably complete.

In this study, a simple project management framework is developed in order to accommodate the core areas of project management. The goal was to identify a boundary for project management in which we can easily categorize measurement areas for project management. This framework is easily modifiable with the addition of new areas or with the removal of outdated areas. It is also modifiable in the sense that it allows the focus to be different areas for different project domains and types.

The framework consists of four main areas of project management:

- People.
- Process.
- Product.
- Risk.

The first letters of main areas are combined and the framework is named as 3PR. These core areas help us to partition the important areas of software project management.

B. MAIN PROJECT MANAGEMENT AREAS

1. People

The importance of people management in project development efforts is quite well established (Brooks, 1995; Bach, 1994; Bach, 1995; Philips, 2000; Curtis et al., 1995; Curtis et al., 2001; Humphrey, 1995; Humphrey, 1997; DeMarco & Lister, 1999). Software projects are developed for people by people. The people area especially gets more focus in a software development environment, since the development is considerablly human-intensive compared to other industries. Kerzner (1992) provided some classification and different characteristics of projects as presented in Table 1.

	In-house R&D	Small Construction	Large Construction	Aerospace/ Defense	MIS	Engineering
	Type of Project/Industry					
Need for Interpersonal Skills	Low	Low	High	High	High	Low
Importance of Organizational Structure	Low	Low	Low	Low	High	Low
Time Management Difficulties	Low	Low	High	High	High	Low
Number of Meetings	Excessive	Low	Excessive	Excessive	High	Medium
Project Manager's Supervisor	Middle Management	Top Management	Top Management	Top Management	Middle Management	Middle Management
Project Sponsor Present	Yes	No	Yes	Yes	No	No
Conflict Intensity	Low	Low	High	High	High	Low
Cost Control Level	Low	Low	High	High	Low	Low
Level of Planning/Scheduling	Milestones only	Milestones only	Detailed plan	Detailed plan	Milestones only	Milestones only

Table 1. Classification of Projects/Characteristics [From (Kerzner, 1992)]

In Table 1, there are two categories of interest related to this study. The first one is the aerospace/defense industry. It is quite fair to assume that most aerospace/defense industry projects rely heavily on software today (Spruill, 2002). The second one is management information systems (MIS).

Therefore, they are examples of software projects as defined in this dissertation. The need for interpersonal skills, number of meetings, and conflict intensity are obviously related to the people aspect of software development. In aerospace/defense projects, the need for interpersonal skills and conflict intensity is high and the number of meetings held is numerous. In contrast, in small construction projects the need for interpersonal skills, conflict intensity, and number of meetings are low. While this shows important differences in projects from different industries, it also stresses the importance of the people aspect in aerospace/defense projects.

James Bach (1995) takes an arguably radical position in what aspect needs more focus in software development projects. He strongly points out that:

> At conferences and in journals, the extraordinary attention we give to software-development processes is misplaced. Far too much is written about processes and methods for developing software; far too little about care and feeding of the minds that actually write the software. Process is useful, but it is not central to successful software projects. The central issue is the human processor – the hero who steps up and solves the problems that lie between a need expressed and a need fulfilled.

He also emphasizes that “I argue that the only basis for success of any kind is the heroic efforts of a dedicated team.” Even though his views might be seen as radical, this may be the result of resentment due to lack of research and emphasis on people issues in software development when compared to research on processes. Weinberg (1994) says, “the three causes of failure are people, people, and people.” Again, Thomsett (1995) points out that “most projects fail because of people and project management concerns rather than technical issues.” Kulpa (2007) states that the one area that is unaddressed by organizations is the people.

Philips (2000) takes a more central approach. He stresses the importance of having a balance between people, process and product. He argues that the road to success passes from harmonizing these 3Ps.

Brooks (1995) pointed out the variations in programmer productivity as a problem. He references studies reporting an order of magnitude variations dated back to 1968 (Sackman, Erickson and Grant, 1968). DeMarco and Lister (1987) reported significant computer programmer productivity variations ranging from one to ten fold. Weinberg (1994) reported variations in programmer productivity and quality from twenty to one. Considerable variations exist in software development productivity. Measuring programmer productivity is not trivial (Spolsky, 2005). It is very hard to setup an experiment in which it is possible to control every factor contributing to and measuring the productivity.

In one of the most widely-known cost estimation technique, COCOMO II, team cohesion affects the effort estimation exponentially. The team cohesion scale factor accounts for the difficulties in synchronizing and managing different stakeholders including users, customers, developers, etc. (CSE, 1999).

Hughes and Cotterell (2002) point out that people with practical experience in software projects will clearly state an important aspect of software project management as people.

Project Management Institute’s (PMI, 2004) “Project Management Body of Knowledge Third Edition” (PMBOK Guide) lists some of the interpersonal skills needed in the management of projects in the areas of expertise section. The list includes effective communication, influencing the organization, leadership, motivation, negotiation and conflict management, and problem solving. The previous PMBOK edition from 1996 (PMI, 1996) lists all of the above except motivation. Even though PMBOK recognizes the importance of people skills in the management of projects, it doesn't go into detail but instead merely lists them.

Given the many evidences of the importance of people area in software development projects, inclusion of the people area to the framework is essential. The study for the validation of the framework conducted in this research also shows that the people aspect has the highest importance in the software project management framework.

2. Process

Without a defined process, gathering a bunch of practitioners and expecting them to work in harmony for a common goal is very unlikely. Two things may happen: either they naturally form a team through group dynamics and even setup a process invisible to the outsider, then start working together to achieve the goal, or they will work toward their personal ambitions. In other cases, where there is a defined process, practitioners are assigned to or voluntarily fill up the project roles. A process is essential to the project. Whether the process is effective or not, or the process is well-defined or vaguely exists, the process is one of the main areas of project management.

IEEE's "Standard Glossary of Software Engineering Terminology" (IEEE, 1990) defines the process as "a sequence of steps performed for a given purpose; for example the software development process." In the same standard, process management is defined as "the direction, control and coordination or work performed to develop a product or a service. Example is quality assurance."

Within the framework, the main area of the process encapsulates the focus on the various key processes for the development of software projects. There are also some other key processes encapsulated in other areas. The partitioning is based on whether a process intuitively fits the main area.

Two of the most widely recognized works mainly focus on processes. CMMI and earlier various CMMs are based on improving the maturity of organizations by improving their processes (CMMI, 2006). CMMI for Development versions 1.1 and 1.2 propose specific and generic goals for each identified process area. As previously mentioned, Project Management Institute's (PMI, 2004) "Project Management Body of Knowledge Third Edition" (PMBOK Guide) identifies five project management processes groups: initiating, planning, executing, monitoring and controlling, and closing. Figures 19 and 20 present the process groups and their interactions.

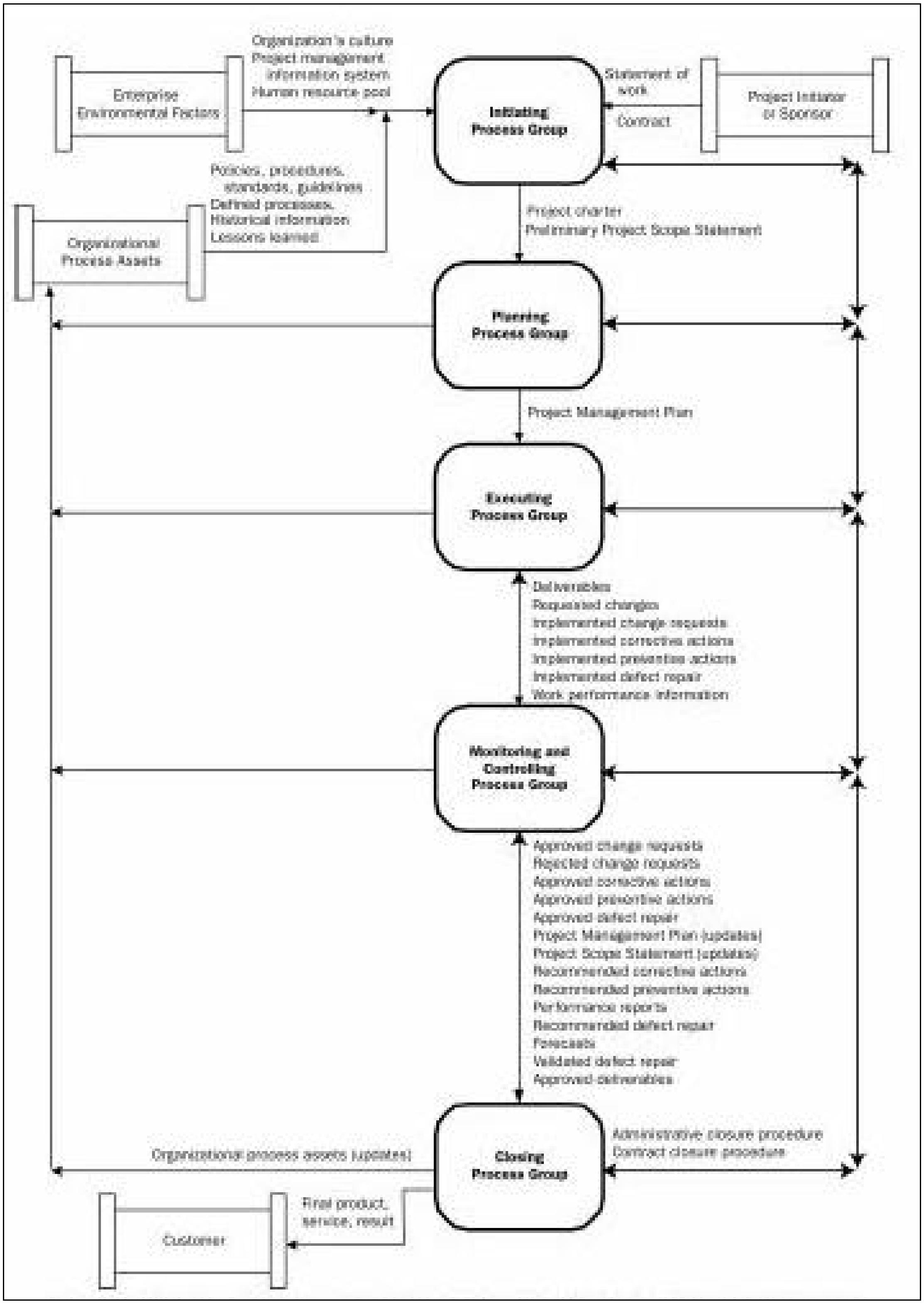

Figure 19. High Level Summary of Process Group' Interactions [From (PMI, 2004)]

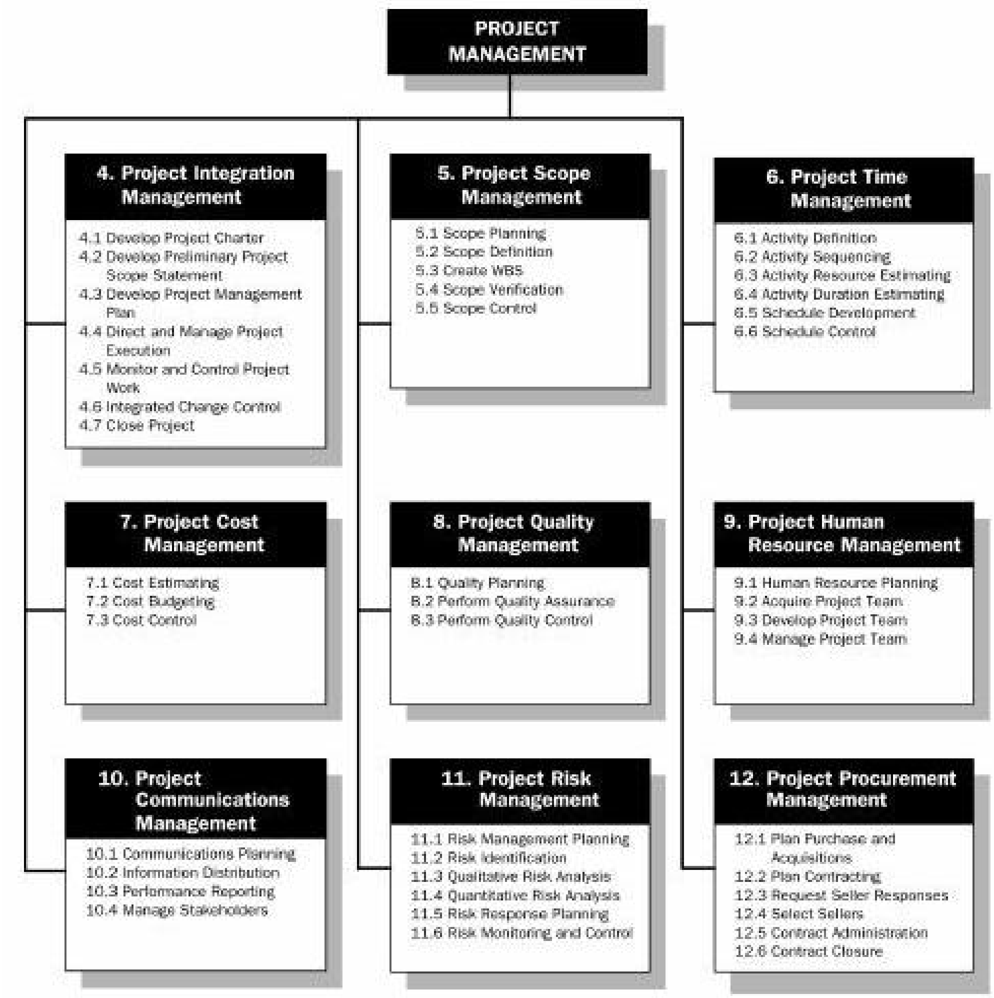

Figure 20. Overview of Project Management Knowledge Areas and Project Management Processes [From (PMI, 2004)]

Endres and Rombach (2003) present Humphrey's law as "mature processes and personal discipline enhance planning, increase productivity, and reduce errors." As a result, inclusion of the process main area to the framework is essential.

3. Product

According to 2004 version of the PMBOK (PMI, 2004), "a project is a temporary endeavor undertaken to create a unique product, service, or result." In the framework, the product is considered as the outcome of the project, which may be a product, service or result. This view is also shared with Philips's (2000) definition of product: "the product is the project's final outcome." Products include software, firmware, documentation, reusable artifacts, training, and even services such as maintenance. The whole purpose of the project is to create a product with which the stakeholders will be satisfied.

The most important characteristic of the product is its quality. In every project, the stakeholders should come to a common understanding of what the product's quality should be. The earlier this common understanding is reached the better it is. According to Blum (1992), there are two views of quality: internal and external. While internal quality is the developer's view of the software, external quality is the stakeholders' view of the software. Internal quality includes, but is not limited to, efficiency, testability, understandability, and modifiability. External quality includes usability, correctness, reliability, maintainability, integrity, etc. It is preferable to make these quality attributes as measurable as possible; however, this is not an easy task in every project. For example, a quality attribute such as usability may mean different things for the developers and the users. Thus, it is essential to define what usable means as early as possible in the project development. It is important to note that quality is not a feature that can be included later in the product. It should be integral to the whole software development process.

4. Risk

As the definition of the project stated in PMBOK, a project is undertaken to create a unique product, service or result. This uniqueness is inherent and creates a certain amount of uncertainty in projects. This is also specifically addressed in Turner's theory of project management (Turner, 2006, pp. 1-3, 93-95, 187-189). In this theory, lemma 4 and lemma 5 state that the work of the product is non-routine, and therefore risky. This is one of the inherent aspects of projects. Every project manager or project management team conducts risk management activities with different levels of rigor. The level of rigor varies from dedicated formal risk management procedures to ad hoc responses to risks.

Risk management has found its place in most well-established standards and guidelines such as PMBOK (PMI, 2004), CMMI (2006), program manager's guide to software acquisition best practices (SPMN, 1998), Guide to the Software Engineering Body of Knowledge (SWEBOK) 2004 Version (IEEE, 2004), INCOSE's (International

Council on Systems Engineering) Systems Engineering Handbook version 3.1 (2003), NASA Systems Engineering Handbook (NASA, 2007), and the Military Standard for Software Development and Documentation (DoD, 1995).

Boehm (1991) points out that in most software project disasters, the problems could have been avoided or reduced if the high-risk elements had been identified and resolved early on in the process. Risk management practices involve two primary steps: risk assessment and risk control. Risk assessment involves risk identification, risk analysis, and risk prioritization. Risk control involves risk management planning, risk resolution, and risk monitoring. Capers Jones (1994) identifies an alphabetic listing of sixty risk factors in his novel book. This book is a good source of information for identification and resolution of risks in software projects.

Since risk management is an inherent aspect of projects, software project management framework includes risk as a main area.

C. PEOPLE

The people main area includes seven project management areas. They are communication, teamwork, leadership, organizational commitment, project manager, stakeholder involvement, staffing and hiring.

1. Communication

Communication can be generally described as the exchange of ideas, opinions and information through written or spoken words, symbols or actions (Pearson Education, 2002). A successful project requires constant and healthy communication between stakeholders. The importance of communication in project development is well established in literature. Among all of the project management areas listed in PMBOK, communications management has the largest impact on project results (Muller, 2003). Grinter (1996) expresses that good communication is vital to establish and maintain control over the software development process.

2. Teamwork

Teamwork may be defined as “the concept of people working together towards a common vision or a goal set as a team.”

3. Leadership

Leadership may be defined as “the ability to lead, including inspiring others in a shared vision. Leaders have clear visions and they communicate these visions to their employees. They foster an environment within their companies that encourages risk taking, recognition and rewards, and empowerment allowing other leaders to emerge” (Industry Canada, 2008).

4. Organizational Commitment

Organizational commitment is the employee's psychological attachment to the organization (Brown, 2003) and organizational goals. In the project management context and in this framework organizational commitment refers to the commitment to project organization and project goals. There is an important difference on how organizational commitment is viewed in this framework and other studies. In this framework especially, organizational commitment refers to commitment from all stakeholders including project team members. In most other studies, organizational commitment is viewed from the employee’s view.

5. Project Manager

The project manager position is a key role in project organization. The project manager is mainly responsible for planning, directing, controlling, structuring, coordinating and motivating in the project organization. In this study, project manager is considered as a role and authority as well as incorporating the personal traits within the role. The role includes characteristics of both a good manager and a good leader.

6. Stakeholder Involvement

Stakeholder involvement is the engagement and involvement of primary and secondary stakeholders during the project development effort. This involvement includes, but is not limited to, planning, decision-making, development, testing and implementation of the project. For a successful project outcome, stakeholder involvement is essential. After all, the project is undertaken to satisfy the needs of the stakeholders.

7. Staffing and Hiring

Staffing may be defined as "the practice of finding, evaluating, and establishing a working relationship with future colleagues on a project and detaching them from the project organization when they are no longer needed. Staffing involves finding people, who may be hired or already working for the company (organization) or may be working for competing companies" (Nation Master, 2005). Hiring can be thought to be within the definition of staffing. In order to avoid confusion due to various definitions of terms, both terms are used in naming the area. In some organizations, hiring means employing project team from outside the organization and staffing means employing project team members within the organization's various departments. In this framework, this area also includes the concept of placing the right people in the right role.

D. PROCESS

The process main area includes four project management areas. They are requirements management, project monitoring and control, project planning and estimation, and scope management.

1. Requirements Management

"The management of all requirements received by or generated by the project, including both technical and non-technical requirements as well as those requirements levied on the project by the organization" (CMMI, 2006). In this framework, as the definition suggests, requirements management is the management of requirements and not the requirements development process. This is an important distinction. The requirements development process may rely on a specific software development life cycle model such as waterfall, spiral, agile, rapid prototyping, etc. The requirements management process itself is often independent of the life cycle development model.

2. Project Monitoring and Control

Project monitoring and control are actually two closely related project management areas combined into one area. Project monitoring is the process of keeping the project, project related factors, and project metrics under continuous observation. Project control is the process of ensuring that project goes according to what is planned in the project plans and other documentation. In addition, the project control process ensures that the deviations from the plan are kept to a minimum and under control.

3. Project Planning and Estimation

CMMI 1.2 defines the project planning as follows:

> project planning includes estimating the attributes of the work products and tasks, determining the resources needed, negotiating commitments, producing a schedule, and identifying and analyzing project risks. Iterating through these activities may be necessary to establish the project plan. The purpose of project planning is to establish and maintain plans that define project activities (CMMI, 2006).

Even though estimation is included in the previous definition, estimation exists in the title to make the term explicit and avoid any confusion. Project estimation includes creating and establishing estimates of project cost, schedule and necessary resources using various methods, techniques and tools.

4. Scope Management

In simple terms, scope management is the process of defining the scope of the project and keeping track of any changes of the scope. It also includes processes to limit the changes to the point that they are not disruptive to the success of the project. According to the project management challenges survey and various other studies, scope management is the most challenging and troublesome area in projects.

E. PRODUCT

The product main area includes two project management areas. They are configuration management and quality engineering.

1. Configuration Management

CMMI 1.2 defines configuration management as:

> A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, (3) record and report change processing and implementation status, and (4) verify compliance with specified requirements (CMMI, 2006).

Sometimes the meanings of configuration management and scope management are mixed among software practitioners. However, the CMMI's definition of configuration management clarifies and stresses that configuration management is about managing the configuration items. These configurations items include intermediate and final project artifacts and products. Even though configuration management is a process itself, the focus of this area is products. Therefore, configuration management is placed under the product main area to avoid confusion due to definition overload.

2. Quality Engineering

Quality engineering is another area placed under the product main area. It is important to note that the term quality engineering is different from quality assurance. In many organizations, quality assurance is used to refer procedures related to the testing of the product. In others, it has a broader meaning. By using the term quality engineering, the framework widens the area and includes all the procedures and processes conducted to ensure products or services are designed and produced to meet or exceed customer requirements. Quality engineering involves all activities and commitment towards the development of a high quality product to meet or increase the stakeholders' satisfaction.

F. RISK

There are two project management areas listed under the main area of risk. They are risk assessment and risk control.

1. Risk Assessment

Risk assessment may be defined as "a process or a set of activities that involves identification, analysis and prioritization of project risks." In some projects, risk assessment is conducted with quantitative and qualitative formal procedures and techniques, while in some others it is conducted as an ad hoc process. It should be noted that whether it is formal or not, the quality of the project risk assessment also depends on the skills and experiences of the responsible project staff. According to Boehm (1991), risk assessment involves risk identification, risk analysis, and risk prioritization.

2. Risk Control

Risk control may be defined as:

> the process of integrating findings from the risk assessment with technical, financial, policy, and non-technical concerns of stakeholders, to develop and select suitable risk control actions, and implementation of these actions. Risk control actions include implementation of policies, standards, procedures and physical changes (LesRisk, 2008).

Risk control involves risk management planning, risk resolution, and risk monitoring (Boehm, 1991). In order to conduct an effective risk control, an effective risk assessment process has to be in place.

G. CONCLUSION

A framework for software project management titled the 3PR framework was presented in this chapter. The framework consists of four main areas: People, Process, Product and Risk. Fifteen project management areas were identified and categorized under these main areas. First, these areas were identified with extensive literature search.

Then, the framework was validated with a survey study with the participation of seventy-eight software practitioners around the world.

The importance of the framework lies in its simplicity. It establishes the main areas in software project management. Every activity or entity that is related to project management can be categorized under one of these main areas. In this sense, the framework is complete. It is also flexible enough to represent all categories and types of projects with different focuses on different main areas. The software project management areas categorized under the main areas provide guidance for project managers while allowing them to focus on different aspect of projects. In addition, the framework guides researchers in developing software project management metrics.

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VI. VALIDATION OF THE FRAMEWORK FOR SOFTWARE PROJECT MANAGEMENT

A. INTRODUCTION

A survey was conducted among software development practitioners in order to validate the framework developed earlier. The following sections provide the information regarding the survey study, methodology and results.

B. SURVEY STUDY

The survey study is an important part of the research. Many approaches were proposed in the literature. Some of them are listed and detailed in the previous sections. However, only few of them are widely applied, tested and empirically supported; the rest of them are based on the views and experiences of various research and practitioners. Therefore, the empirical support of the framework is an important contribution of this research.

C. PILOT SURVEY STUDY

1. Pilot Study Introduction

Before launching the full-scale survey study, a pilot study was conducted. Van Teijlingen, Rennie, Hundley and Graham (2001) stress the importance of pilot studies. According to them, the term pilot study refers to “mini versions of a full-scale study (also called “feasibility studies”), as well as the specific pre-testing of a particular research instrument such as a questionnaire or interview schedule.” Pilot studies are an important part of a good study design. Sometimes pilot studies are omitted due to various reasons. They are costly, time-consuming, and they consume resources otherwise reserved for the full-scale study. However, they increase the likelihood of survey study success, and pilot studies help to avoid a disaster such as wasting all the critical resources due to various design errors.

The reasons for completing the pilot study in this research are:

- Guiding the development of the research design.
- Testing the research design and the instrument.
- Testing of the surveying technique (whether web-based and paper based surveys are adequate, or if structured or semi-structured interviews will be needed).
- Understanding and forecasting of difficulties for the full-scale study.
- Testing whether the population sampling method is viable.
- Testing the understandability of the wording.
- Understanding the limitations of the survey study.
- Guiding the assessment of the construct, internal and external validity.

The pilot study was extremely useful in this case. The results of the pilot study led to modifications and enhancements in the full-scale study. It helped uncover some problems regarding the surveying protocol.

Some of the characteristics of the pilot study for this research are listed as follows:

- The pilot survey instrument and research design followed the same principles as the full-scale study.
- The participants of the pilot study were randomly drawn from the pool of the sampling population of the full-scale study. The pilot survey participants were not used again in the study.
- The data collection methodology of the pilot study is identical with the full-scale study. Both the pilot study and the study used a self-administered questionnaire. The questionnaires had two versions. One is web-based and the other is paper-based.

2. Pilot Study Instrument

The pilot study instrument is a self-administered questionnaire. The questionnaire consists of an administrative introductory section and four research related sections. The paper-based version of the survey instrument includes six questions. A copy of the pilot survey questionnaire is provided in Appendix B. The web-based survey instrument has eight questions. It was developed using a commercial surveying tool (SurveyMonkey, 2007). The tool utilizes various web technologies to develop quick web surveys. Both versions are essentially the same. The only difference is that the web-based version has the administrative sections presented as questions. The first two questions in the web-based survey instrument are used for the administrative section.

In the pilot study, there was an open-ended question, which was left out in the full-scale study. The goal of the question was to gather the participant's opinion on how to improve the survey instrument. Valuable insights were collected from the feedback provided via this question.

3. Pilot Study Results

The pilot study results led to some improvements in the study. The results and some of the improvements for the full-scale study are listed as follows:

- Forty-four survey invitations were sent out. This population was randomly selected from the pool of the total sample population. There were twelve responses, yielding a response rate of 27.7%. This rate is almost the same as the response rate in the full-scale study. The responses showed that the selected population is the right population for the study.
- One of the feedbacks indicated the necessity of a glossary section for the survey to eliminate possible misunderstandings. Therefore, a glossary section was added to the study.
- Two of the participants indicated the need for an explicit scale for the second question in the paper version of the survey. Even though an explicit scale was not provided for this question, the participants were able to answer the question without difficulty. A scale was added with the question.
- Most respondents indicated that the framework proposed was sufficient. No significant improvement was suggested for the framework.

- Two of the responses specifically indicated that all areas regarding the software project management were covered in the research.
- The survey length was found to be reasonable.
- The participants found the questions understandable.
- The last question of the survey, inquiring about possible suggestions to improve the survey, was deleted in the full-scale study, since this question was specifically amended for the pilot study.
- The analysis of the responses to the third question were as follows:
    - People = 39.16 %
    - Product = 18.33 %
    - Process = 25.00 %
    - Risk = 17.50 %
    - The same ordering with similar ratings was found in the full-scale study.
- The responses to the second question of the pilot study were analyzed and the ratings were ordered. The ordering of the ratings was significantly similar to the one gathered from full-scale study.
- Even though the sample size was quite limited for the pilot study, the analysis of the responses showed that the responses are significantly close to the responses gathered from the study. This may be the result of a good random sampling in the pilot study.
- As a result, the survey instrument and the data collection procedures were found to be sufficient with the necessity of a few modifications and improvements.

D. SURVEY INSTRUMENT

A copy of the survey instrument is provided in Appendix C. The survey instrument was a self-administered questionnaire and contained thirteen questions. The first two questions were needed for the surveying protocol. In the third and fourth questions, necessary background information regarding the respondents was collected.

The fifth, eleventh and twelfth questions were used to identify the importance of project management areas listed previously. The sixth, seventh, eighth, ninth, and tenth questions were used to identify challenging project management areas in software projects. In the online version of the questionnaire, the order of the choices in the fifth question was randomized. Such randomization eliminates bias due to ordering of the choices.

E. TIME FRAME OF THE SURVEY

The timeframe of the survey study is the first quarter of 2007. The survey study took around four months in total, including the pilot study.

F. POPULATION OF THE SURVEY

The survey invitation was distributed to over four-hundred software development practitioners. The exact number of invitations that reached the survey sample population is not known because a portion of the sample population is from Software Development Forum Software Engineering Management Special Interest Group (SDFORUMSEMSIG). An invitation was posted on the special interest group web page, where the number of members was increasing every day. Therefore, at the time of the start of survey study, it is assumed that the posting reached around 170 members of the group via periodic e-mail messages. Two-hundred thirty-four e-mail invitations were sent to software development practitioners. This sample population is gathered from various sources such as known colleagues and references, web search, and authors of books and articles from various journals. The primary qualification criterion was having software project development experience. The selection of the sample population was random.

G. ANALYSIS OF THE RESPONSES TO THE SURVEY

- There were 104 responses to the survey. The response rate is around 26%.
- Two of the 104 indicated that they don’t want to be included in the study, so their responses were left out.
- One of the 104 indicated his lack of experience in the field, and therefore the response was left out.

- Twenty-one of the 104 responses were incomplete, therefore unusable.
- There were around eighty valid responses. Only a few of them were partially usable and the rest were completely usable.

Table 2 provides the number of responses to each question.

Question #	Total Number of Responses	Number of Valid Responses
1	101	101
2	104	102
3	90	78
4	92	78
5	82	78
6	81	78
7	81	78
8	81	78
9	81	78
10	81	78
11	79	75
12	72	70
13	49	47

Table 2. The Number of Responses to Each Question

1. Question 1

This question was used to record the identification code assigned to the prospective survey participant. It was only used in the web-based questionnaire because the commercial tool required such a method. For the paper-based version, it was already coded in the survey instrument packet.

Among 104 survey respondents, 101 of them provided the identification code they were sent. These codes were used as identifiers and to keep track of responses.

2. Question 2

This question asked for consent to participate in the study. While it appeared as a question in the web-based survey instrument, there was a separate section in the paper-based version in which the section wasn't assigned a question number.

Among 104 survey respondents, 102 of them indicated that they were willing to participate in the study by responding with a "Yes" to this question. Two of the survey participants indicated their unwillingness for participation to the study.

3. Question 3

Among 104 survey respondents, ninety of them responded to this question. However, only seventy-eight of the participants who filled out this question participated in the rest of the survey.

This question inquired about past work experiences of the survey participants. The respondents provided their roles in software projects with corresponding experience in years. Figure 21 shows these responses.

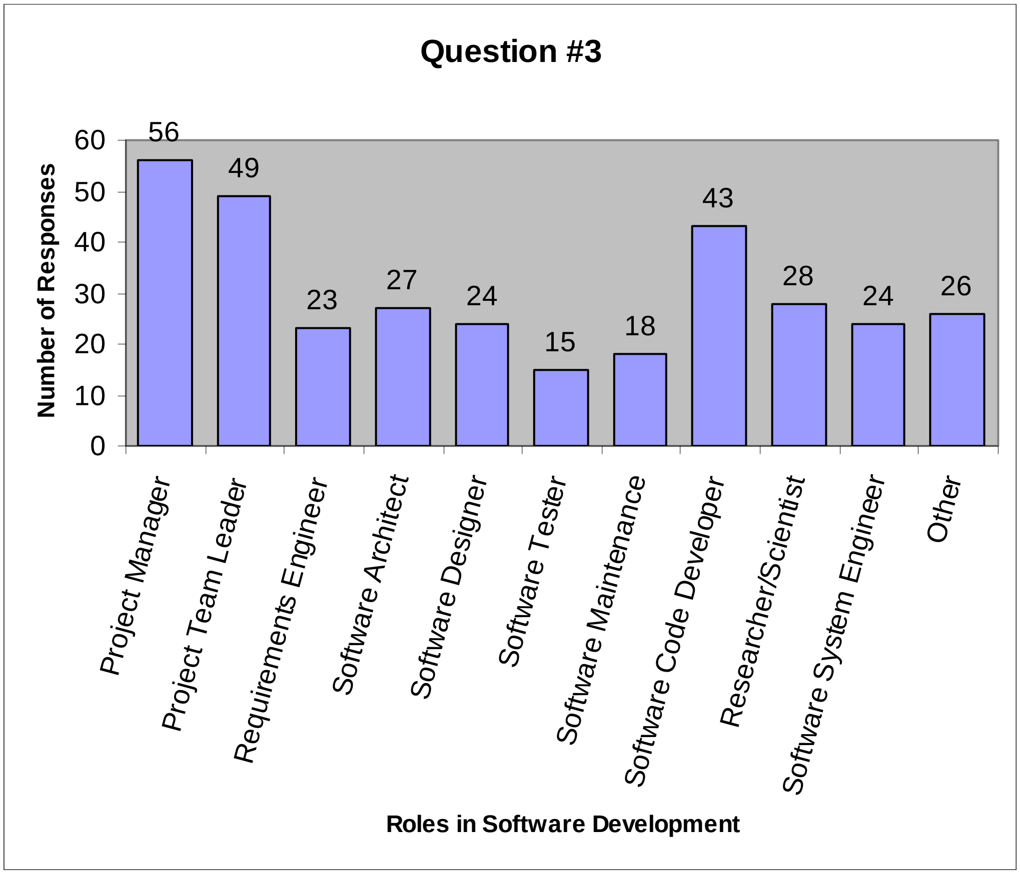

Figure 21. Past Roles of Survey Participants

4. Question 4

Question 4 simply inquired about the project experience of the survey participants. The goal of this question was to gather background data on respondents. Figures 22 and 23 show a graph of the responses by response count and percentage respectively.

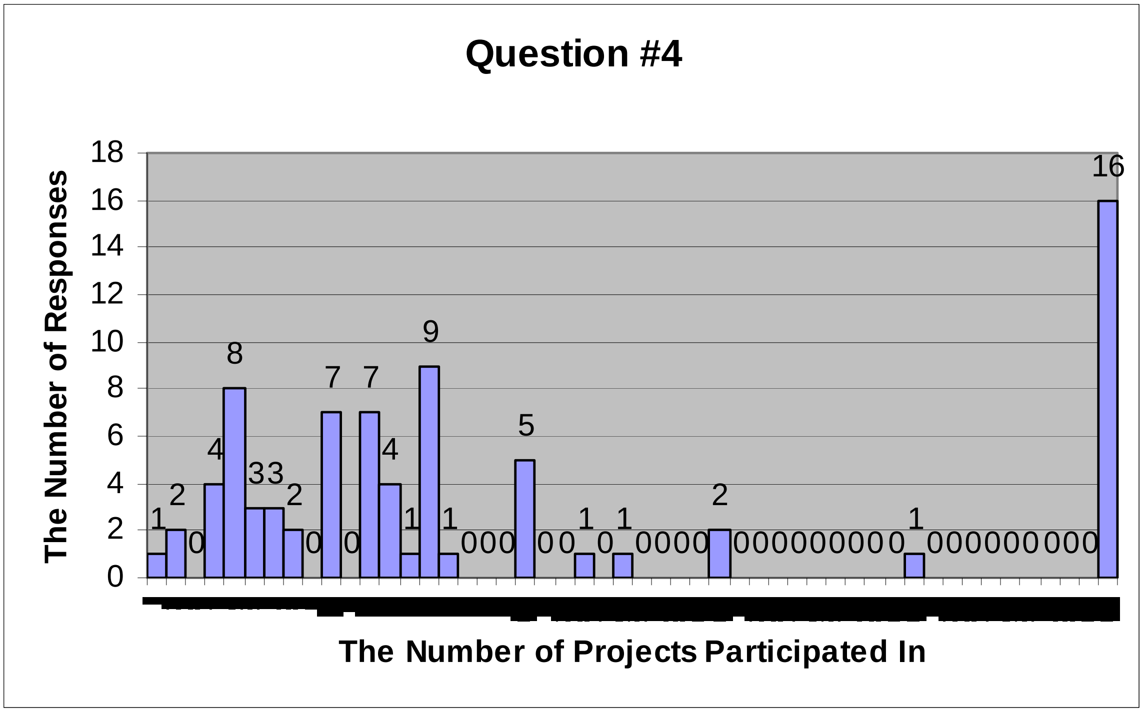

Figure 22. Question #4: The Number of Projects Participated In – The Number of Responses

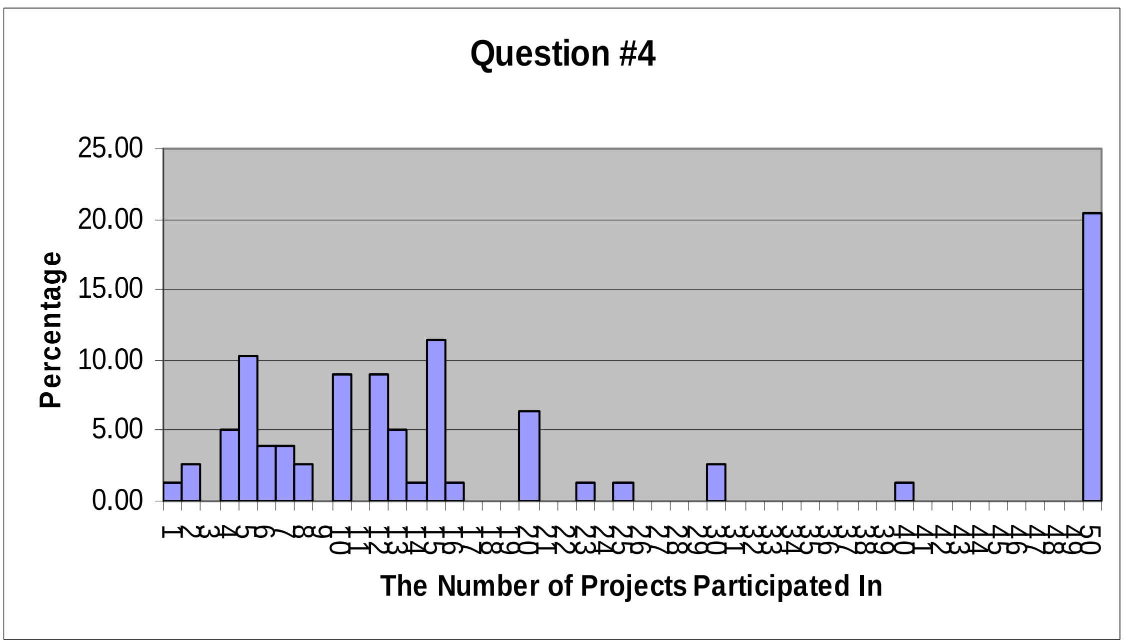

Figure 23. Question #4: The Number of Projects Participated In – Percentage

5. Question 5

This question was one of the key questions of the survey. The goal of this question was to gather the opinions of software development practitioners in regards to the importance of certain aspects of software project management. The respondents were asked to rate the importance of a particular concept, activity or role within software project management. The rating was based on a 7-point Likert scale.

The response count for this question was 78 out of 104 respondents. Two more respondents filled out this question; however, they were eliminated due to lack of experience and not providing adequate background information. For each item in the question, the mean ratings were calculated. Then they are ordered from highest to lowest. Table 3 presents the ordering.

Items in Question #5	Means of Ratings
Communication	5.69
Teamwork	5.41
Leadership	5.32
Requirements Management	5.21
Organizational Commitment	5.10
Project Manager	5.09
Stakeholder Involvement	5.05
Project Monitoring and Control	5.01
Project Planning and Estimation	4.99
Scope Management	4.91
Risk Control	4.86
Staffing and Hiring	4.82
Configuration Management	4.81
Risk Assessment	4.72
Quality Engineering	4.64
Support Activities (Training, tools, etc.)	4.27
Technical Complexity	4.17

Table 3. Software Project Management Areas and Ordering of Ratings

One of the choices in the ratings was “No Opinion.” There were a significantly low number of “No Opinion” responses. This means that almost none of the respondents had difficulty in associating the identified areas with software project management. This is also attributed to the careful design of the question. In total, there were eight “No Opinion” selections. These are respectively one in communication, one in scope management, one in staffing and hiring, two in quality engineering, and three in technical complexity.

There is a significant finding in the analysis of responses to these questions. The survey participants rated six of the software project management areas related to the people dimension among the top seven of the ratings. This is also a confirmation to what will be found later in question 11; the people dimension of software project management rated the highest among other dimensions. Also, process dimension related areas, which is rated the second highest in question 11, are found to be among the second highest ratings. The distinction between product and risk related areas are not as clear as people and process related areas. However, it is also important to note that the ratings are very close to each other between these dimensions. The means of ratings are tabulated according to the dimensions and presented in Table 4.

People Related Areas	**Means of Ratings**
Communication	5.69
Teamwork	5.41
Leadership	5.32
Organizational Commitment	5.10
Project Manager	5.09
Stakeholder Involvement	5.05
Staffing and Hiring	4.82
Process Related Areas	**Means of Ratings**
Requirements Management	5.21
Project Monitoring and Control	5.01

Project Planning and Estimation	4.99
Scope Management	4.91
Support Activities (Training, tools, etc.)	4.27
Product Related Areas	**Means of Ratings**
Configuration Management	4.81
Quality Engineering	4.64
Technical Complexity	4.17
Risk Related Areas	**Means of Ratings**
Risk Control	4.86
Risk Assessment	4.72

Table 4. Means of Ratings

6. Question 6

Question 6 was the first question of the third part of the survey. This and the next four questions constitute the entire third part of the survey study. In this part, the focus is the respondents' most recent project experience. The question simply inquires as to the size of the project in terms of the number of people who worked on the project. Figures 24 and 25 show a bar and pie chart of the responses respectively.

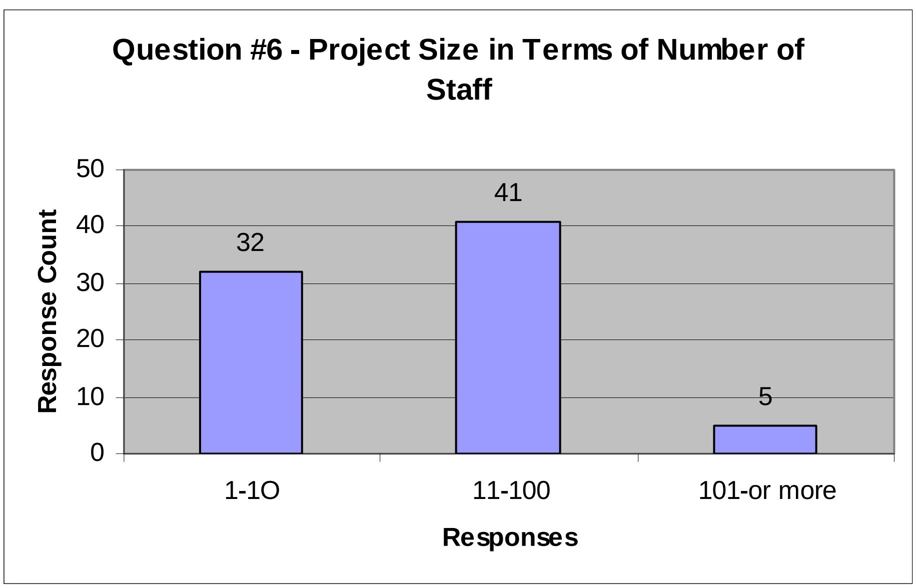

Figure 24. Question #6: Bar Chart of the Responses

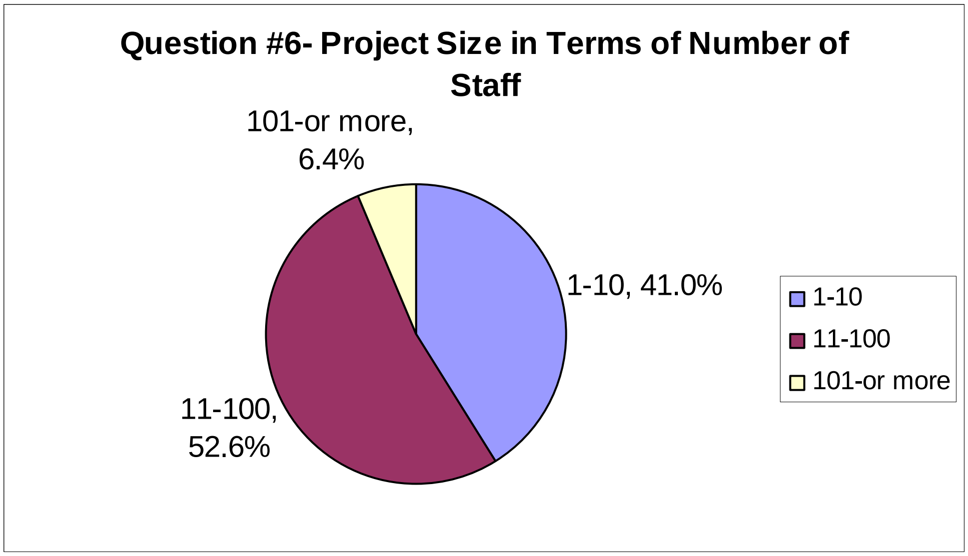

Figure 25. Question #6: Pie Chart of the Responses

7. Question 7

The goal of this question was to obtain project size data in terms of source lines of code (SLOC). The scale is divided into three categories: small (less than 20,000 SLOC), medium (between 20,000 and 2 Millions SLOC), and large (more than 2 Millions SLOC). Even though this categorization makes sense, it is not possible to draw conclusions about large projects due to the limited number of responses. Figures 26 and 27 show a bar and pie chart of the responses respectively.

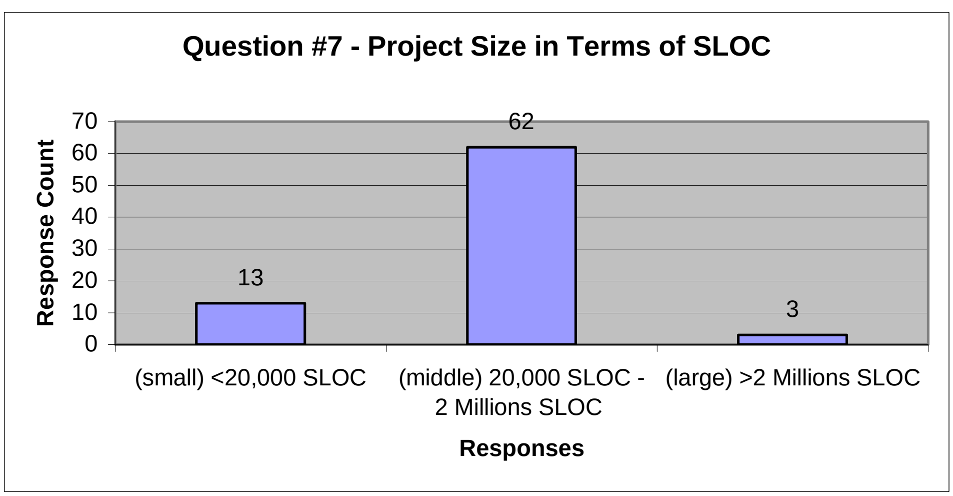

Figure 26. Question #7: Bar Chart of the Responses

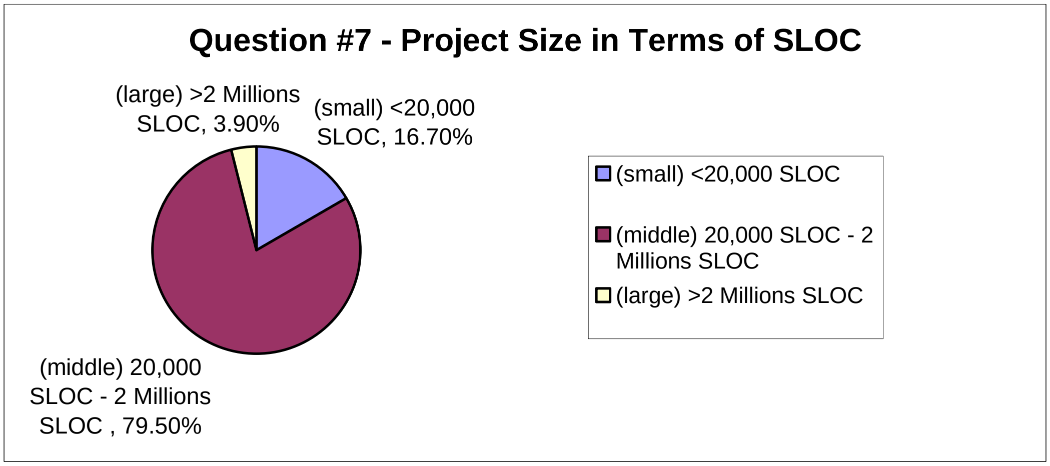

Figure 27. Question #7: Pie Chart of the Responses

8. Question 8

This question sought to identify the organization type in which the project was developed. Figures 28 and 29 show a bar and pie chart of the responses respectively.

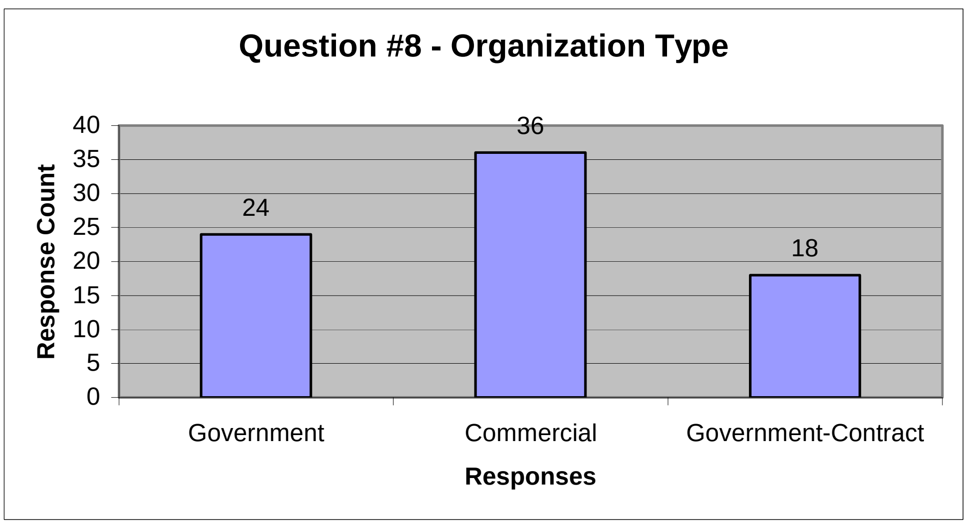

Figure 28. Question #8: Bar Chart of the Responses

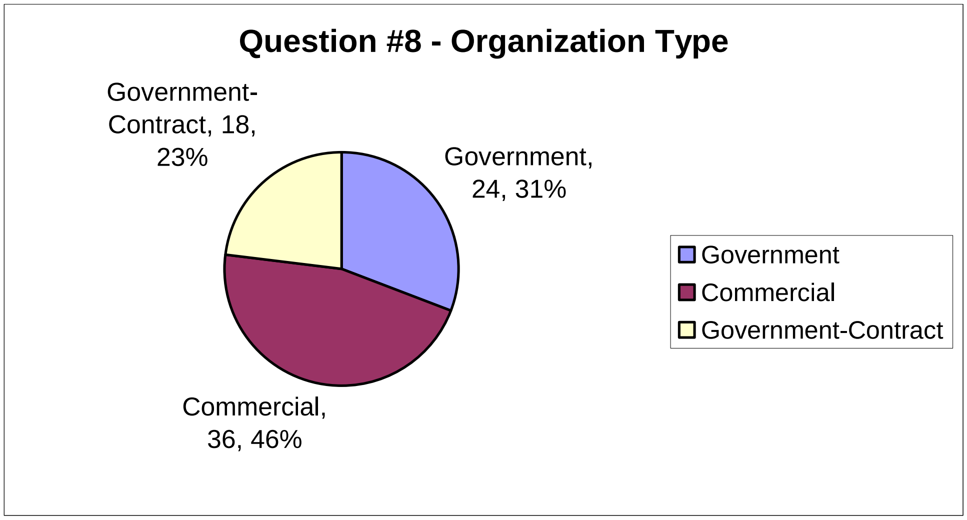

Figure 29. Question #8: Pie Chart of the Responses

9. Question 9

In this question, the application type developed in the project was gathered. There may be many different categorizations of software applications. However, such rigorous categorization is not crucial for the purposes of this study. Some of the applications carry characteristics that fit more than one type, such as real-time embedded system, or web-based database application, etc. They are counted in both categories for analysis purposes.

Type of Application	**Response Count**
Real-Time Application	30
Web-Based Application	12
Database Application	8
Embedded System	7
Various Types of Management Software	5
Distributed System	2

Various Types of Applications (such as expert, testing, financial, business software etc.)	9
Various Types of System Applications (such as drivers, IDE extensions, mainframe application, integration software etc.)	12

Table 5. Question #9 : Number of Responses Categorized Based on Type of Application Developed

10. Question 10

In this question, the survey participants were asked about the management challenges they faced in their last project. The responses gathered via this question are provided in Table 6. The goal was to determine if there is a change in the trend of challenges faced in software projects. The results of this question are similar to previous studies. The conclusion is that there has not been a significant change in the trend of challenges faced during software developments. Therefore, analysis, findings, and furthermore the assumptions regarding software project management from previously related literature is still applicable for this research.

Project Management Area	**Response Percentage**	**Response Count**
Scope management	52.6 %	41
Requirements management	51.3%	40
Project planning & estimation	41.0%	32
Communication	38.5%	30
Staffing and hiring	33.3%	26
Project monitoring & control	28.2%	22
Risk control	26.9%	21
Technical complexity	26.9%	21

Stakeholder involvement	25.6%	20
Leadership	25.6%	20
Configuration management	25.6%	20
Organizational commitment	24.4%	19
Quality engineering	23.1%	18
Teamwork	21.8%	17
Risk assessment	19.2%	15
Project manager	14.1%	11
Other	10.3%	8
Support activities (Training, tools etc.)	9.0%	7
The last project was smooth in every.	2.6%	2

Table 6. Question #10 : Management Challenges in Software Projects

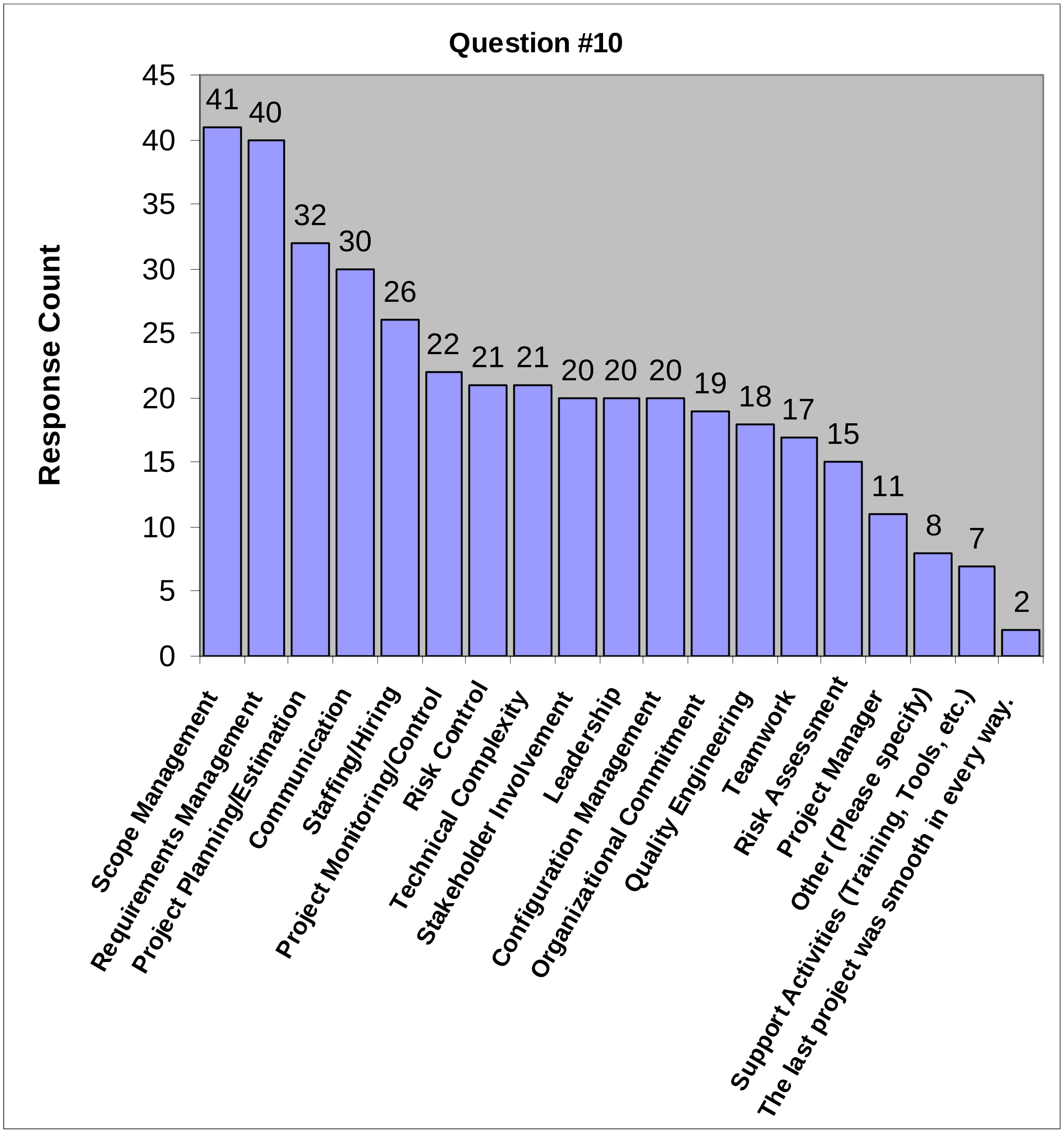

Figure 30. Question #10: Management Challenges in Software Projects

11. Question 11

In the eleventh question of the survey instrument, participants were asked to rate four main project management areas:

1. **People** (Project Manager, Staffing/Hiring, Leadership, Communication, Teamwork, Stakeholder Involvement, Organizational Commitment).

2. **Process** (Project Planning/Estimation, Scope Management, Project Monitoring and Control, Support Activities, Requirements Management).
3. **Product** (Quality Engineering, Technical Complexity, and Configuration Management).
4. **Risk** (Risk Assessment, Risk Control).

The total rating of all four areas should add up to 100%. There were seventy-five usable responses to this question. The mean of the ratings are as follows:

People: 33.00%

Process: 29.07%

Product: 20.40%

Risk: 17.53%

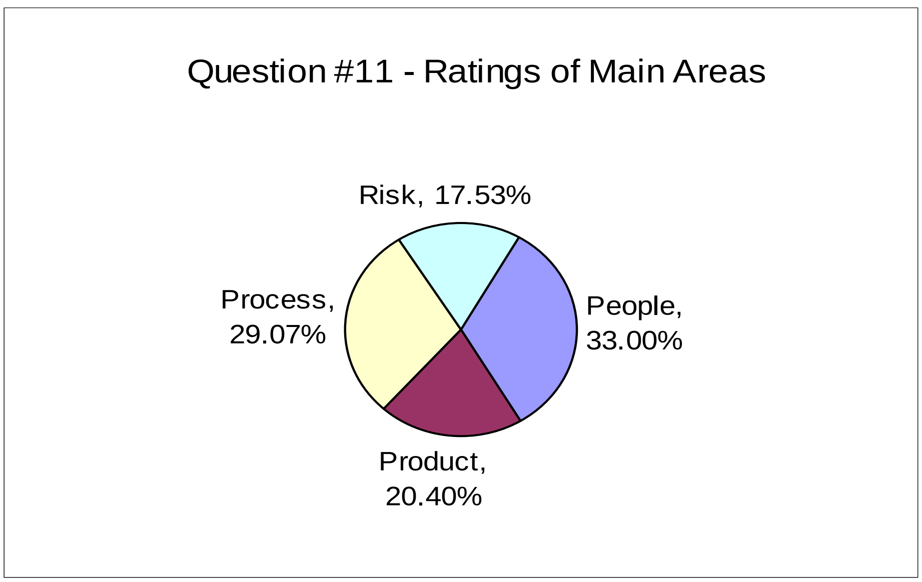

Figure 31. Mean Ratings of Main Project Management Areas

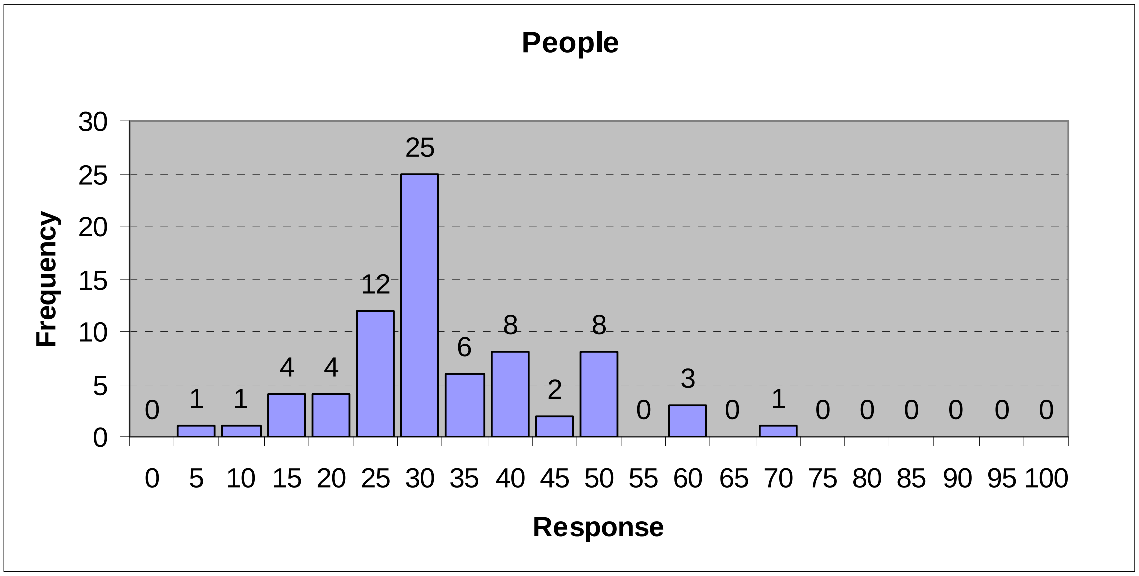

Figure 32. Distribution of Responses in People Area

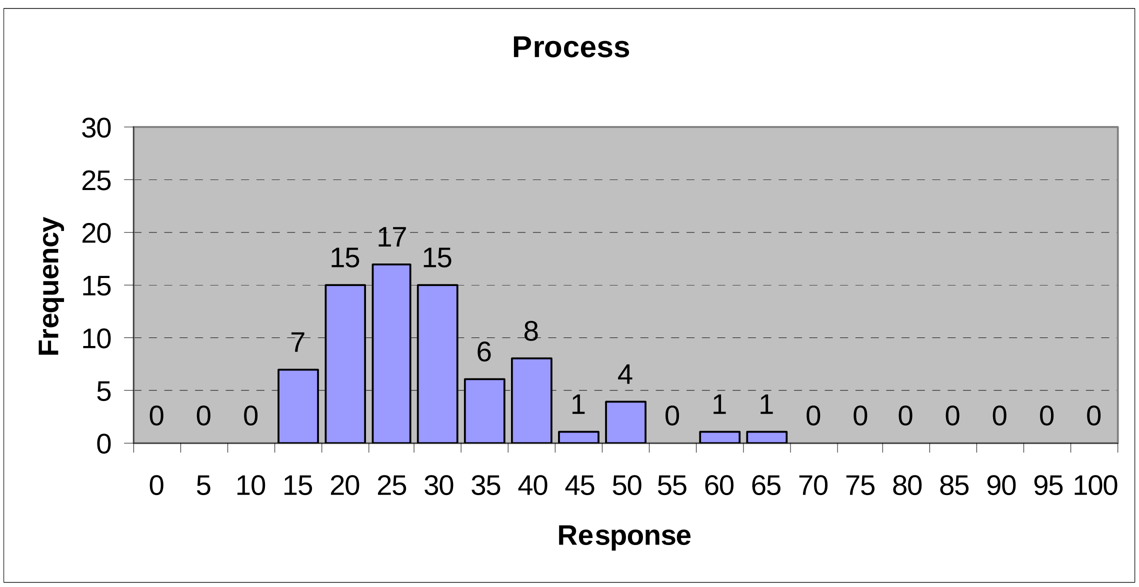

Figure 33. Distribution of Responses in Process Area

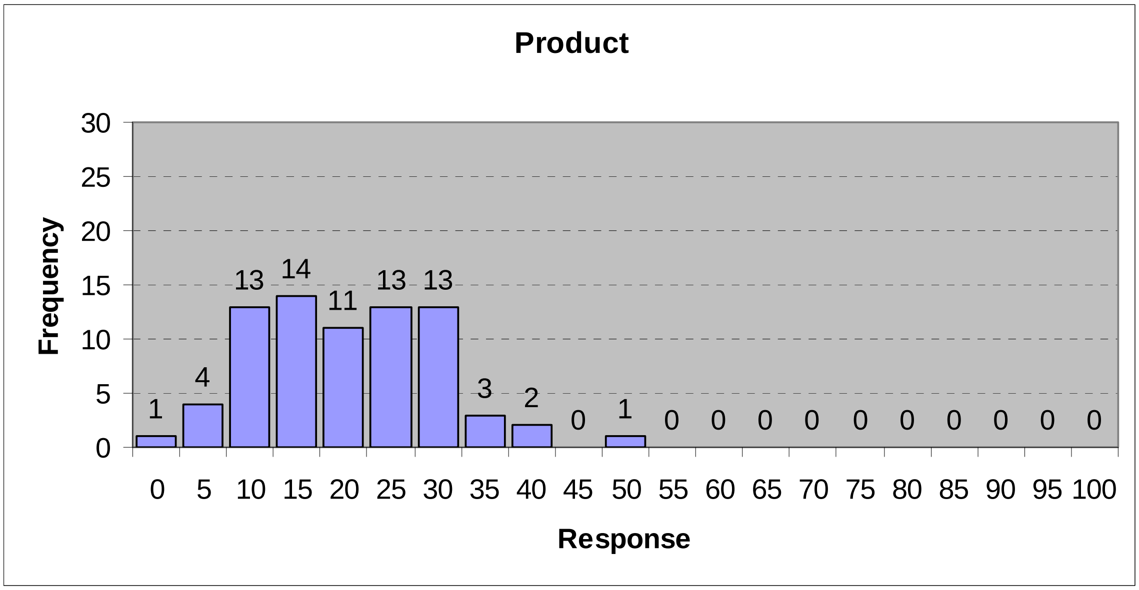

Figure 34. Distribution of Responses in Product Area

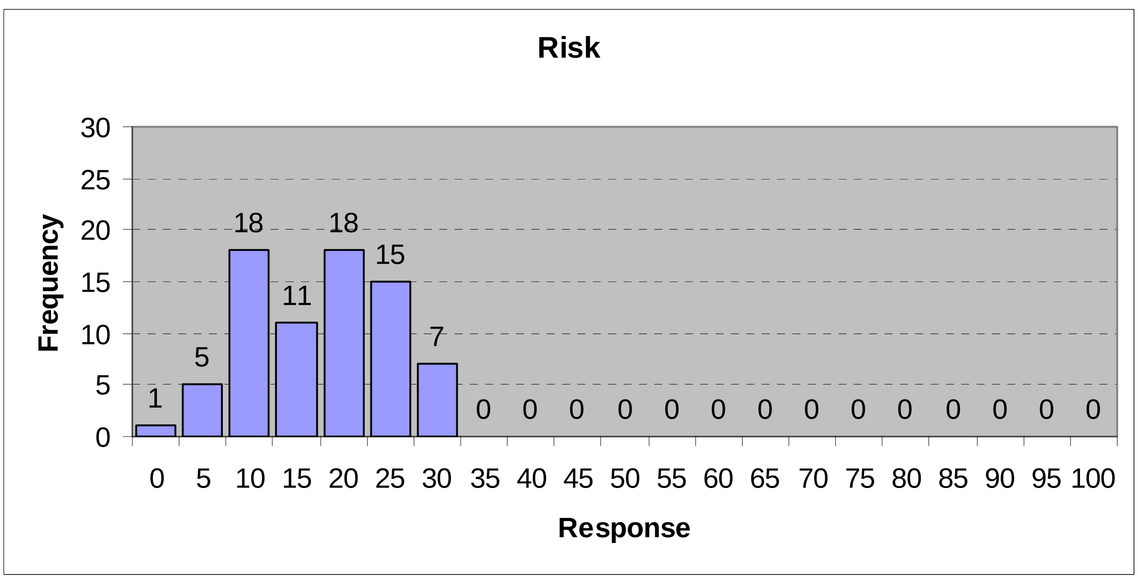

Figure 35. Distribution of Responses in Risk Area

12. Question 12

This question was an open-ended question. The goal of this question was to collect the participants' view on the most important aspects: principles or practices.

There were seventy responses out of 104. The responses are categorized using a coding method referred in Seaman (1999). Tables 7 and 8 present the classification of responses to software project management (SPM) areas and corresponding frequencies. Table 9 provides other responses left out in the categorization.

Project Management Area	**Frequency**
Project Planning and Estimation	27
Communication	24
Requirements Management	24
Teamwork	20
Stakeholder Involvement	19
Project Monitoring and Control	18
Leadership	16
Other	16
Scope Management	14
Organizational Commitment	13
Staffing and Hiring	10
Project Manager	8
Quality Engineering	7
Risk Control	6
Configuration Management	6
Risk Assessment	6
Support Activities (Training, tools, etc.)	4
Technical Complexity	0

Table 7. Classification of Responses to Question #12 – Sorted from Highest Frequency to Lowest

People Related Areas	Frequency
Communication	24
Teamwork	20
Leadership	16
Organizational Commitment	13
Project Manager	8
Stakeholder Involvement	19
Staffing and Hiring	10
Process Related Areas	**Frequency**
Requirements Management	24
Project Monitoring and Control	18
Project Planning and Estimation	27
Scope Management	14
Support Activities (Training, tools, etc.)	4
Product Related Areas	**Frequency**
Configuration Management	6
Quality Engineering	7
Technical Complexity	0
Risk Related Areas	**Frequency**
Risk Control	6
Risk Assessment	6

Table 8. Classification of Responses to Question #12 - Rearranged with Respect to Main Project Management Areas

Other Responses	Frequency
Need balance in areas	2
Need attention to design	2
Metrics and measurement is important.	2
Sponsorship is important.	1
Testing is important.	1
Being open to various technical solutions	1
Technical part is easy.	1
Follow CMMI	1
Managing heroes at work	1
Consideration of technical aspects	1
Lessons learned	1
Different organizations require focus on different areas.	1
Consideration of systems architecture and systems approach	1

Table 9. Other Responses to Question #12

A quick overview of the responses will yield that quite a significant portion of the responses were covered with software project management areas inquired in question 5. This is a strong indication that the proposed framework is valid and provides good coverage.

It is observed that there are some minor differences with the ordering of ratings derived from responses to question 5 and the ordering of frequencies derived from the categorization of responses to this question. There may be a few reasons for these differences. First, the coding technique, reducing similar issues to one category, inevitably causes some data loss. Second, the factor of unresponsive participants may have played a role in the differences. Not all the participants who responded to question 5 responded to this question. Also, the ratings gathered from question 5 may include insignificant statistical analysis errors that lead to differences. However, the obvious overlap in responses to both questions is significant for this research. It validates the framework. The responses to both questions help assess the internal validity of the survey study.

13. Question 13

This question was an open-ended question. The goal of this question was to collect the survey participants' feedback on the issues that are mentioned in the survey instrument. Because of the variance in the responses, a coding method was not successfully applied.

- There were specific responses indicating that the survey instrument has good coverage.
- There were quite a number of responses reemphasizing some of the areas already mentioned in the survey. They may be listed as politics, teamwork, human side of software development, importance of leadership, importance of risk management, and project championship (such concept is implicitly covered in the area of stakeholder management such as project champion is a stakeholder).
- There were some responses indicating the importance of measurement and process improvement activities in software projects.
- In a few responses, it is mentioned that it is difficult to separate different aspects of project management listed in the survey. Most areas depend on each other.
- Two of the respondents indicated the importance of security considerations during project development such as software assurance and information security.

- In a few responses, the importance of systems thinking is emphasized. The respondents indicated that the software component is part of a system and eventually the software development effort has to integrate to a bigger system development effort.
- In a few responses, the respondents suggested investigating the link between different software life cycle development approaches and the project management areas covered in the survey study.
- Others respondents indicated the importance of requirements activities, creating and visiting lessons learned documents, the use of tools, the negative effects of task switching and multitasking, the importance of project effort estimation, project monitoring and control, iterative development, reuse, significance of having adequate testing facilities, project monitoring, the importance of developer feedback in project planning efforts, protecting the project team from counterproductive external interference, and system safety issues.

H. VALIDITY OF THE SURVEY STUDY

The validity of the study is discussed here. This study was conducted as a descriptive study. In descriptive studies, the researcher merely observes the events and there is no intervention. Descriptive studies are observational in nature, and hence they are also called observational studies. In this study, we asked the survey respondents' view on identified project management areas. Project management challenges they have faced in their last projects were also gathered. We did not intervene in their projects and therefore affect their views. In most research experiments, researchers apply a controlled event, method or procedure to understand the relations between dependent and independent variables. Thus, there is an intervention by the researcher. This intervention increases the complexity of the study, which in turn raises many validity concerns. As a result, the researchers must be careful in these experiments. Most validity concerns do not apply to descriptive studies. For example, internal validity is only relevant when the researchers try to establish casual relations. Therefore, here only external validity related issues are briefly addressed.

External validity refers to the validity with which a casual relationship can be generalized across persons, settings, and times (Emory, 1980).

The survey instrument was distributed to the practitioners from different geographical regions. These regions include North America, South America, Europe and Asia. There were no responses from Australia even though survey invitations were sent to practitioners located in this region. It was observed that there are no significant differences among practitioner views from different regions of the world.

The survey study was conducted in the first quarter of 2007. There are other survey studies reported in the literature. The survey results are similar to the other survey study results conducted earlier.

The survey participants may be divided into two categories based on the roles they had in software projects. The first category is project managers, while the second category is developers. The responses from the practitioners in these two categories are similar, especially the responses to question 11. Overall, there were no significant differences.

The sample size in this study can be categorized as medium compared to other survey studies conducted on the topic. Random sampling was utilized. When the sampling method is appropriate, even small samples will provide reliable results. The responses were continuously monitored during the study. The responses to the question 11 did not significantly differ when the sample size was 5, 10, 20, 50 and 78. This is attributed to the quality of the sampling.

I. CONCLUSION

The objectives of this survey study were to identify (i) the importance of various project management areas and (ii) project management challenges in software projects. For the purposes of this research, the survey study reached its goals. The importance of project management areas in software projects has successfully been identified. This identification led to the conclusion that the software project management framework proposed in the previous section is valid. The results of this survey study guided the development of the software project management evaluation instrument and evaluation model.

The survey results indicate that the differences in the importance ratings of the main areas (people, process, product and risk) are distinct. However, that is not the case for the project management areas listed in question 5. The survey results showed that even though it is possible to rank project management areas based on their importance, the differences between the ratings of project management areas are small.

VII. SOFTWARE PROJECT MANAGEMENT EVALUATION INSTRUMENT (SPMEI) AND SOFTWARE PROJECT MANAGEMENT EVALUATION MODEL (SPMEM)

A. INTRODUCTION

A theory of project management presented in this research and the 3PR framework for software project management guided the development of the instrument and the evaluation model. The instrument and the evaluation model design was a major task in this research. While half of the research effort was focused on building the necessary theoretical foundation for this research, the other half of the effort was focused on the development of the instrument, the development of the evaluation model and conducting survey studies on software projects to investigate the use and applicability of the metric. It took more than fifteen months to develop the SPMEI and the evaluation model. The main goal of SPMEI is to gather data on what happened during the project development. The instrument is responded to as such.

B. SOFTWARE PROJECT MANAGEMENT EVALUATION INSTRUMENT (SPMEI)

1. Basic Characteristics of the Instrument

Basic characteristics of software project management evaluation instrument (SPMEI) are provided below in Table 10.

Name of the Instrument	Software project management evaluation instrument
Acronym	SPMEI (The first letters of the words in the name)
Main Use of Instrument	To get data on what happened during the project development
Type of Instrument	Self-administered Questionnaire
Who may use it?	- Executive managers overseeing projects - Project managers

	- Project technical managers - Process improvement or metrics experts/engineers - Project team leaders - Project team members who has extensive knowledge in all aspects of the project
Applicability	- Software development projects - Software-intensive development projects - Applicable to any project organization size - Applicable with any software development life-cycle model - Applicable to project phases after some requirements development activities are conducted
Scope	Project start to project delivery (Project start is the time when the business decision is made)
Number of Sections	15
Number of Questions	330-335
Type of Questions	- Multiple choice - Statements with a psychometric scale (5-point Likert item based on agreement to a statement) - All questions are closed form
Time to complete	2-3 hours

Table 10. Basic Characteristics of SPMEI

SPMEI is designed as a self-administered questionnaire consisting of fifteen sections. Each section corresponds to a project management area in the 3PR framework with the same name. While collecting data for survey studies in this research, another section was included to collect basic data about the projects such as the cost of the project, the number of people involved in the project, the length of the project, etc. In Appendix F, a copy of the instrument is provided. Each question in SPMEI inquires about the effectiveness of an activity or an entity related to project management.

SPMEI includes 330 to 335 questions. Depending on the characteristics of the project, the participant responds to the appropriate questions. Table 11 presents the number of questions in each section of SPMEI. Table 12 provides the number of questions in SPMEI categorized by the corresponding main area.

Project Management Area	**Number of**
Communication	23
Teamwork	30
Leadership	17
Organizational Commitment	26
Project Manager	27
Stakeholder Involvement (Market or Contract)	12 or 16
Staffing and Hiring	29
Requirements Management	27
Project Monitoring and Control	19
Project Planning and Estimation	35
Scope Management	16
Configuration Management	13
Quality Engineering	20
Risk Control	17
Risk Assessment (With Subcontracting or Without Subcontracting)	20 or 19
Total	330-335

Table 11. Number of Questions in SPMEI

	Number of Questions
People Area (Communication, Teamwork, Leadership, Organizational Commitment, Project Manager, Stakeholder Involvement, Staffing and Hiring)	164-168
Process Area (Requirements Management, Project Planning and Estimation, Project Monitoring and Control, Scope Management)	97
Product Area (Configuration Management, Quality Engineering)	33
Risk Area (Risk Assessment, Risk Control)	36-37
Total	330-335

Table 12. Number of Questions in SPMEI Categorized with Respect to the Main Area

2. Basic Design Characteristics of the Instrument

a. SPMEI is a Self-administered Questionnaire

The software project management evaluation instrument (SPMEI) is designed to be used as a project management tool for software managers. It is not a research instrument for a specific research goal, but an actual project management tool. The selection of a self-administered tool is driven by this requirement. SPMEI is designed in such a way that the software managers should be able to use it without difficulty. The pilot studies conducted significantly improved the wording and the usability of the instrument. During survey studies, it was observed that none of the participants had difficulty in understanding and using this instrument. In addition, there was another significant advantage for making the instrument a self-administered questionnaire. This was an advantage for data collection during survey studies. Brace (2004) states:

> Self-completion methods, whether paper based or electronic, can benefit from the complete absence of an interviewer from the process. This removes a major source of potential bias in the responses, and makes it easier for respondents to be honest about sensitive subjects.

In some cases, the study participants may feel an urge to impress the interviewer. As Brace pointed out, this may be a major source of bias.

The reasons for the selection of a questionnaire-based approach were provided previously in Chapter III.

b. SPEMI is Composed of Sections

This type of instrument design is specifically chosen for two purposes. First, it makes the SPMEI a modular instrument. Hence, it is possible to replace a section with a better one in future studies. In addition, a section or a collection of sections may be used in other related studies. However, researchers should be very careful. Their research goals should align with the possible uses of the sections.

Second, it provides a context for the questions. Providing a context for statements and questions decreases the probability of confusion while responding to them. Such a design reduces the necessary wording, enabling faster completion time.

c. SPMEI is User-friendly

The questions in SPMEI are not open-ended but closed-form. The respondents are only supposed to check boxes where appropriate. Such designs are user-friendly by nature and significantly reduce the response time for each question. Closed questions include pre-coded responses. Since the responses are pre-coded, it is easier to compare responses. SPMEI is designed to be used in a measurement activity. By nature, such activity includes comparison based on responses in this type of research. A questionnaire that measures behavior is likely to consist of mostly closed questions

(Brace, 2004). Inquiring about the project on the identified activities and entities related to project management may be considered as a form of measuring project behavior. Brace (2004) states that:

> Respondents are able to respond relatively easily to behavioral questions, limited by only their memory of events, the amount of effort they are prepared to give to answering the questions and the degree to which they are prepared to be truthful.

Thus, closed questions are preferred in the design of the instrument.

d. SPMEI is Comprehensive

Software project management is complex by nature (Larry Bernstein, personal communication, August 20, 2008). Management of a software project involves many activities and entities. To evaluate the project management effectiveness successfully, it is imperative to inquire about project management of the project in many aspects. Therefore, SPMEI had to be a comprehensive tool. It includes fifteen project management areas and over 330 questions. Naturally, the instrument is not short. In research designs, short and focused instruments are better. However, as mentioned previously, this instrument is mainly designed to be a project management tool rather than be a research instrument.

3. The Instrument Design Process

An iterative process was used in the design of the instrument. There have been at least three major iterations during the design. There were also several minor iterations to improve specific sections. The major steps in the instrument design are listed here in order to guide other researchers in their future studies.

a. Step 1: Search for the Sources of Information

In this step, the sources of information that can be used in the design of the instrument have been identified. Many sources of information were sought. These sources include software practitioners' interviews, subject books, related standards, best and worst practice guidelines, journal publications, conference publications, professional seminars, and other relevant written or verbal material that can be found on the World Wide Web (WWW). Another source of information was personal correspondence with some of the survey study participants. Most of these sources are referenced throughout the dissertation.

This search for information was conducted based on two main themes. The first theme was software project management knowledge areas and practices. Most of the relevant information was found in the project management and software engineering literature as well as via interviews with practitioners. However, especially for the human side of software project management, many sources were found in other disciplines such as organizational management, sociology, psychology, etc. The second main theme was how to measure or evaluate the effectiveness of these project management knowledge areas and practices. It is important to note that, especially for the guidance of other researchers, a big portion of the information in this theme did not come from project management or software engineering related literature, but from literature in other disciplines. These other disciplines include sociology, organizational management, organizational behavior, psychology, engineering management, human resource management, sales management and other related disciplines.

b. Step 2: Categorization of Information

All these sources identified in the previous step were carefully reviewed. The relevant information from these sources was extracted for use in the design of the instrument. Then the information was categorized based on relevance. A separate folder was created for each category to place the relevant information in one place.

These sources were also rated based on their relevance and applicability. This was important because most of the sources or studies were only applicable to some extent. In social sciences, it is possible to identify a few recognized questionnaires that are commonly used in studies. For instance, one such example is the organizational commitment questionnaire (OCQ) developed by Porter et al. (1974). This recognized questionnaire was only applicable to a very limited extent. However, there was value in reviewing such a questionnaire. The development of a few questions and statements in the instrument was influenced by this questionnaire.

On the other hand, there were studies which influenced the development of the instrument to a great extent. One such example is CMMI v1.1 and v1.2. A significant number of questions in some of the project management areas were guided by CMMI.

c. Step 3: Detailed Analysis of Information Gathered

At the end of the first two steps in the design of the instrument, a significant amount of information was gathered. Among the information gathered, naturally there was redundancy. This redundancy, to a certain extent, was considered as an indication of the importance of a certain area, activity or entity. There were also pieces of information which only existed in a few sources. These were also carefully reviewed for inclusion in the design of the instrument. Even though some of this information was referenced in a few sources or the focus of a few studies, valuable insight was attained during the review. At the end of this step, a list of activities and entities was generated for each project management area. These lists contained activities and entities found related to software project management in a short, bulleted, categorized form.

d. Step 4: Development of Questions

The result of the previous steps was the creation of systematic lists for each project management area in the 3PR framework. For each item in these lists, a question was developed.

Careful consideration for the context was significant in the design of the instrument. For example, each section in the instrument corresponds to a project management area from the 3PR framework. This provided a context for the questions and reduced the necessary number of words used in wording the questions.

The questions were worded very carefully. The wording of the questions was kept as simple and straightforward as possible. The wording was very important since the reliability of the responses was very much tied to the quality of these questions.

Questions inquiring about similar issues were closely located within the sections in the instrument. Such localization reduced the amount of context switching required by the respondents while completing the questionnaire-based instrument.

The chosen question types were closed questions and statements with a Likert scale. These types enabled faster response time.

There were also other factors considered during the development of the questions. There are many specific subject books focused on guidelines for the development of questionnaires. These books were consulted extensively whenever necessary. A good one on the topic was authored by Ian Brace (2004) and it is titled "Questionnaire Design."

e. Step 5: Interface Design

The interface design of the instrument was an important step, thus it is specifically mentioned as a major step. The first versions of the questionnaire-based instrument were more than sixty pages. This length is intimidating for many potential study participants. This length was reduced during major iterations.

Another important issue was the selection of a specific interface for each question. A number of different interfaces were tried. After the pilot studies on the instrument, the latest version of the instrument was finalized.

f. Step 6: Testing and Redesign

Pilot studies were conducted to test the instrument. After these pilot studies were concluded, it was understood that the content of the instrument was satisfactory. Only minor changes were found to be required. On the other hand, the interface was improved significantly. In the pilot studies, the study participants were carefully observed for their reactions to the instrument. The interface was an important factor that required special attention in order to achieve better results. The interface took its final form after the pilot studies.

4. Question Types in SPMEI

In SPMEI, there are three types of questions. In the first type, the respondent is requested to select the statement or statements that apply to the project. This question type is extensively used in the design of SPMEI. An example of this type of question is provided below.

RC6. Check the statement/s that applies to the project. (Check only one.)
- ☐ Adequate slack time is planned in the schedule for consequences due to risks.
- ☐ There is not any slack time planned for consequences due to risks.
- ☐ Not enough slack time is planned in the schedule for consequences due to risks.

In the second question type, the respondent is asked about an aspect of the project management. A question taken from the communication section of the instrument is presented below.

C2. Who are generally present in the project status meetings? (Check all that apply.)
- ☐ Project manager
- ☐ Project team leaders
- ☐ Project team members
- ☐ Customer/s and/or user representatives
- ☐ Various stakeholders or stakeholder representatives
- ☐ Executive management / Project sponsor

The third type of question uses a statement associated with a Likert scale, which is a psychometric scale that is commonly used in questionnaires. The Likert scale is frequently known as an "agree-disagree" scale (Brace, 2004). This technique is easy to distribute in self-administered questionnaires. Often, responses using the Likert scale are associated with scores. These scores may be from 1 to 5, negative or positive, or -2 to +2 (Brace, 2004). Brace states that "as these are interval data, means and standard deviations can be calculated for each statement." An example to this type of question is presented below.

RM9	**Automated requirements development and management tools are used.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

Project management efforts naturally employ a set of best, worst and common practices. Jones (2004) analyzed about 250 large software projects for software project management practices. In his analysis, he identified a set of factors associated with successful and failed projects. One of the factors is change control management. He identified that while effective change control management is a factor in achieving success, ineffective change control management is a factor in failure. In this particular example, effective change control management may be considered as an example for a best practice associated with success. Ineffective change control management may be considered as an example for a worst practice associated with failure. For example, SPMEI investigates the project for the existence and quality of change control management related practices in its various sections such as scope management and requirements management. Conducting project status meetings may be considered as an example of common practice. Today, in most projects, project status meetings are held with the participation of various people at various times. With broad involvement of necessary stakeholders, the items discussed in these meetings determine the effectiveness or the quality of project status meetings. SPMEI also investigates such practices.

Project management best, worst and common practices result in a set of activities and entities. SPMEI investigates the effectiveness of activities and entities related to project management in four different approaches. Examples will be provided for each approach.

a. Approach 1: The Existence of an Activity

In this approach, the existence of a certain activity is sought. This activity is generally the result of a best practice. The example below is taken from the configuration management section of SPMEI.

CM3. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ Baselines and configuration items are identified at the beginning of the project and updated as necessary.
☐ The owner or responsible staff is identified for each configuration item.
☐ Every configuration item has a unique identifier.
☐ Important characteristics for each configuration item are identified such as author, type, date, version number etc.
☐ None

In the second statement above, SPMEI gathers project data whether the owner or responsible staff is identified for each configuration item or not. This particular activity is a practice from Capability Maturity Model Integration 1.1 (CMMI v1.1). This practice is listed as a subpractice under the identify configuration items specific practice of configuration management process area in CMMI v1.1 (CMMI v1.1 Continuous Presentation, page 504).

b. Approach 2: The Existence of an Entity

In this approach, the existence of a certain entity is sought. During project development, the best practices result in certain entities. For example, an effective configuration management requires the development of configuration management document, the establishment of a configuration control board, and generation of a configuration item list. SPMEI searches the existence of these entities as follows in the example below.

CM2. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ There is a configuration management document.
☐ There is a configuration or change control board, committee or team.
☐ There is a configuration items list.
☐ None

c. Approach 3: How Well an Activity is Conducted

In this approach, SPMEI gathers data on the rigor or the quality of certain activities. Jones (1998) emphasizes the importance of automation in project management by stating, "…*the lagging projects tend to be essentially manual for most project management functions. The leading projects deploy a notable quantity of quality control* *and project management automation.*" In the example below, the rigor in using the automating of project management tools in planning the project is inquired.

PPE 22	**Various project management tools are used in planning the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

d. *Approach 4: The Rigor or the Quality in the Existence of an Entity*

In this final approach, SPMEI gathers data on the rigor or the quality of certain entities. Having more experienced project team members than inexperienced project team members is an obvious advantage for project organizations. This aspect is inquired in SPMEI as follows in the example below.

T14	**There are more experienced team members than the inexperienced team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

5. Optional Questions in SPMEI

In SPMEI, some of the questions are only applicable when certain conditions exist in the project. These questions and the conditions are presented in Table 13.

Question Identifier	Condition
L17	When the team mostly consists of inexperienced staff
L18	When the team mostly consists of experienced staff
SI11-SI12	When the project is developed for the market without a specific contract
SI13-SI18	When the project is developed under a contract with a customer

RA20	When subcontracting is utilized during the project

Table 13. Optional Questions in SPMEI Based on Certain Conditions

6. Other Significant Characteristics of the Instrument

Other notable characteristics of the SPMEI are highlighted in the sections below.

The instrument is only applicable to the projects that have conducted within a certain period. Many scholars would agree that the concepts of projects and management of projects date back to the early days of civilization. “Projects have been the part of human scene since civilization started” (Lock, 1987).

> Managing projects is one of the oldest and most respected accomplishments of mankind. We stand in awe of the achievements of the builders of the pyramids, the architects of cities, the masons and craftsmen of great cathedrals and mosques; of the might and labor behind the Great Wall of China and other wonders of the world (Morris, 1994).

Some of the principles, activities and concepts that are used in those early days of the civilization exist today even though the application of them may have changed. For example, Cooke-Davies (2001) states, “the subdivision of manpower into smaller units for the purposes of oversight appears to have been well established in the ancient world. The first recorded reference to a supervisor dates from 1750 B.C.” The idea of subcontracting again dates back to the early days, such as the Colosseum being built by four contractors (Morris, 1994). “Modern project management is built on foundations nearly as old as civilization itself” (Cooke-Davies, 2001).

Cooke-Davies divides the history of project management into four eras:

1. Projects in a pre- and proto-capitalist society (before 1850).
2. The era of classic capitalism: project management from 1850 to 1950.
3. The era of “managerial capitalism”: project management from 1950 to the mid-1980s.
4. The era of “intellectual capitalism”: project management since the mid-1980s.

In each of these eras, a certain social environment and emergent concepts dominate that era. Table 14 provides these eras in a tabular format.

Social Environment	*Emergent concepts*
1. Projects in a pre- and proto-capitalist society. (before c.1850).	a) Mobilisation and management hierarchy. b) Client-contractor relationship
2. Projects and project management in a world dominated economically by "classic capitalism". (c.1850 to c.1950) Evolution of formal techniques.	c) Management disciplines d) Project planning techniques. e) Logistics planning. f) Work breakdown structure. g) Time-driven research.
3. Projects and project management during the era of "managerial capitalism". (c.1950 to mid-1980s) Birth of a profession. Widespread adoption of project management by the engineering and construction industries in the 1970s. Early application of project management techniques in other industries such as IT and Entertainment. The expansion of project management from "traditional" environments into strategic business management and IT during the 1980s.	h) Systems management. i) Scheduling techniques. j) Procurement management. k) Performance measurement (Earned Value Analysis). l) Programme management. m) Project management professional societies. n) Project matrix organisations. o) Refinement of defence development life-cycles. p) Widespread acceptance of project management practices. q) New forms of contract - BOO (T). r) Macro-technology programmes. s) Application of project management to IT projects. t) Systems engineering and software project management.
4. Projects and project management during an age of "intellectual capitalism". (mid-1980s and beyond). Project management as a "core business discipline": The current trend towards the "project-based organisation" and "management by projects".	u) Business process re-engineering. v) Project-based organisations. w) New contract philosophies (Partnering, Alliancing). x) Attempts to apply "Benchmarking" techniques to projects

Table 14. Origin of Elements Present in Current Project Management Practice [From Cooke-Davies, 2001)]

In the era of managerial capitalism from 1950 to mid 1980s, systems engineering and software project management are among the emergent concepts. During this era, there were significant advancements in the computing as well as project management fields. For example, 1969 is the year that the Project Management Institute (PMI) was formed. In 1981, PMI started the effort for the first edition of "A Guide to the Project Management Body of Knowledge," (PMBOK). This is the result of building a knowledge base in this era. Again in this era, the number of software-based system projects exponentially increased. Towards the end of this era, the experiences gained from managing software projects were to take their place in the project management literature. A good example is the work “The Mythical Man-Month” by Frederick Brooks in 1975 (Brooks, 1975). Another example is the work “Software Engineering Economics” by Barry Boehm in 1981 (Boehm, 1981). The principles stated in these and other similar works by various scholars guided many software projects in the era of intellectual capitalism. In the last era of project management, management of software projects has become more systematic.

The development of the SPMEI was implicitly guided by two sets of principles. The first set of these may be considered as time-independent principles. This is because these are the principles that have existed since the early days of civilization and are still applicable today. Naturally, these principles guided the development of a certain portion of questions in the instrument. The second set of principles may be considered as time-dependent principles. These principles are derived by the needs of the current social environment. Therefore, their applicability is limited within a specific period. A big portion of the instrument is developed by the guidance of these time-dependent principles. As a result, the SPMEI is only applicable to those projects that are conducted in the last era of project management, which is described as intellectual capitalism by Terence J. Cooke Davies.

The author has conducted two test cases that support the argument. One of the test cases is conducted on a software project that took place in 1974. The test case shows that the SPMEI and the evaluation model are not applicable to this project. The other test case is conducted on a software project that took place in 1984. This test case shows that the instrument and the evaluation model are applicable to this project. Therefore, it is possible to assume that the SPMEI and the evaluation model are applicable to the projects that were conducted after the 1970s. Another question that is of interest is the time the instrument becomes inapplicable. This is a hard question to answer since it requires a good prediction of future advancements in the software project management field. Unless there are breakthroughs, with the observed rate of advancements in software engineering and project management fields, it is possible to assume the SPMEI and the evaluation model will be applicable to software projects that will be conducted in the next 15-20 years. This is based on the past progression in the knowledge base of project management in the era of intellectual capitalism.

The existence of these two sets of principles guiding the development of the instrument has two implications. First, because of the time-independent principles, a certain portion of the SPMEI may be reused by researchers in the future. Therefore, the existence of SPMEI saves time and effort for future research works. Second, because of the time-dependent principles, the use of the instrument and the evaluation model are applicable to projects that are conducted within a certain period.

The instrument is only applicable to software or software intensive development projects. It is not applicable to software maintenance projects. In the life cycle of a project, the maintenance phase of the project is significant in many ways. According to Schach (2002), 67% of the project total cost is devoted to the maintenance. The maintenance phase generally starts when the project deliverables (the products, the services, the manuals, etc.) are handed to the customer. After this milestone, all activities related to the changes in the deliverables are considered as maintenance activities. Prior to this milestone, all activities related to the project are considered as development activities. This milestone has important significance for the purposes of this research as well as other purposes. This milestone in the project life cycle is the cornerstone for many changes in the context or environment of the project. The first context change is that the project deliverables are no longer being developed by the project team but they are in operational use by the users and the customers. The second important context change is that the development team dissolves in many cases. The project manager, the project team leaders and many other stakeholders move on to other projects. Another significance of this milestone is that the project budget is estimated based on this milestone in most cases. In some cases, the project is even handed to the customer when the project funding runs out. Testing is the last phase of the software development effort. If the activities before testing cost more than expected, the amount of testing gets cut to meet the budget. The same treatment is also true for the project schedule. Basically, the project variables that drive the project plans are all based on this milestone in the life cycle. Even though the maintenance phase of the project in the life cycle of a project is widely accepted as a natural extension, for the project planning and estimation purposes this milestone is considered the end of the project. For many years, project success was evaluated based on delivering the project on time, within budget and with expected functionality. All these variables relate to this milestone. For the sake of raising an argument, isn't that contradictory when the project maintenance is considered a natural phase in the software evolution, when all the project planning and estimation is targeted to the end of development phase? Another interesting observation is that PMI's PMBOK (2004) does not include a section for maintenance phase.

All these context changes naturally affect the project management principles deriving the activities in the project life cycle. Even though there are many studies on the technical aspects of the maintenance phase, the literature lacks studies on managing the maintenance phase of projects. It is the author's belief that managing the maintenance activities may rely on different project management principles than project development activities. For example, most current project estimation methods and approaches are based on estimating initial development activities. There is a set of activities called reverse engineering that come into play during maintenance of legacy code. Reverse engineering activities are different then development activities. Management of the maintenance phase seems a prospective area for future research.

There are three types of maintenance (Schach, 2002). They are corrective, perfective, and adaptive maintenance. It is possible to argue that all these maintenance activities may also be considered another project by themselves. Some even make the distinction between development and maintenance activities by dividing software projects into two categories such as software development projects and software maintenance projects. Stating this distinction is a sign that there is a difference between software development and maintenance projects.

Whether the maintenance activities are considered a separate but related project or a natural extension of the project development activities, managing these sets of activities is different then managing development activities. Munns and Bjeirmi (1996) and Cooke-

Davies (2001) argue that the scope of project management success is up until to the handover (see Figure 36). The test cases presented in the following sections align with the argument. Since the instrument is focused on software development projects, it is therefore not applicable to software maintenance projects. SPMEI scope excludes the maintenance phase in the life cycle of a project.

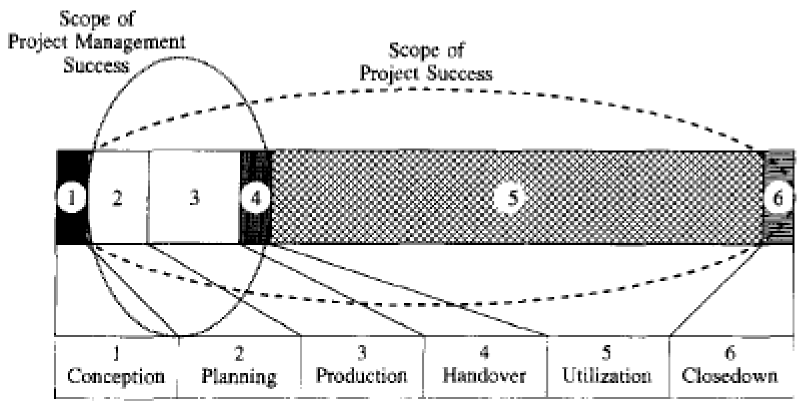

Figure 36. The Scope of Success within Project Life Cycle [From (Munns and Bjeirmi, 1996)]

The scope of the instrument is limited to the project phases between conception and delivery (handover). Figure 36 above already depicts the scope of project management success. Munns and Bjeirmi (1996) explain in detail what the scope of project success and project management successes are and why. De Wit (1988) makes a distinction between project success and project management success. Furthermore, Cooke-Davies (2004a) lists three levels of success:

1. Project Management Success: Was the project done right?
2. Project Success: Was the right project done?
3. Consistent Project Success: Were the right projects done, right time after time?

Detailed discussions regarding the different scopes were presented earlier. Why maintenance projects or the maintenance phase of the projects is out of the scope of the instrument is presented in the previous section.

According to Munns and Bjeirmi (1996), the conception phase of a project is when the idea for the project is birthed within the client organization and its feasibility determined. Basically, in this phase the decision to undertake or not to undertake the project is determined. This decision is driven by many internal and external factors. Some of these factors are the problem to be solved, the applicability of the implementation alternatives, aligning and resolving the conflicting concerns of all stakeholders, the adequacy of resources, the availability of project personnel and the skills needed to successfully complete the project, the changing market dynamics, the availability of the necessary technologies, competing organizations, other similar and supplementary products in the market, the social and political environment, etc. This list is not complete by any means. Most definitions of a project state that the project is unique. Therefore, for every project, the factors may be quite different, and these factors influence the project "go" decision. Some scholars and practitioners argue that the success of the project is determined in this phase even before any implementation takes place. Boehm and Jain (2005) state that:

> …software-intensive enterprises and their success are subject to multiple concurrent influences, some of which are unpredictable. For example, a project that is poorly requirements-engineered and architected, poorly managed, behind schedule, and over budget can still turn into a great success with the appearance of just the right new COTS product to satisfy stakeholder needs. The reverse is true as well.

Cooke-Davies states that different stakeholders may have different success criteria. Such differences make the measurement of project success a complex and inexact matter. What is considered a success for one stakeholder may be considered as a disaster for another stakeholder. What can appear a success one day may be a failure the next day (Cooke-Davies, 2001). Other prominent scholars in the project management area, such as Pinto and Slevin, stress the difficulties in establishing what constitutes a success.

The scope of this instrument is the same as the views of Munns and Bjeirmi (1996) as depicted in the Figure 36. The focus of the instrument is aligned with the views of Cooke-Davies for project management success: “Was the project done right?” As a result, the instrument inquires how well the project is managed.

SPMEI is a self-evaluation instrument. Software project management is complex by nature and has many aspects. Not every stakeholder is subject to the “big picture” of the project. The software project management evaluation instrument, SPMEI, should only be used by a person who has extensive knowledge and understanding of various aspects during project development. Generally, this person is the project manager or the technical manager of the project. This person may also be an executive manager, a project team leader, a project metrics or process engineering expert, or even a developer when the project team is not big. SPMEI is not designed to be used by an outsider such as a researcher or a stakeholder who is only subject to certain limited aspects of the project. The self-evaluation characteristic of the SPMEI is the result of this natural requirement. The instrument is designed based on this assumption. It involves inquiries requiring a response from a person who has first-hand experience in the complex dynamics of the project management.

Such a characteristic raises an important issue. It is possible that this person may not be objective in responding to the questions in the instrument; therefore the resulting metric may not be reliable. Even though this is a valid issue, in practice the occurrences of such evaluations will not be common. First of all, the instrument is designed in such a way that strong biases are likely to be identified. The instrument is extensive and inclusive. It includes fifteen project management areas. Because of the nature of project management, the areas are closely tied to each other. For example, an effective risk control can only be the result of an effective risk assessment. Effective teamwork can be achieved via effective communication, an able project manager, effective leadership of various leaders in the project organization and commitment from stakeholders. Therefore, inconsistencies among responses in related areas will reveal intentional and unintentional biases. Second, the instrument will likely be used by managers and organizations that are committed to achieve better results in projects. These managers and organizations value candid assessments and improvement efforts. Thus, there is no value for these managers and organizations when evaluations are not based on candid responses. The expectance is that the instrument will likely to be used in this context. There is a solution to this issue. The instrument may be applied by two individuals satisfying the condition that these individuals are one of the stakeholders mentioned above. For example, a project manager and a team leader may apply the instrument at the same time, and evaluations based on the responses of these individuals are compared to identify when the existence of a bias is suspected.

The goal of the project management effectiveness evaluation is to provide feedback to the interested stakeholders. In most cases, the customers or the end users would not be interested in the quality of the project management as long as the project result, the product or the service, satisfies their need. A good question would be: why would the project managers need a tool such as SPMEI to evaluate the project management effectiveness or to identify the project problems when they already have an intuition based on experience? Don't they already know what the project problems are? In most cases, team members including project managers have a sense of the project management quality. They may not need a tool to say what they may already know. However, they need SPMEI and the evaluation model when it is time to convince other stakeholders for the reasons of ineffectiveness during project development. Because most project management related problems require a solution that includes commitments from a range of project stakeholders. A few examples of these problems are inadequate funding, lack of commitment from the users for necessary participation in requirements development or testing phase, the need for a more realistic schedule, the need to stabilize the requirements, etc. The evaluations based on SPMEI and the accompanying evaluation model will empower the software managers with a scientific systematic tool that will help them to convince other project stakeholders for more commitment. The analysis of two survey studies conducted for this research revealed that even though the technical managers objected to the project schedule due to infeasibility at the beginning of the project, the projects went ahead with their current schedule estimations. Also, in both of these projects the customer and the users did not participate enough to make those schedules possible. In one of the cases, the project suffered from schedule slip. In the other, the project delivered much less functionality than planned. SPMEI helps the managers to make their cases to other stakeholders. It is possible to prevent such problems with the use of a PME metric.

In other cases, it is possible that software managers lose the big picture and have a tainted view regarding the quality of the project management. SPMEI provides and reminds them of the big picture in these cases. It is possible for software managers to be carried away with the day-to-day problems of the project and they may lose focus. Organizational politics is a prime source of such problems. If used as a monitoring tool, SPMEI will help software managers to focus on the big picture of the project.

SPMEI may also be used as a monitoring tool. The primary goal of the instrument is to be used as an evaluation tool after the project is completed. The feedback from the evaluation is to be used as guidance for the upcoming projects. The instrument and the evaluation model provide the best evaluation when the project is delivered to the customer. During the development of the instrument, it became clear that the tool can also be used as a project monitoring tool. To confirm such a hypothesis, one of the surveys was conducted on a project that was in its implementation phase. The study result supported the hypothesis.

The earliest that the evaluations may be performed is after some requirements development activities are carried out because by the time the project reached this point, many of the essential project management related activities are already conducted. These activities include:

- The project manager is already chosen. The project manager's role is shaped with the influence of many factors including political and social factors.
- The project is staffed to a certain threshold. The project team structure becomes clear. The project organization is identified.
- Ideally, all stakeholders should have been identified by this time. Even if not, the concerns of primary stakeholders and the conflicting agendas start affecting the project in many ways.
- Most planning and estimation activities are carried out.

- Hopefully, the project scope is clear at this point. In the case that the scope is not clear, naturally there is an effort to identify the proper scope.
- Many supplementary systems should be in place. For example, necessary communications systems, configuration management systems, project databases and other automated systems required for the project execution.
- Ideally, the quality policy should be clear. Even though there is not an explicit quality policy, the project team already has an idea of what the overall quality will be in the project.
- Project monitoring and control procedures should be in place.
- Project communication procedures should be in place.
- The work breakdown structure or similar document has at least its overall structure.
- Project risks should have been identified. Risk management procedures should be in place.
- Requirements management procedures should be in place.

The list above is only a collection of activities that should have been conducted by the time some of the requirements development activities are carried out. At this point in the life cycle of the project, political issues are already pulling the project to a certain course. Requirements development is the phase in which the effects of these forces are reflected in the requirements documents. Project politics are being shaped. Executive management desires to maximize their profit by either providing less functionality while abiding to the contract or pushing the project team to work overtime. The customers and users desire all the functionality and performance they can get out of the project while keeping the cost low. The project team desires to provide a high quality product that they can be proud of. Secondary stakeholders want their issues resolved and their concerns reflected in the requirements document. Some scholars pointed out that to a high degree project success is determined by the decisions in the project planning phase. For example, O'Connell (2002) states that the fate of the project is sealed in the planning phase. In his view, the planning phase includes requirements development. A prominent project management scholar Jeffrey K. Pinto stresses that:

> In my research and consulting experience, I have found that most companies spend thousands of hours planning and implementing a multimillion or even multibillion dollar investment, developing intricate plans and schedules, forming a cohesive team, and maintaining realistic specification and time targets, all to have the project derailed by political processes. This is a pity, particularly because the end result is often foreseeable early in the development of the project- usually as the result of a project manager's refusal to acknowledge and cultivate political ties, both internal to the organization and externally with the clients (Pinto and Slevin, 1998, p. 257).

As Pinto stresses, the project's result is often foreseeable early in the development of the project. SPMEI's capability of being a project-monitoring tool is no coincidence. It is possible to argue that such capability is driven by project reality. By the time the project is in the requirements development phase, most planning activities are conducted and project dynamics reach a certain threshold with considerable influence from project politics. Therefore, after this point in the life cycle of the software project, SPMEI-based project management effectiveness evaluations may be conducted in a periodic or aperiodic manner. Such use of the tool enables project managers to monitor their projects.

Why does the SPMEI include fifteen project management areas? Why is it not fourteen or sixteen? In this study, the total number of areas in SPMEI is only driven by the research. In the beginning of the study, there was not a target number for the total number of areas that should be included in the design of SPMEI. The 3PR framework guided the design of SPMEI and the areas within it. Project management is a complex endeavor. The study conducted by Fortune and White (2006) listed twenty-six different critical success factors extracted from the review of sixty-three publications. Furthermore, not all studies include the same factors. Such study indicates the complexity involved in realizing a successful project. A quote from the personal communications with Dr. Larry Bernstein (2008) is, "…real project management does not lead to simple answers. Things are by their nature complex and need analysis."

Therefore, the instrument concentrates on not just a few areas but a broad number of areas. The more questions we ask regarding the project management, the more insight we will have on the success or failure of the projects, assuming the questions are based on a sound research design and the responses are candid. In the survey study conducted, there were seventeen areas inquired via question #5 (Appendix D). The areas of support activities and technical complexity were excluded from the design of SPMEI. The results of the survey indicate that these areas are the least important areas among those listed. These areas are excluded in the design of the SPMEI mainly to limit the length of the instrument. Even though we would like to get more data by asking more questions, we may have to limit the length of the overall procedure. If the data gathering procedure takes too long, the study participants may get tired toward the end of the procedure. Thus, the reliability of the responses may be negatively affected due to this. A balance in the design of experimentation between these two factors should be sought by researchers.

The content and the number of sections in the instrument may be modified depending on the researcher's proposed project management effectiveness evaluation model. For example, the sections of risk assessment and risk control may be combined together under the title risk management with changes in the content of the sections. Then, the instrument will consist of fourteen sections instead of fifteen. The section of project planning and estimation may be divided into two sections such as project planning and project estimation. Then, the instrument will consist of sixteen sections instead of fifteen.

The software project management evaluation instrument, SPMEI, and the evaluation model in this research should be considered separately. Even though the instrument and the evaluation model design are closely related to each other, it is also possible to use the instrument, SPMEI, with other evaluation models. Such uses may or may not necessitate modifications in the instrument depending on the research goals and research design.

7. Pilot Studies on the Instrument

Conducting pilot studies has indispensible benefits. Four pilot studies were conducted with the participation of one project manager, one technical manager and two software developers.

C. SOFTWARE PROJECT MANAGEMENT EVALUATION MODEL (SPMEM)

The framework for software project management guides the development of the evaluation model. The project management areas in the framework have a one-to-one mapping to the model variables. The variables in the high-level model are people area score (PeopleS), process area score (ProcessS), product area score (ProductS), and risk area score (RiskS). These variables correspond to the main areas in the framework that were explained in the Chapter V of this dissertation. Furthermore, the coefficient of each variable (in other words the associated weight of each variable) is identified based on the results of the survey.

The variables in the high-level model are calculated based on the responses to the SPMEI. The project management areas (such as requirements management, risk assessment, stakeholder involvement, etc.) in the framework are categorized under one of the main areas. For example, teamwork and communication is categorized under the people main area. Project planning and estimation area is categorized under the process main area, and so forth. For each of these project management areas, there is an associated model to determine the score for that area. These scores are determined based on the responses to software project management evaluation instrument (SPMEI) questions.

1. High-Level Evaluation Model

The high-level evaluation model for the metric is as follows:

$$PME\ Score = PeopleS \times 0.33 + ProcessS \times 0.2907 + ProductS \times 0.204 + RiskS \times 0.1753$$

where:

PME Score: Software Project Management Effectiveness Score,

PeopleS: People Main Area Score,

ProcessS: Process Main Area Score,

ProductS: Product Main Area Score, and

RiskS: Risk Main Area Score.

The people main area score (PeopleS) is calculated as follows:

$$People\ Area\ Score = \frac{(C + T + L + OC + PM + SI + S)}{7}$$

where:

C: Communication Area Score,

T: Teamwork Area Score,

L: Leadership Area Score,

OC: Organizational Commitment Area Score,

PM: Project Management Area Score,

SI: Stakeholder Involvement Area Score, and

S: Staffing and Hiring Area Score.

The process main area score (ProcessS) is calculated as follows:

$$Process\ Area\ Score = \frac{(RM + PMC + PPE + SM)}{4}$$

where:

RM: Requirements Management Area Score,

PMC: Project Monitoring and Control Area Score,

PPE: Project Planning and Estimation Area Score, and

SM: Scope Management Area Score.

The product main area score (ProductS) is calculated as follows:

$$Product\ Area\ Score = \frac{(CM + QE)}{2}$$

where:

CM: Configuration Management Score and

QE: Quality Engineering Score.

The risk main area score (RiskS) is calculated as follows:

$$Risk\,Area\,Score = \frac{(RA + RC)}{2}$$

where:

RA: Risk Assessment Area Score and

RC: Risk Control Area Score.

2. Project Management Area Evaluation Models

The software project management evaluation instrument (SPMEI) is divided into sections based on the project management areas in the framework. The high-level model uses the project management area scores. These scores are determined via evaluation models developed for each area. These models use the scores derived from the participant's responses to SPMEI questions inquiring about the project management effectiveness. Therefore, for each response or responses to a question in SPMEI, there is an associated score. For example, the responses to question RM3 in the requirements management section is scored as follows:

RM3. Which of the following activities are conducted in the project? (Check all that apply.)

- ☐ Market surveys
- ☒ Customer/User interviews
- ☒ Prototyping
- ☒ Scenarios/ use cases
- ☐ Observation of the user in operation
- ☐ None

In the example above, the study participant indicated that they have conducted customer/user surveys, prototyping, and development of scenarios/use cases to increase the effectiveness of requirements management activities. Each response to this question has a score of “1” except for the response of “None” which is associated with a score of “0.” Since the study participant checked three of the responses, the total score for this question is “3.”

The above question, RM3, allows for multiple responses. Not all questions in the SPMEI allow for multiple responses. Some of them only allow for one response among all possible responses. For example, question PPE4 in the project planning and estimation section allows for one response as shown below:

PPE4. Check the <u>statement</u> that applies to the project. (Check only one.) ☐ The project plan is approved by the stakeholders such as customers, users, project team members, executive management etc. ☒ There is no approval process.

In the example above, the study participant indicated that there is no approval process for the project plan. This response is associated with a score of “-2,” while the other response is associated with a score of “2.” In this example, the total score for this question to be used in the evaluation model for project planning and estimation section is “-2.”

Another example from the quality engineering section is as follows:

QE18	**There are adequate tools, equipment and resources for testing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☒	Not Applicable ☐

In the example above, the study participant completely disagreed to the statement that “there are adequate tools, equipment and resources for testing.” The score associated with this response is “-2.”

The associated scores for each response or responses to the questions in SPMEI are provided in Appendix G. Adding the scores associated with the responses in each section provides an initial score for that section. Since some of the responses are associated with a negative score, it is possible to have an initial score for a section lower than zero. In order to shift the lowest score to a base score of zero, the lowest possible score for each section is converted to positive and then added to the initial score. This converted lowest score is called the shifting factor. Table 15 presents the number of questions, the lowest score, the highest score and the range of scores for each project management area. Then, this shifted score is normalized to a scale of 0 to 10 by multiplying it with a scaling factor. Table 16 provides the shifting factors and scaling factors for each project management area.

PEOPLE MAIN AREA	**Number of Questions**	**Lowest Score**	**Highest Score**	**Difference between the highest and lowest score**
Communication	23	-38	66	104
Teamwork	30	-54	73	127
Leadership	17	-34	34	68
Organizational Commitment	26	-50	62	112
Project Manager	27	-52	60	112
Stakeholder Involvement – Contract	16	-30	42	72
Stakeholder Involvement – Market	12	-22	34	56
Staffing and Hiring	29	-52	64	116
PROCESS MAIN AREA				
Requirements Management	27	-50	73	123
Project Monitoring and Control	19	-32	54	86
Project Planning and Estimation	35	-70	104	174
Scope Management	16	-26	45	71
PRODUCT MAIN AREA				
Configuration Management	13	-22	38	60
Quality Engineering	20	-36	57	93
RISK MAIN AREA				
Risk Assessment - No Subcontracting	19	-34	57	91
Risk Assessment - With Subcontracting	20	-38	63	101
Risk Control	17	-26	28	54

Table 15. Number of Questions, Lowest and Highest Possible Score and Range of Scores for each Project Management Area

Project Management Area	Shifting Factor	Scaling Factor
Communication	38	$\frac{10}{104}$
Teamwork	54	$\frac{10}{127}$
Leadership	34	$\frac{10}{68}$
Organizational Commitment	50	$\frac{10}{112}$
Project Manager	52	$\frac{10}{112}$
Stakeholder Involvement - Contract	30	$\frac{10}{72}$
Stakeholder Involvement - Market	22	$\frac{10}{56}$
Staffing and Hiring	52	$\frac{10}{116}$
Requirements Management	50	$\frac{10}{123}$
Project Monitoring and Control	32	$\frac{10}{86}$
Project Planning and Estimation	70	$\frac{10}{174}$
Scope Management	26	$\frac{10}{71}$
Configuration Management	22	$\frac{10}{60}$
Quality Engineering	36	$\frac{10}{93}$

Risk Assessment – No Subcontracting	34	$\frac{10}{91}$
Risk Assessment – With Subcontracting	38	$\frac{10}{101}$
Risk Control	26	$\frac{10}{54}$

Table 16. Scaling Factors for Project Management Areas

The steps for calculating the score for a project management area are listed as follows:

1. Add the scores for each response in a section. This step provides an initial score for a project management area.
2. Add the shifting factor to the sum of the scores calculated in the previous step. This step provides a shifted initial score for a project management area.
3. Multiply the shifted sum of scores with a scaling factor to normalize the score to a scale of 0 to 10. After this step, the project management area score is normalized to be used in the high-level model.

The generic model to determine a project management area score is:

$$Project\ Management\ Area\ Score = Scaling\ Factor \times \left(\sum_{i=1}^{n} PMA_i + Shifting\ Factor \right).$$

In the model above, n is the number of questions for a specific project management area. PMA_i is the score computed from the response or responses to a specific question. For example, in the communication section of the SPMEI, there are twenty-three questions. Thus, n is 23 for this area model. For the communication area, the scaling factor is $\frac{10}{104}$ and the shifting factor is 38. The identifiers used for questions in each section are presented in Table 17.

Project Management Area (PMA)	Identifier
Communication	C
Teamwork	T
Leadership	L
Organizational Commitment	OC
Project Manager	PM
Stakeholder Involvement	SI
Staffing and Hiring	S
Requirements Management	RM
Project Monitoring and Control	PMC
Project Planning and Estimation	PPE
Scope Management	SM
Configuration Management	CM
Quality Engineering	QE
Risk Assessment	RA
Risk Control	RC

Table 17. Identifiers Corresponding to Project Management Areas

a. Communication Area Evaluation Model

$$\textit{Communication Area Score} = \frac{10}{104} \times \left(\sum_{i=1}^{n=23} C_i + 38 \right).$$

b. Teamwork Area Evaluation Model

$$\textit{Teamwork Area Score} = \frac{10}{127} \times \left(\sum_{i=1}^{n=30} T_i + 54 \right).$$

c. Leadership Area Evaluation Model

In the leadership section of SPMEI, the respondent has to choose to respond to one of two questions: L17 and L18. If the project team mostly consists of inexperienced staff then the respondent should answer question L17. If the project team mostly consists of experienced staff, then the respondent should answer question L18. The choices for these questions are identical. However, the scoring is different. The model for both cases is presented below.

If the team mostly consists of inexperienced staff, then the leadership area model is as follows:

$$Leadership\ Area\ Score = \frac{10}{68} \times \left(\sum_{i=1}^{n=17} L_i + 34 \right).$$

If the team mostly consists of experienced staff, then the leadership area model is as follows:

$$Leadership\ Area\ Score = \frac{10}{68} \times \left(\sum_{i=1}^{n=16} L_i + L_{18} + 34 \right).$$

d. Organizational Commitment Evaluation Area Model

$$Organizational\ Commitment\ Area\ Score = \frac{10}{112} \times \left(\sum_{i=1}^{n=26} OC_i + 50 \right).$$

e. Project Manager Area Evaluation Model

$$Project\ Manager\ Area\ Score = \frac{10}{112} \times \left(\sum_{i=1}^{n=27} PM_i + 52 \right).$$

f. Stakeholder Involvement Area Evaluation Model

In the stakeholder involvement section of SPMEI, the questions after SI10 are divided into two sections. If the project is developed for the market without a specific contract, then the respondent should answer questions SI11 and SI12. If the project is developed under a contract with a customer, then the respondent should not answer the questions SI11 and SI12, but the questions from SI13 to SI18 instead.

If the project is developed for the market, then the stakeholder involvement area model is as follows:

$$Stakeholder\ Involvement\ Area\ Score = \frac{10}{56} \times \left(\sum_{i=1}^{n=12} SI_i + 22 \right).$$

If the project is developed for the market, then the stakeholder involvement area model is as follows:

$$Stakeholder\ Involvement\ Area\ Score = \frac{10}{72} \times \left(\sum_{i=1}^{n=10} SI_i + \sum_{i=13}^{18} SI_i + 30 \right).$$

g. Staffing and Hiring Area Evaluation Model

$$Staffing\ and\ Hiring\ Area\ Score = \frac{10}{116} \times \left(\sum_{i=1}^{n=29} S_i + 52 \right).$$

h. Requirements Management Area Evaluation Model

$$Requirements\ Management\ Area\ Score = \frac{10}{123} \times \left(\sum_{i=1}^{n=27} RM_i + 50 \right).$$

i. Project Monitoring and Control Area Evaluation Model

$$Project\ Monitoring\ and\ Control\ Area\ Score = \frac{10}{86} \times \left(\sum_{i=1}^{n=19} PMC_i + 32 \right).$$

j. Project Planning and Estimation Area Evaluation Model

$$Project\ Planning\ and\ Estimation\ Area\ Score = \frac{10}{174} \times \left(\sum_{i=1}^{n=35} PPE_i + 70 \right).$$

k. Scope Management Area Evaluation Model

$$Scope\ Management\ Area\ Score = \frac{10}{71} \times \left(\sum_{i=1}^{n=16} SM_i + 26 \right).$$

l. Configuration Management Area Evaluation Model

$$Configuration\ Management\ Area\ Score = \frac{10}{60} \times \left(\sum_{i=1}^{n=13} CM_i + 22 \right).$$

m. Quality Engineering Area Evaluation Model

$$Quality\ Engineering\ Area\ Score = \frac{10}{93} \times \left(\sum_{i=1}^{n=20} QE_i + 36 \right).$$

n. Risk Assessment Area Evaluation Model

In the risk assessment section of the SPMEI, there is an additional question at the end of the section for the projects in which subcontracting is used. The question identifier is RA20.

If the project does not utilize subcontracting, then the risk assessment area model is as follows:

$$\mathit{Risk\ Assessment\ Area\ Score} = \frac{10}{90} \times \left(\sum_{i=1}^{n=19} RA_i + 34 \right).$$

If the project utilizes subcontracting, then the risk assessment area model is as follows:

$$\mathit{Risk\ Assessment\ Area\ Score} = \frac{10}{100} \times \left(\sum_{i=1}^{n=20} RA_i + 38 \right).$$

o. Risk Control Area Evaluation Model

In the risk control section of the SPMEI, there are four questions that are excluded from the evaluation model: RC1, RC2, RC3, and RC4. These questions are included in the instrument to enable a consistency check among the responses and for other research purposes. Therefore, for the risk control area model, only the responses from RC5 to RC17 are included in the evaluation model:

$$\mathit{Risk\ Control\ Area\ Score} = \frac{10}{54} \times \left(\sum_{i=5}^{n=17} RC_i + 26 \right).$$

VIII. SURVEY STUDIES ON SOFTWARE PROJECTS AND DATA ANALYSIS

A. INTRODUCTION

In order to test the hypothesis stated in this research, data from real-world software projects were collected. The data were collected using the software project management evaluation instrument (SPMEI). Additional and supplemental data is gathered with face-to-face, phone interviews, or electronic correspondence with the study participants. The study participants consisted of project managers, executive managers, technical managers, project team leaders, and process/metrics experts who worked on the projects. An essential piece of data collected was the project success ratings provided by these study participants for their software development projects. The responses to the SPMEI and the evaluation model (SPMEM) developed were used to measure the project management effectiveness in software projects. The dataset consisted of two metrics, the project success rating and software project management effectiveness (PME) metric. These two measures were used to test the research hypothesis. In order to understand the measure of association between these two metrics, a parametric correlation analysis was conducted. The analysis showed that there is a strong positive correlation, r, between the software project management effectiveness (PME) metric proposed in this research and the software project success rating provided by the study participants.

B. DATA COLLECTION

The project data collection for the studies was one of the most challenging parts of this research. Even though the author gained experience in surveying methods during validation of the framework, data collection for the validation of the metric presented a number of new and different challenges.

Two different strategies were utilized to accomplish data collection. The first strategy involved calling practitioners for participation via advertisements in magazines and websites. In addition, bulk e-mails are sent to special interest groups. Call for participation announcements were posted in software development forum (SDForum) newsletter, software technology support center website maintained by the Air Force, worldwide software process improvement network initiated by Software Engineering Institute, software development forum leadership special interest group network and in some other special interest group networks. Some of these networks reach thousands of software practitioners. However, this strategy did not yield effective results. Very little participation was acquired using this strategy. It is observed that sharing the project data with a researcher requires a trust relationship, which is hard to establish with such an advertisement-based campaign.

Since the first strategy was found to be ineffective, a new strategy for data collection was devised. The new strategy involved establishing direct communication to software managers via personal relationships or via acquaintances of friends and colleagues. This strategy yielded much better results. Most of the participation in this research was acquired using this strategy. Direct communication with possible study participants enables easier establishment of trust relationships.

The author conducted interviews with study participants after they completed SPMEI. The goal of these interviews was to acquire additional insight into their project development efforts. Not all the participants were available for interviews due to their busy schedules. However, most of them were interviewed. Whenever possible, these interviews were conducted in person. When a face-to-face interview was not possible, the interviews were conducted either by phone or by electronic correspondence.

C. SURVEY STUDIES

In this section, the projects analyzed will be presented one-by-one in detail. The information gathered during interviews with the study participants were also presented briefly. The projects were given identifiers to ensure the anonymity of the responses. These identifiers are letters from the alphabet assigned to each project.

The small sample size limits our ability to perform many advanced statistical analysis. On the other hand, the statistical analyses performed provided valuable information. In addition, each project was analyzed in detail. These in-depth analyses revealed additional information.

As indicated by many scholars and practitioners, project management is complex by nature. Analysis of this complex endeavor requires careful and appropriate selection of research methods. In this research, it has been observed that in order to develop an effectiveness measure for software project management, a broad range of project management areas should be inquired into. Such necessity of comprehensive and broad inquiry led to conducting in-depth analysis of each project in addition to conducting statistical analysis on the dataset. The software project management evaluation instrument, SPMEI, gathers data from a software project for over 500 data points. The amount of data gathered from software projects is much more than the amount of data gathered from projects in some other studies. This amount of data enables us to conduct detailed analysis for each project, which helped to test the hypothesis stated in this study.

1. Project A

The goal of this project was to deliver a software product that integrates various functions and reports of various information management systems used in the client's company. The final product itself was another information management system. The project is considered a success with reservations by the study participant. This project was conducted by a small software company in the U.S.A. between February 2006 and November 2006. The project's original schedule was planned as seven months, while the project took ten months to complete. All of the functionality agreed upon in the baseline was delivered. The planned budget for the project was $500,000. There was 50% cost overrun. The actual cost of the project was $750,000. The average number of project team members involved from start to end was four. The technical manager of this project completed the SPMEI.

This study was initially planned as a pilot study. However, after the study was completed, it was found that the research protocol and SPMEI do not need any significant modifications. Only a few of the questions were deleted from the instrument, while very few of them were combined together. This did not have any affect on the evaluations. Therefore, this sample is included in the main study.

After the participant filled out the instrument, an interview was conducted. In the interview, the technical manager was asked if he had any remarks on this project. The technical manager indicated that there were a couple of problems in this project. These problems led the late delivery of the product. The first problem was that executive management dictated the schedule and budget; they were merely trying to win the contract. Even though the technical manager opposed the schedule from the start, the project was a go with its original schedule. The project manager felt that he had to do what he could with what he had. The project manager did not oppose the schedule. During the project, he also did not inform executive management regarding the project problems. Not informing executive management resulted in the lack of involvement from executive management when needed. The second biggest problem was the underestimation of the project scope. The technical manager thought the discussions regarding the project scope were cut short. The project was undertaken without the necessary initial investigation. On the other hand, the project was well-planned according to its estimated scope. The third problem was from the customer side. The users did not get involved with the project even though it was requested by the project team. Since one of the goals of the project was to automate some of the procedures and generate reports for the customer' organization, the project team needed to understand these procedures. The project team requested input from the users, for example to help identify report contents, formats, etc. The project team could not get the necessary input in time. There were some hidden factors in the customer's organization for such lack of necessary user involvement. There were some political and procedural issues within departments in the customer's organization which created extra challenges for the project team. This was another significant factor for late delivery.

The technical manager rated the overall success of the project with a "6." The SPMEI score of the project was "7."

Timeframe of the Project A	2006
Location	U.S.A.
Actual Cost/ Cost Overrun	$750K / 50%
Actual Schedule/Schedule Overrun	10 Months / 43%
Functionality Delivered	100%
Size of the Product	100 KLOC
Average Number of People Involved in the Project	4
Number of People Involved in Requirements Phase	3
Number of People Involved in Design Phase	2
Number of People Involved in Implementation Phase	4
Number of People Involved in Testing and Delivery Phase	4
Communication Area Score	6.5
Teamwork Area Score	6.1
Leadership Area Score	5.9
Organizational Commitment Area Score	5.4
Project Manager Area Score	7.1
Stakeholder Involvement Area Score	7.1
Staffing and Hiring Area Score	4.4
Requirements Management Area Score	7.0
Project Planning and Estimation Area Score	6.4
Project Monitoring and Control Area Score	7.6
Scope Management Area Score	6.9
Configuration Management Area Score	8.7
Quality Engineering Area Score	7.1
Risk Assessment Area Score	6.4
Risk Control Area Score	6.3
People Area Score	6.1
Process Area Score	7.0
Product Area Score	7.9
Risk Area Score	6.3
PME Score	6.7
Rounded PME Score	7
Project's Overall Success Rating	6

Table 18. Project A Data in Tabular Form

2. Project B

The goal in this project was to provide a DSL CPE firmware/software upgrade to a commercially available DSL CPE chipset and reference design. The study participant was the executive manager who oversaw the project.

The project took six months to complete and took place in 2006. The project was planned to be completed in six months, thus it was completed on time. 95% of the planned functionality was delivered with the project. The average number of people involved from start to end in this project was ten. The project was conducted in the U.S.A. by a commercial vendor. The study participant did not reveal the planned and actual effort, nor the planned budget and the cost of the project.

After the study, a brief interview was conducted via e-mail. The study participant indicated that he chose this project because it was completed recently and he could still remember most of the details. The study participant is generally involved with Silicon-On-Chip projects that include a portion of software development. He mentioned that this was a typical software project in his group.

The study participant rated the overall success of the project with a “9.” The PME score for this project was a “7.”

Timeframe of the Project B	2006
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	6 Months / On Time
Functionality Delivered	95%
Size of the Product	N/A
Average Number of People Involved in the Project	10
Number of People Involved in Requirements Phase	4
Number of People Involved in Design Phase	10
Number of People Involved in Implementation Phase	15
Number of People Involved in Testing and Delivery Phase	10
Communication Area Score	7.2
Teamwork Area Score	7.8
Leadership Area Score	8.4
Organizational Commitment Area Score	7.3
Project Manager Area Score	7.9
Stakeholder Involvement Area Score	6.6
Staffing and Hiring Area Score	7.3
Requirements Management Area Score	7.1
Project Planning and Estimation Area Score	6.8
Project Monitoring and Control Area Score	5.5
Scope Management Area Score	7.0
Configuration Management Area Score	7.2
Quality Engineering Area Score	6.9
Risk Assessment Area Score	5.6
Risk Control Area Score	5.9
People Area Score	7.5
Process Area Score	6.6
Product Area Score	7.0
Risk Area Score	5.8
PME Score	6.8
Rounded PME Score	7
Project’s Overall Success Rating	9

Table 19. Project B Data in Tabular Form

3. Project C

This study was different in one important aspect from other projects in this data set. When this survey was conducted, the project was still in progress. Study results support the case for the use of PME and the evaluation model as a monitoring tool. The model successfully evaluated the project management effectiveness in this project as it was intended.

The goal of this project was to develop a small size medical instrument. A portion of the project involves embedded software development and a PC installer application for this medical instrument. The study was conducted not just on the software development part but also on the whole project. This project started in September 2007 and is expected to finalize in February 2009 with schedule slippages. Originally, it was planned to be completed in twelve months. However, the project schedule is already slipping and at the time of study, it was expected to finish in seventeen months. The study took place during the seventh month of the development. The overall projected effort for the project was 125 man-months. At the time of evaluation, the expected actual effort was 175 man-months. For the software development effort, the projected effort was ten man-months and the expected actual effort was twenty man-months. The planned budget for the project was $3.5 million. At the time of evaluation, the expected actual cost was $4.5 million with the changes occurring in the project. For the software development effort, the projected budget was $200,000 and the expected actual cost became $400,000. At the time of study, one-third of the expected functionality was completed. The project team expects to deliver 100% functionality. In total, eighteen people are involved in this project, with the average being ten. For the software development effort, four people are involved in the project with the average being four people. This project is being conducted in the U.S.A. with most of the team being geographically dispersed. Most of the project team is composed of contractors working temporarily on this project. This project is conducted in a commercial environment and the company funding the project expects to distribute the developed medical instrument to the market in different countries.

In this study, the participant was an executive manager who was overseeing the project. He was an experienced manager with more than twenty years of experience in software development projects. The author was with the study participant while he was completing the SPMEI for the project he was overseeing at the time. The author merely observed the study participant and did not interfere with the procedure. It was observed that the study participant did not have any difficulty in responding to the statements and questions in SPMEI. After the participant completed SPMEI, a comprehensive interview was conducted on the project and project management challenges.

A major challenge in this project was overcoming the bureaucratic procedures to get the medical instrument approved by regulatory agencies. Preparation and submission of the necessary documents and waiting for responses were all challenging tasks in the project even though they hired experts and consultants for these issues. The responsible regulatory agency in the U.S. is the Federal Drug Administration (FDA). Since the company is also planning to distribute the medical instrument in other countries, they also needed to comply with medical regulations in other countries. Naturally, regulations are not the same for all the countries. The study participant attributed the reason for the schedule slip partially to these issues. In order to finalize some of the specifications, they needed to wait for certain approvals from these regulatory agencies. Because of these issues, the requirements in this project have not reached stability at the time of the study.

During the interview, the study participant mentioned that they recently discovered an important issue. In their last project meeting, they realized that the project was suffering from not having a shared vision; not all project team members were sharing the same vision for the project. They were having discussions on how to make the project vision more clear and ensuring that it is understood by the project team members.

Another issue they had just realized during the project was that notable project accomplishments/milestones/deliverables were not celebrated with social events and parties. This became an issue because the developers would like to see such social events in this project. This issue is specifically addressed in PME with the question T3. At the time of study, the executive management was reviewing how to distribute the bonuses to project team members. This issue was particularly important for them since most of the team members are contractors and they believed this would be a significant factor on the project performance.

The study participant made a controversial remark during the study. He said that, “the project plan changes regularly so I am not sure whether it is better than no plan.” All project plans change. This is almost a fact for project management. This case was no different. The controversy in his remark was that the project plan was changing so much that it was questionable whether there was any use for it. He also indicated that even though there was a formal documented plan, the updates had been informal.

The study participant rated the current success of the project with a “5” at the time of the study. The PME score for this project was a “6.” The study participant assessed the status of the project as a “painful success.” Even though the project was having difficulties in project management, the participant was expecting a significant project success from the business perspective.

Timeframe of the Project C	2007 – 2009
Location	U.S.A.
Actual Cost/ Cost Overrun	$4.5 Million / 28.5%
Actual Schedule/Schedule Overrun	17 Months / 42%
Functionality Delivered	100% (expected)
Size of the Product	100 KLOC
Average Number of People Involved in the Project	10 (Whole Project)
Number of People Involved in Requirements Phase	3 (SW portion)
Number of People Involved in Design Phase	3 (SW portion)
Number of People Involved in Implementation Phase	4 (SW portion)
Number of People Involved in Testing and Delivery Phase	4 (SW portion)
Communication Area Score	6.4
Teamwork Area Score	6.1
Leadership Area Score	6.2
Organizational Commitment Area Score	7.6
Project Manager Area Score	5.2
Stakeholder Involvement Area Score	5.7
Staffing and Hiring Area Score	5.9
Requirements Management Area Score	7.2
Project Planning and Estimation Area Score	5.6
Project Monitoring and Control Area Score	6.2
Scope Management Area Score	6.1
Configuration Management Area Score	4.5
Quality Engineering Area Score	7.8
Risk Assessment Area Score	5.5
Risk Control Area Score	4.4
People Area Score	6.4
Process Area Score	6.3
Product Area Score	6.2
Risk Area Score	5.0
PME Score	6.1
Rounded PME Score	6
Project's Overall Success Rating	5

Table 20. Project C Data in Tabular Form

4. Project D

The goal in this project was to create a prototype of software which was to be run on a stand-alone device. The prototype would be a technical proof-of-concept to be used for demos and presentations to senior management and other stakeholders. A Java application was developed using an XML file for configuration and Derby as a database. Deliverables were the software application as an installer, installation and setup guide, and user manual. The study participant was a project team leader in this project.

This project was conducted between July 2006 and November 2006. The project was planned for completion in six months but was completed in just four months, so the project was completed earlier than expected. The planned budget for the project was $29,000 and the actual cost was $20,000. The projected effort was twenty-four man-months, while the actual effort was sixteen man-months. The project team delivered 100% functionality. The average number of people involved in the project was five. The lines of code in the final product totaled 30,000.

This project was different from other projects in this data set in one aspect: it was developed by project team members who were geographically dispersed across several countries. The project was developed by team members from the U.S., UK and India. This project was developed in a commercial environment.

An interview could not be conducted with the participant after the survey study. The participant also did not provide any special remarks on this project. The participant was quite concerned with the anonymity of the project data.

The study participant rated the overall success of the project with a “7.” The PME score for this project was a “6.”

Timeframe of the Project D	2006
Location	U.S.A., UK, India
Actual Cost/ Cost Overrun	$20K / Under Budget
Actual Schedule/Schedule Overrun	4 Months / On Time
Functionality Delivered	100%
Size of the Product	30 KLOC
Average Number of People Involved in the Project	5
Number of People Involved in Requirements Phase	4
Number of People Involved in Design Phase	4
Number of People Involved in Implementation Phase	5
Number of People Involved in Testing and Delivery Phase	5
Communication Area Score	7.1
Teamwork Area Score	7.1
Leadership Area Score	6.6
Organizational Commitment Area Score	6.7
Project Manager Area Score	8.1
Stakeholder Involvement Area Score	7.7
Staffing and Hiring Area Score	5.9
Requirements Management Area Score	5.4
Project Planning and Estimation Area Score	6.7
Project Monitoring and Control Area Score	6.9
Scope Management Area Score	5.9
Configuration Management Area Score	2.2
Quality Engineering Area Score	5.6
Risk Assessment Area Score	5.5
Risk Control Area Score	5.7
People Area Score	7.0
Process Area Score	6.2
Product Area Score	3.9
Risk Area Score	5.6
PME Score	5.9
Rounded PME Score	6
Project’s Overall Success Rating	7

Table 21. Project D Data in Tabular Form

5. Project E

The goal in this project was to create and deliver a system that would perform sales order management and “pick and pack” operations in the packaging and distribution center, while creating a new hardware and network infrastructure for the client’s IT people. The study participant was the quality and metrics subject matter expert of the project.

This project suffered a significant schedule slip. The schedule overrun was 267%. The project was originally planned for completion in nine months. However, it took twenty-four months to complete. The project was developed between August 1993 and July 1995. The projected effort was 180 man-months, while the actual became 360 man-months. In addition, only 70% of the functionality in the initial baseline was delivered. The product size was over than 10,000 function points. The total number of people involved in this development effort was forty-three. The participant did not reveal the budget and the cost of the project. This project was developed by a major commercial software development company in the U.S.

A brief interview was conducted with the study participant after the completion of PME. The study participant viewed the project as a failure even though the company delivered the project. The participant indicated that the root cause for the failure of the project was that the chief architect ran away with the project. The project became his, not the project manager’s project.

The study participant rated the overall success of the project with a “3.” The PME score for this project was a “5.”

Timeframe of the Project E	1993-1995
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	24 Months / 167%
Functionality Delivered	70%
Size of the Product	10,000 + FP
Average Number of People Involved in the Project	N/A
Number of People Involved in Requirements Phase	4
Number of People Involved in Design Phase	4
Number of People Involved in Implementation Phase	20
Number of People Involved in Testing and Delivery Phase	15
Communication Area Score	6.3
Teamwork Area Score	7.1
Leadership Area Score	5.0
Organizational Commitment Area Score	8.1
Project Manager Area Score	6.7
Stakeholder Involvement Area Score	5.7
Staffing and Hiring Area Score	6.1
Requirements Management Area Score	3.8
Project Planning and Estimation Area Score	7.1
Project Monitoring and Control Area Score	5.2
Scope Management Area Score	4.2
Configuration Management Area Score	2.2
Quality Engineering Area Score	7.1
Risk Assessment Area Score	3.7
Risk Control Area Score	3.7
People Area Score	6.4
Process Area Score	5.1
Product Area Score	4.6
Risk Area Score	3.7
PME Score	5.2
Rounded PME Score	5
Project's Overall Success Rating	3

Table 22. Project E Data in Tabular Form

6. Project F

The goal in this project was to create a new version of an existing contact center application for sales to customers throughout the world. The application is based on C++ and Java, and has elements that involve VoIP telephony, as well as thin- and thick-clients. The deliverables of the project included the application, documentation, and statistical information to the business partner, including defect trends, test reports, etc. The study participant was the program and engineering manager of the project.

This project took place between July 2007 and July 2008. The original schedule planned completion in ten months. However, the project took twelve months to complete. The projected effort in this project was 220 man-months while the actual effort was 275 man-months. The study participant did not reveal budget and cost data for the project because of privacy reasons. The company delivered 95% of the functionality in the initial baseline. The average number of people involved in this project was twenty. This project was developed by a commercial company in the U.S.

An interview could not be conducted with the participant after the study. Also, the participant did not provide any special remarks on this project.

The study participant rated the overall success of the project with a “7.” The PME score for this project was a “6.”

Timeframe of the Project F	2007-2008
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	12 Months / 20%
Functionality Delivered	95%
Size of the Product	N/A
Average Number of People Involved in the Project	20
Number of People Involved in Requirements Phase	5
Number of People Involved in Design Phase	14
Number of People Involved in Implementation Phase	16
Number of People Involved in Testing and Delivery Phase	22
Communication Area Score	6.1
Teamwork Area Score	6.4
Leadership Area Score	7.9
Organizational Commitment Area Score	6.4
Project Manager Area Score	7.7
Stakeholder Involvement Area Score	3.4
Staffing and Hiring Area Score	6.3
Requirements Management Area Score	4.8
Project Planning and Estimation Area Score	4.9
Project Monitoring and Control Area Score	6.6
Scope Management Area Score	4.9
Configuration Management Area Score	4.0
Quality Engineering Area Score	7.2
Risk Assessment Area Score	5.6
Risk Control Area Score	5.4
People Area Score	6.3
Process Area Score	5.3
Product Area Score	5.6
Risk Area Score	5.5
PME Score	5.7
Rounded PME Score	6
Project’s Overall Success Rating	7

Table 23. Project F Data in Tabular Form

7. Project G

The goal in this project was to deliver an upgrade for a command and control system for an air training range. Real-time software was developed and delivered. The study participant was the technical manager of this project.

The project took place between September 1982 and July 1983. The projected schedule was ten months and the project was completed in ten months. In this project, there was going to be a schedule slip; however, the functionality was cut down and the project was delivered at the end of the schedule. 70% of the functionality from the initial baseline was delivered in this project. The projected and the actual cost data was not revealed by the study participant. The projected effort in this project was 96 man-months and the actual effort was 96 man-months. The average number of people involved in this project was ten. 16,000 lines of code were delivered with the product. This project was developed by a major software company in the U.S.

A brief interview was conducted with the study participant after the completion of SPMEI. The participant indicated that this was an interesting project from a project management perspective. At the start of the project, even though the entire technical team objected to the budget and schedule, the company management signed up to deliver all of the functionality and other deliverables the customer wanted. The technical team assured the management it was not possible to deliver all functionality requested within the budget and schedule given. As a technical manager, the participant was criticized for being behind in project status meetings the first several months. There were three tasks out of ten the technical team had not started to work on. By the fourth to fifth months into the contract, the customer had failed to deliver the needed interface control documents for interfaces the three tasks required. These tasks were the ones the project team had not started to work on. By the end of the contract, the customer was happy with the functionality delivered, and agreed that their failure to deliver the needed interface control documents was an adequate basis for the non-completion of three of the ten tasks. The other seven tasks were delivered successfully.

The study participant rated the overall success of the project with an “8.” The PME score for this project was “7.”

Timeframe of the Project G	1982-1983
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	10 Months / On Time
Functionality Delivered	70%
Size of the Product	16 KLOC
Average Number of People Involved in the Project	10
Number of People Involved in Requirements Phase	8
Number of People Involved in Design Phase	10
Number of People Involved in Implementation Phase	10
Number of People Involved in Testing and Delivery Phase	10
Communication Area Score	5.0
Teamwork Area Score	5.9
Leadership Area Score	5.9
Organizational Commitment Area Score	5.7
Project Manager Area Score	6.6
Stakeholder Involvement Area Score	5.4
Staffing and Hiring Area Score	6.6
Requirements Management Area Score	7.0
Project Planning and Estimation Area Score	6.3
Project Monitoring and Control Area Score	7.0
Scope Management Area Score	6.1
Configuration Management Area Score	8.2
Quality Engineering Area Score	7.5
Risk Assessment Area Score	6.8
Risk Control Area Score	5.9
People Area Score	5.9
Process Area Score	6.6
Product Area Score	7.8
Risk Area Score	6.4

PME Score	6.6
Rounded PME Score	7
Project's Overall Success Rating	8

Table 24. Project G Data in Tabular Form

8. Project H

The goal in this project was to develop Navy command control software for service oriented based object management and data fusion over low bandwidth IP-based data links. The study participant was the project manager of the project.

The project was developed between July 2003 and July 2005. The projected schedule was twenty-four months and the project took twenty-four months to complete, so the project did not suffer from a schedule overrun. The projected budget was $3.2 million and the cost of the project was the same. There was a slight overrun in terms of effort: the projected effort was 200 man-months, while the actual effort was 230 man-months. 90% of the functionality from the initial baseline was delivered at the end. The average number of people involved in this project was eight. The project size was 10,000 lines of code and fifty function points. This project was developed by a government organization in the U.S.

A brief interview was conducted with the participant after this survey study. The participant viewed the project as a success overall. The participant indicated that they used very expensive and talented developers in this project. They also kept the team size small and kept the requirements tight. In this project, they were challenged by keeping the developers interacting with the users. A unique aspect of this project is that the system ended up transitioning for a different user than originally intended.

The study participant rated the overall success of the project with a "7." The PME score for this project was "6."

Timeframe of the Project H	2003-2005
Location	U.S.A.
Actual Cost/ Cost Overrun	$3.2 Million / None
Actual Schedule/Schedule Overrun	24 Months / On Time
Functionality Delivered	90%
Size of the Product	10 KLOC / 50 FP
Average Number of People Involved in the Project	8
Number of People Involved in Requirements Phase	2
Number of People Involved in Design Phase	2
Number of People Involved in Implementation Phase	4
Number of People Involved in Testing and Delivery Phase	5
Communication Area Score	6.2
Teamwork Area Score	5.7
Leadership Area Score	5.9
Organizational Commitment Area Score	5.3
Project Manager Area Score	6.4
Stakeholder Involvement Area Score	7.2
Staffing and Hiring Area Score	4.6
Requirements Management Area Score	5.3
Project Planning and Estimation Area Score	6.2
Project Monitoring and Control Area Score	5.1
Scope Management Area Score	3.7
Configuration Management Area Score	5.5
Quality Engineering Area Score	5.5
Risk Assessment Area Score	5.0
Risk Control Area Score	6.3
People Area Score	5.9
Process Area Score	5.1
Product Area Score	5.5
Risk Area Score	5.7
PME Score	5.5
Rounded PME Score	6
Project's Overall Success Rating	7

Table 25. Project H Data in Tabular Form

9. Project I

The goal in this project was to automate 100 million paper records in U.S. telephone companies and streamline administrative functions. This was a very large-scale project. The study participant was the project manager of the project.

This project was the biggest project in this data set in terms of cost, scope and number of people involved in its development. It was considered a big success by the project manager. The developed system was successfully used for twenty years. The cost of the project was $1 billion and it saved $1 billion every year. The return on investment from this project was multiplied every year. In addition, it has the highest PME score within this data set.

This project was undertaken between 1980 and 1983. It was one of the biggest projects of its time. When the project started, it was not even known whether it could be accomplished or not. There had been five attempts on the project before and all of them failed. The projected schedule was thirty-six months. At the end of the schedule, it was understood that additional functionality was needed for the system to be used effectively. Therefore, the schedule was extended to forty-eight months. At the end of this updated schedule, because of the functionality added to the baseline, the overall functionality delivered became 150% when compared to initial baseline. The projected effort for this project was 1,000 man-months. The total cost of the project was $1 billion. The average number of people involved in this development effort was 300. This project was developed in the U.S. and it became the infrastructure for the telephone companies in the U.S.

A brief interview was conducted with the project manager. In addition, the study participant provided the author with a report on the project. This report, dated 2000, was a detailed analysis of the project prepared in a semester by four students. Therefore, there was abundant information. The study participant indicated that this project was a big success and it saved $1 billion a year after it was in use. The project manager and his second level managers were well rewarded with promotions and other compensation. In this project, risks were managed with a semi-formal action item tracking and each item was carefully tracked. Configuration management was executed by a special group of software manufacturers. The findings of the report provided more detail on the project. Because of the earlier failed attempts on the project, the company knew the complexity and the uncertainty surrounding this project. They took the project very seriously from the start. This project was so important that the survival of the customer depended on its successful completion and deployment. Therefore, cost was not an issue and schedule was only an issue to a certain extent. Full delivery of the necessary functionality and successful operation of the deployed systems were of the utmost importance for survival. The project manager indicated that because of this he was allowed to have as many people and resources as he needed at his disposal in this project. The customer was a telephone company in this project. The customer's operations were manual at the time and these manual operations were no longer able to sustain the needs of the company.

Effective communication was an important success factor in this project. There were bi-weekly meetings with broad inclusion of managers, executive management, customer, users, and project team members. In the weeks that there were no meetings, the project manager and his development managers published a project newsletter. This bi-weekly newsletter informed all interested parties of the hot topics and important issues of the project. The project manager, including development managers, nourished an open project environment in which project problems were openly reported and discussed.

At the beginning of the project, there were two separate teams for the development of the project. One of the teams had competent and skillful management but lacked talented developers with the necessary skills for the project. The other team was just the opposite, and was composed of talented and skilful developers with poor management. The project manager established a project organization out of these two teams by switching the necessary people to form a team of talented, skillful, and competent managers and technicians.

Effective communication also brought the support of executive management and users. The deployed system was adapted quickly by the users since their inputs were valued from the start of the project. The need for survival also brought support.

This project was quite a challenging one which had been attempted earlier and failed. The project team was aware of this challenge. There were also unproven technologies involved in the development. This was the first time relational databases were to be used in such a commercial project. This made the project interesting for the talented developers. There were social considerations as well. Involvement in a project of this scale and the successful completion of it may be considered a reward.

The project managers and other managers in this project were quite talented and competent. They protected the team from outside interference and unnecessary politics. They employed various techniques to motivate the team. One of them was "punishment through embarrassment." Whenever a project team member could not accomplish what he was supposed to, the project manager would openly, yet jocularly, ridicule the team member in front of his or her peers. Rather than using harsh remarks or other forms of punishment, this technique made the team comfortable with each other. They were able to laugh at their mistakes and openly discuss project problems.

Gantt charts were used in monitoring and managing the project. The project manager felt that PERT charts were too complicated and would lead to spending too much time on reports instead of working on the project. He also thought that PERT charts may have had a demoralizing effect on team members. Therefore, monitoring of the project was done via periodic updates by team members and reflected on Gantt charts. In project resource and schedule estimations, a bottom-up approach is used. The developers and team members were asked for estimations.

This project was so successful that the system developed was still in use in 2000. The study participant rated the overall success of the project with a "10." The PME score for this project was "8," which is the highest score in this data set.

Timeframe of the Project I	1980-1983
Location	U.S.A.
Actual Cost/ Cost Overrun	$1 Billion / N/A
Actual Schedule/Schedule Overrun	36 Months / On Time
Functionality Delivered	150%
Size of the Product	N/A
Average Number of People Involved in the Project	300
Number of People Involved in Requirements Phase	25
Number of People Involved in Design Phase	100
Number of People Involved in Implementation Phase	300
Number of People Involved in Testing and Delivery Phase	300
Communication Area Score	7.8
Teamwork Area Score	8.0
Leadership Area Score	6.9
Organizational Commitment Area Score	7.5
Project Manager Area Score	9.1
Stakeholder Involvement Area Score	8.9
Staffing and Hiring Area Score	7.2
Requirements Management Area Score	7.3
Project Planning and Estimation Area Score	7.9
Project Monitoring and Control Area Score	7.9
Scope Management Area Score	6.9
Configuration Management Area Score	8.5
Quality Engineering Area Score	8.1
Risk Assessment Area Score	7.6
Risk Control Area Score	8.1
People Area Score	7.9
Process Area Score	7.5
Product Area Score	8.3
Risk Area Score	7.9
PME Score	7.9
Rounded PME Score	8
Project's Overall Success Rating	10

Table 26. Project I Data in Tabular Form

10. Project J

The goal in this project was to create an online, real-time, credit card authorization switching system. The system was to enable merchants who accept credit cards to get quick authorizations from the banks issuing the credit cards. This was a mainframe software and hardware project. The study participant was the project manager of this project.

This project was developed between 1976 and 1977. The projected schedule was twelve months and the project took twelve months to complete. The projected budget was $3.7 million while the actual cost was only $3.5 million. All of the functionality from the initial baseline was delivered at the end of the project. The average number of people involved in this project was seventeen. This project was developed by a major software development company in the U.S.

The study participant explicitly indicated that this was a very successful project. When the study participant was asked about the size of the product in terms of lines of code, the participant indicated that he did not have a clue. In this project, a substantial amount of work went into the technology, not the application code. Therefore, projecting the size of the project from the code size would be quite misleading in this particular case. For example, in this project the project team took an airline control program, used by the largest airlines in their reservation systems, and down-scaled it to run on a much a smaller mainframe. Because this mini airline control program needed a dedicated environment for testing, they had to set up virtual machines using a particular operating system. The actual application code was comparatively simple. The study participant indicated that all people involved in this project, both the developers and the customer, were very motivated to succeed. Everyone was dedicated and worked whatever hours were required to meet deadlines. There was none of the personal competition or positioning that seems to exist in some projects. The will to succeed and the fear of failure overwhelmed any personal motivations.

The author observed that when a project was developed in the past and its successful operation was proven throughout the years, the participants would declare the success of the project openly with pride.

The study participant rated the overall success of the project with a "10." The PME score for this project was "7."

Timeframe of the Project J	1976 - 1977
Location	U.S.A.
Actual Cost/ Cost Overrun	$4.7 Million / None
Actual Schedule/Schedule Overrun	12 Months / On Time
Functionality Delivered	100%
Size of the Product	N/A
Average Number of People Involved in the Project	17
Number of People Involved in Requirements Phase	5
Number of People Involved in Design Phase	3
Number of People Involved in Implementation Phase	20
Number of People Involved in Testing and Delivery Phase	15
Communication Area Score	8.8
Teamwork Area Score	7.8
Leadership Area Score	7.9
Organizational Commitment Area Score	8.0
Project Manager Area Score	8.6
Stakeholder Involvement Area Score	6.8
Staffing and Hiring Area Score	6.8
Requirements Management Area Score	6.8
Project Planning and Estimation Area Score	7.4
Project Monitoring and Control Area Score	7.0
Scope Management Area Score	5.8
Configuration Management Area Score	5.5
Quality Engineering Area Score	8.4
Risk Assessment Area Score	4.9
Risk Control Area Score	6.1
People Area Score	7.8
Process Area Score	6.7
Product Area Score	6.9
Risk Area Score	5.5
PME Score	6.9

Rounded PME Score	7
Project's Overall Success Rating	10

Table 27. Project J Data in Tabular Form

11. Project K

In this survey study, the participant was quite concerned about the privacy of the organization. Therefore, the participant did not report the goal and the deliverables of the project. In addition, the participant did not report the projected budget and actual cost of the project. This data might lead to identification of the organization and the participant thought that this specific data might have implications on the organization's competitive advantage. The study participant was the project manager of this project.

This project was conducted between 2006 and 2008. The projected schedule was twenty-four months and the project took twenty-four months. There was no schedule slip at the end. The projected effort for the project was 172 man-months while the actual effort was 174 man-months. 100% of the functionality in the initial baseline was delivered at the end of the project. The average number of people involved in the development was seven. The product size was 215,400 lines of code. This project was developed by a company in Turkey.

An interview could not be conducted with the study participant after the completion of SPMEI.

The study participant rated the overall success of the project with a "9." The PME score for this project was "7."

Timeframe of the Project K	2006-2008
Location	Turkey
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	24 Months / On Time
Functionality Delivered	100%
Size of the Product	215.4 KLOC
Average Number of People Involved in the Project	7
Number of People Involved in Requirements Phase	5
Number of People Involved in Design Phase	7
Number of People Involved in Implementation Phase	8
Number of People Involved in Testing and Delivery Phase	7
Communication Area Score	6.8
Teamwork Area Score	6.9
Leadership Area Score	7.4
Organizational Commitment Area Score	6.9
Project Manager Area Score	7.4
Stakeholder Involvement Area Score	6.0
Staffing and Hiring Area Score	6.5
Requirements Management Area Score	7.2
Project Planning and Estimation Area Score	6.6
Project Monitoring and Control Area Score	6.2
Scope Management Area Score	6.3
Configuration Management Area Score	8.7
Quality Engineering Area Score	6.9
Risk Assessment Area Score	6.4
Risk Control Area Score	4.6
People Area Score	6.8
Process Area Score	6.6
Product Area Score	7.8
Risk Area Score	5.5
PME Score	6.7
Rounded PME Score	7
Project’s Overall Success Rating	9

Table 28. Project K Data in Tabular Form

12. Project L

The goal in this project was to develop various subsystems of a large-scale real-time defense system. The deliverables were the subsystems developed with all produced life-cycle documents. This project was a subcontracted portion of a large-scale system. The study participant was the project manager of this development effort.

This project was conducted between 2003 and 2005. The projected schedule was twenty-four months; however, the project took thirty months to complete. There was a 25% schedule overrun. The projected effort for this development effort was 1,024 man-months while the actual effort was much less than 700 man-months. The budget and the cost of the project will not be reported here at the request of the study participant. However, it is possible to report that the project was completed under budget. All of the functionality requested was delivered at the end of the project. Eight-hundred people had worked on the development of this large-scale project. The average number of people involved in this subcontracted portion of the development was twenty-five. The product size at the end of this development effort was 440,000 lines of code. This project was developed by a company in Turkey.

An interview could not be conducted with the study participant after the completion of SPMEI.

The study participant rated the overall success of the project with a “7.” The PME score for this project was “6.”

Timeframe of the Project L	2003-2005
Location	Turkey
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	30 Months / 25%
Functionality Delivered	100%
Size of the Product	440 KLOC
Average Number of People Involved in the Project	25
Number of People Involved in Requirements Phase	100
Number of People Involved in Design Phase	250
Number of People Involved in Implementation Phase	350
Number of People Involved in Testing and Delivery Phase	100
Communication Area Score	5.1
Teamwork Area Score	5.7
Leadership Area Score	6.6
Organizational Commitment Area Score	6.5
Project Manager Area Score	6.3
Stakeholder Involvement Area Score	4.2
Staffing and Hiring Area Score	5.7
Requirements Management Area Score	6.1
Project Planning and Estimation Area Score	5.2
Project Monitoring and Control Area Score	5.6
Scope Management Area Score	3.4
Configuration Management Area Score	8.0
Quality Engineering Area Score	6.2
Risk Assessment Area Score	3.8
Risk Control Area Score	3.7
People Area Score	5.7
Process Area Score	5.1
Product Area Score	7.1
Risk Area Score	3.7
PME Score	5.5
Rounded PME Score	6
Project's Overall Success Rating	7

Table 29. Project L Data in Tabular Form

13. Project M

The goal of this project was to develop a prototype system for secure data transfer for a communication system. This project was a mix of software and hardware development. The deliverables included the prototype and all the documents produced during the life cycle of the project. The participant in this study was the project manager of this development effort.

This project was developed in 2006. The projected schedule was six months and the actual schedule was seven months. The projected effort in this project was forty-eight man-months, though the actual effort became fifty man-months. Even though the planned budget and actual cost were reported, they will not be stated here for privacy reasons. However, it is possible to state that the project had a slight overrun in the budget. 95% of the functionality from the initial baseline was delivered at the end of the project. The average number of people involved in the development effort was four. This project was developed by a government organization in Turkey.

A detailed interview was conducted with the project manager of this project. After the completion of this project, the developed prototype was accepted by the organization for full-scale production. Therefore, the project may be considered as a success. The project manager indicated that the organization was new to the domain of the problem to be solved in this project. Thus, there were some risks involved and the organization started with a prototype. The executive management was aware of these risks and there was significant support for the successful completion of the project. In the early phases of development, the project team conducted detailed analysis on the problem and on the solution. The risk items were identified early and incorporated into a risk management plan. These project risks were avoided whenever possible or risk mitigation techniques were used to reduce their severity. The project manager mentioned that he advocates the use of small teams with talented and skillful developers when the environment allows. Building small but effective teams is an approach used by many accomplished project managers. The small team size with skillful developers increased the communication effectiveness in this project. He pointed out that the level of teamwork achieved in this project was high and the project environment was friendly. The project manager also indicated that developers participated in the project decisions. In addition to these positive features, the executive management was very supportive. The organization was committed to the success of the project. These were among the main factors in reaching the successful outcome. Naturally, there were challenges during project development. This project required cooperation from various organizations. As expected, achieving cooperation was not an easy task. However, they were able to overcome these challenges with the support of executive management.

The study participant rated the overall success of the project with an “8.” The PME score for this project was “6.”

Timeframe of the Project M	2006
Location	Turkey
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	7 Months / 17%
Functionality Delivered	95%
Size of the Product	115 KLOC
Average Number of People Involved in the Project	4
Number of People Involved in Requirements Phase	4
Number of People Involved in Design Phase	4
Number of People Involved in Implementation Phase	3
Number of People Involved in Testing and Delivery Phase	4
Communication Area Score	6.3
Teamwork Area Score	7.6
Leadership Area Score	8.1
Organizational Commitment Area Score	7.4
Project Manager Area Score	7.8
Stakeholder Involvement Area Score	6.3
Staffing and Hiring Area Score	6.4
Requirements Management Area Score	6.1
Project Planning and Estimation Area Score	5.9
Project Monitoring and Control Area Score	6.4
Scope Management Area Score	5.8
Configuration Management Area Score	5.0
Quality Engineering Area Score	5.4
Risk Assessment Area Score	6.2
Risk Control Area Score	5.0
People Area Score	7.1
Process Area Score	6.0
Product Area Score	5.2
Risk Area Score	5.6
PME Score	6.1
Rounded PME Score	6
Project's Overall Success Rating	8

Table 30. Project M Data in Tabular Form

14. Project N

The goal of this project was to develop $16 million worth of software upgrade to a bomber airplane. The upgrade was to be conducted on various functions of the bomber plane. Naturally, this project was a defense project. The participant in this study was the program manager of the project.

This project was developed between 2000 and 2002. The projected schedule was twenty-four months and the actual schedule was twenty-four months. The planned budget and the actual cost of the project were $16 million. So, this project did not suffer from a schedule or a cost overrun. However, only 98% of the functionality from the initial baseline was delivered. The average number of people involved in this development effort was nine. This project was developed as a government project in the U.S. It included developers from the government agency and contractors from the commercial world.

A brief interview was conducted with the study participant. This project was challenged in a couple ways. During the development effort, the project manger changed more than once. The study participant indicated that when she took over, the project was behind schedule and probably heading for a cost overrun. She pressured the contractors and in-house developer for better performance. The strategy she used was “manage by walking around” to get the project back on schedule. She was among the developers almost all the time. This is a strategy sometimes employed by various project managers. When the conditions are right, this strategy helps boost performance as it is observed in this case.

The study participant rated the overall success of the project with a “9.” The PME score for this project was “8.”

Timeframe of the Project N	2000-2002
Location	U.S.A.
Actual Cost/ Cost Overrun	$16 Million / None
Actual Schedule/Schedule Overrun	24 Months / On Time
Functionality Delivered	98%
Size of the Product	N/A
Average Number of People Involved in the Project	9
Number of People Involved in Requirements Phase	5
Number of People Involved in Design Phase	15
Number of People Involved in Implementation Phase	10
Number of People Involved in Testing and Delivery Phase	8
Communication Area Score	9.2
Teamwork Area Score	7.6
Leadership Area Score	9.1
Organizational Commitment Area Score	6.6
Project Manager Area Score	9.2
Stakeholder Involvement Area Score	7.5
Staffing and Hiring Area Score	5.8
Requirements Management Area Score	8.0
Project Planning and Estimation Area Score	7.3
Project Monitoring and Control Area Score	8.1
Scope Management Area Score	7.7
Configuration Management Area Score	7.2
Quality Engineering Area Score	7.3
Risk Assessment Area Score	8.1
Risk Control Area Score	8.0
People Area Score	7.9
Process Area Score	7.8
Product Area Score	7.2
Risk Area Score	8.0
PME Score	7.8
Rounded PME Score	8
Project's Overall Success Rating	9

Table 31. Project N Data in Tabular Form

15. Project O

The goal of this project was to develop a web application to collect and analyze security related data over a secure network. The participant in this study was the development lead of the project.

This project was developed between 2005 and 2007. The projected schedule was twenty-four months and actually took thirty months to complete. The budget and the actual cost of the project were not reported. This is either because of privacy concerns or because the study participant does not have access to this specific information since the data related to the cost of the project is governed by a different group in the government agency. In some government projects, cost is not a priority. The priority is acquiring the necessary system or the functionality. 80% of the functionality from the initial baseline was delivered at the end of the project. The average number of people involved in the development effort was around six to ten. The study participant did not provide this data either. Instead, the participant indicated that overall twenty-nine people were involved in various aspects of the project. This project was developed by a government agency in the U.S. Developers from the government agency and contractors worked on the project.

An interview could not be conducted with the study participant.

The study participant rated the overall success of the project with a "7." The PME score for this project was "7."

Timeframe of the Project O	2005-2007
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	30 Months / 25%
Functionality Delivered	80%
Size of the Product	N/A
Average Number of People Involved in the Project	N/A
Number of People Involved in Requirements Phase	6
Number of People Involved in Design Phase	6
Number of People Involved in Implementation Phase	12
Number of People Involved in Testing and Delivery Phase	5
Communication Area Score	6.3
Teamwork Area Score	6.5
Leadership Area Score	6.3
Organizational Commitment Area Score	7.9
Project Manager Area Score	8.1
Stakeholder Involvement Area Score	6.5
Staffing and Hiring Area Score	7.9
Requirements Management Area Score	9.2
Project Planning and Estimation Area Score	7.1
Project Monitoring and Control Area Score	5.8
Scope Management Area Score	5.6
Configuration Management Area Score	8.2
Quality Engineering Area Score	6.8
Risk Assessment Area Score	6.2
Risk Control Area Score	5.0
People Area Score	7.1
Process Area Score	6.9
Product Area Score	7.5
Risk Area Score	5.6
PME Score	6.9
Rounded PME Score	7
Project's Overall Success Rating	7

Table 32. Project O Data in Tabular Form

16. Project P

The goal of this project was to rewrite a post-flight data analysis system. The system includes an ORACLE database, a robotic storage subsystem and various applications. Some of these FORTRAN applications were rewritten in C. The study participant in this study was the lead post-flight analyst of the development.

The project took place between 1994 and 1995. The projected schedule was not reported by the study participant, but the actual schedule of the project was fourteen months. The budget and the actual cost of the project were not reported. This is probably due to the fact that the study participant did not have access to such data. This project was developed by a government agency and sometimes in these types of projects, the cost data is kept by another branch in the agency. In addition, acquiring the necessary functionality has a higher priority than the cost of the project. All of the functionality in the baseline was delivered at the end of the project. The average number of people involved in this project was ten. This project was developed by a government agency in the U.S.

An interview could not be conducted with the study participant.

The study participant rated the overall success of the project as a “9.” The PME score for this project was “9.”

Timeframe of the Project P	1994-1995

Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	14 Months / 17%
Functionality Delivered	100%
Size of the Product	N/A
Average Number of People Involved in the Project	10
Number of People Involved in Requirements Phase	10
Number of People Involved in Design Phase	10
Number of People Involved in Implementation Phase	5
Number of People Involved in Testing and Delivery Phase	5
Communication Area Score	9.0
Teamwork Area Score	9.6
Leadership Area Score	9.1
Organizational Commitment Area Score	10.0
Project Manager Area Score	9.6
Stakeholder Involvement Area Score	8.3
Staffing and Hiring Area Score	9.8
Requirements Management Area Score	9.7
Project Planning and Estimation Area Score	8.7
Project Monitoring and Control Area Score	8.1
Scope Management Area Score	7.9
Configuration Management Area Score	9.3
Quality Engineering Area Score	9.7
Risk Assessment Area Score	8.5
Risk Control Area Score	5.6
People Area Score	9.4
Process Area Score	8.6
Product Area Score	9.5
Risk Area Score	7.0
PME Score	8.8
Rounded PME Score	9
Project’s Overall Success Rating	9

Table 33. Project P Data in Tabular Form

17. Project R

In this survey study, the study participant and his executive manager were very much concerned with the privacy of the organization. Therefore, they did not report many of the overall project statistics such as the budget, cost, schedule, number of people involved, etc. In fact, the executive manager said that this type of information was only accessible to certain people in the organization. Their company policy strictly prohibits releasing such information to third parties. Due to lack of data, this project could not be categorized. So, this survey study was excluded from the main dataset. However, there is an important piece of information gathered as the result of this study. This project was developed by an organization with a CMMI level 5 rating. Consequently, it is expected that the project management effectiveness in this software project was high. The results of the study confirmed what was expected — this project reached the highest project management effectiveness score among the projects analyzed in this research. The PME score for this project was "9."

The goal in this project was to develop an electronic warfare training simulation system to train military personnel for electronic warfare concepts and operations. The study participant was the project manager of this project. The communication for the participation to the study was first directed to the public relations officer of the company. The public relations officer passed the request to the executive manager of the project manager. The executive manager analyzed the request and agreed to participation in the study and after that, the executive manager acted as an intermediary during the study. The professionalism in this process was an indication of the established corporate culture of this organization.

A detailed interview was conducted with the study participant. The participant indicated that this project was his first project as a project manager in this organization. He also mentioned that he worked in other organizations prior to joining his current organization. The participant pointed out that the commitment to excellence in this organization especially by the executive management was notable. The organization has a CMMI level 5 rating and other quality certifications. In addition, the executive management was committed to excellence and quality in every aspect of software project development. The study participant said that the project was overseen by an oversight committee. This oversight committee was internal to the organization but external to the project team. The task of the committee was to ensure that necessary and adequate processes were in place to achieve high quality in project management and software development. This committee would not allow the projects to derail.

In this project, the project team consisted of talented and experienced developers. However, the developers were not familiar with the domain. Therefore, there was a learning curve during the development. The productivity was low compared to other projects at the beginning, but when the developers became familiar with the domain, the productivity quickly boosted. Another challenging part of this project was that the project required increased coordination among various stakeholders. There were more than a couple of organizations on the client side. Logistics such as traveling and arrangement of meetings was an issue in this project. The support from executive management helped to overcome these challenges.

The study participant indicated that the coverage of SPMEI was good. He mentioned that SPMEI covered most essential project management areas. Since the organization has recognized quality certifications, strict quality controls and good software development processes and procedures were already in place. Most of these were covered in SPMEI, so it was easy for him to respond to SPMEI. In addition, he mentioned that SPMEI pointed out some practices they were not employing at the time. Some of these are people management related practices. According to him, these were good to know.

The study participant rated the overall success of the project with a “7.” The PME score for this project was “9.”

Timeframe of the Project R	N/A
Location	Europe
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	N/A
Functionality Delivered	N/A
Size of the Product	N/A
Average Number of People Involved in the Project	N/A
Number of People Involved in Requirements Phase	N/A
Number of People Involved in Design Phase	N/A
Number of People Involved in Implementation Phase	N/A
Number of People Involved in Testing and Delivery Phase	N/A
Communication Area Score	9.5
Teamwork Area Score	8.4
Leadership Area Score	7.6
Organizational Commitment Area Score	8.2
Project Manager Area Score	7.3
Stakeholder Involvement Area Score	9.6
Staffing and Hiring Area Score	7.6
Requirements Management Area Score	9.2
Project Planning and Estimation Area Score	8.4
Project Monitoring and Control Area Score	9.3
Scope Management Area Score	7.6
Configuration Management Area Score	9.0
Quality Engineering Area Score	9.8
Risk Assessment Area Score	9.6
Risk Control Area Score	6.9
People Area Score	8.3
Process Area Score	8.6
Product Area Score	9.4
Risk Area Score	8.2
PME Score	8.6
Rounded PME Score	9
Project’s Overall Success Rating	7

Table 34. Project R Data in Tabular Form

18. Project X

The goal in this project was to add functionality to an existing system. The system was a hospital's patient admission system. The new functionality was to improve the admission system with enhanced statistical analysis capabilities. The final product included the executables, source code and a manual. This application was not intended to be a commercial product, but an experimental tool to be used by management scientists and hospital management. The study participant was the analyst and the developer of the project.

This project was developed in 2007. The projected schedule was three months, and the project was completed in only two months. The planned effort was two man-months and the actual effort was 1.5 man-months. The budget and the cost of the project were not reported. 95% of the functionality in the baseline was delivered. The average number of people involved in the development of this project was two. Only one developer was used in the design and implementation phase. Only three people were involved in the overall project. The size of the product was 4,489 lines of code. This project was mainly developed by a graduate student in an academic environment in the United Kingdom.

The study participant rated the overall success of the project with an ".8. The PME score for this project was a "4."

The metric proposed in this doctoral research is not applicable to this project. Even though the metric is applicable to a wide variety of software projects, of course there are exceptions. Even a brief introduction of the project presented above explains why this metric is not applicable in this specific case. For the most part, the project was developed by only one person. It is likely that the graduate student developed the project in addition to his other responsibilities. The total effort was only 1.5 man-months and the project was developed in just two months. Basically, this was a small maintenance effort to enhance some of the functionality in an existing system. There was no project plan. No project management data or metrics gathered. There was no requirements change and control process, no risk management process, no configuration management process, no scope and baseline tracking process. No project estimation was used. A detailed analysis of the responses would reveal why the metric is not applicable. Therefore, in this project expectance of a full-scale project management effort and trying to measure its effectiveness would be far from meaningful. This survey study is included here in order to show an example of the cases in which the metric is not applicable. It is likely this project was as a successful project. It is just that the metric proposed will not provide any meaningful measurement in this case.

There is also a more concrete way to identify whether the metric is applicable to a particular project or not. An analysis of the responses in the SPMEI would reveal the applicability. The number of “Not Applicable” responses is an indicator for applicability check. In this survey study, the participant responded with a “Not Applicable” to the statements and questions in approximately forty different instances. This number is much higher than the number of “Not Applicable” and “None” responses observed in the cases where the metric is applicable.

Timeframe of the Project X	2007
Location	UK
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	2 Months / On Time
Functionality Delivered	95%
Size of the Product	4.5 KLOC
Average Number of People Involved in the Project	2
Number of People Involved in Requirements Phase	2
Number of People Involved in Design Phase	1
Number of People Involved in Implementation Phase	1
Number of People Involved in Testing and Delivery Phase	2
Communication Area Score	6.3
Teamwork Area Score	6.7
Leadership Area Score	8.5
Organizational Commitment Area Score	6.7
Project Manager Area Score	7.2
Stakeholder Involvement Area Score	4.4
Staffing and Hiring Area Score	5.3
Requirements Management Area Score	4.6
Project Planning and Estimation Area Score	3.0
Project Monitoring and Control Area Score	2.8
Scope Management Area Score	2.8
Configuration Management Area Score	2.2
Quality Engineering Area Score	3.5
Risk Assessment Area Score	2.4
Risk Control Area Score	2.0
People Area Score	6.5
Process Area Score	3.3
Product Area Score	2.9
Risk Area Score	2.2
PME Score	4.1
Rounded PME Score	4
Project's Overall Success Rating	8

Table 35. Project X Data in Tabular Form

19. Project Y

The goal in this project was to create a Java batch application to process requests for printed letters to be generated. The deliverable was a JAR (Java Archive) file.

This project was conducted in 2008. The projected schedule was three months, yet the project was completed in only two months. The planned effort was 3.25 man-months and the actual effort was 2.25 man-months. The budget and the cost of the project were not known. All of the functionality was delivered at the end. The product size was only 1,500 lines of code. The total number of people involved in this effort was four. The calculated average number of people was 2.25. This project was developed in the U.S. as a government contract.

The study participant rated the overall success of the project with a “10.” The PME score for this project was a “4.”

This study is another example for a case in which the metric is not applicable. The final product in this project was a very small application. It is a batch application that processes outputs from other applications. This project may be viewed as a maintenance effort because of the application developed. The total effort was small, and the number of people involved in this effort was few. Most importantly, the project scope was very limited. In every aspect, this project is a small project. In these types of projects, there is no need for a full-blown project management effort. It may even get in the way of developers involved due to unnecessary overhead. Because the scope is small and the schedule is very short, it is even possible to start over if the project fails as the consequences of starting over would not be catastrophic compared to bigger projects.

Again, this survey study is included to show an example of the cases in which the metric is not applicable. There were over forty “Not Applicable” and “None” responses in the completed SPMEI.

Timeframe of the Project Y	2008
Location	U.S.A.
Actual Cost/ Cost Overrun	N/A
Actual Schedule/Schedule Overrun	2 Months / On Time
Functionality Delivered	100%
Size of the Product	1.5 KLOC
Average Number of People Involved in the Project	2
Number of People Involved in Requirements Phase	1
Number of People Involved in Design Phase	2
Number of People Involved in Implementation Phase	3
Number of People Involved in Testing and Delivery Phase	3
Communication Area Score	4.5
Teamwork Area Score	5.9
Leadership Area Score	5.1
Organizational Commitment Area Score	5.1
Project Manager Area Score	6.3
Stakeholder Involvement Area Score	4.7
Staffing and Hiring Area Score	5.3
Requirements Management Area Score	3.5
Project Planning and Estimation Area Score	4.1
Project Monitoring and Control Area Score	3.5
Scope Management Area Score	4.8
Configuration Management Area Score	3.5
Quality Engineering Area Score	4.0
Risk Assessment Area Score	3.6
Risk Control Area Score	4.4
People Area Score	5.3
Process Area Score	4.0
Product Area Score	3.7
Risk Area Score	4.0
PME Score	4.4
Rounded PME Score	4
Project's Overall Success Rating	10

Table 36. Project Y Data in Tabular Form

20. Project Z

The goal in this project was to develop an ALGOL compiler for a supercomputer. The participant was the project manager of this project.

This project was developed in between 1974 and 1975. The projected schedule was nine months, though the project took twelve months to complete. The planned effort for the project was nine man-months and the actual effort was eighteen man-months. The budget for the project was $50,000, while the cost of the project was $80,000. 95% of the functionality in the baseline was delivered at the end. The average number of people involved in the development of this project was four. This project was developed in the U.S. in an academic environment. The project manager and the developers were faculty and graduate students.

A brief interview was conducted with the project manager after the providing responses to SPMEI. The study participant indicated that this project was a small project done over thirty years ago when the participant was a highly inexperienced project manager. The three graduate students who were involved in the development were also highly inexperienced with real projects for real customers. The study participant indicated that they did not know how to run a real project and made all kinds of mistakes. On the other hand, the requirements in the project were relatively fixed which worked well for them. They had quite a challenge that contributed to late delivery and increased cost. The project team could not gain the necessary access to the target computer for which they were developing software. They could not execute the test runs as planned.

The study participant rated the overall success of the project with “8.” The PME score for this project was “4.”

The proposed metric is not applicable to this project for a couple of reasons. The main reason is that this project was developed in 1974. In those years, the body of knowledge in project management was quite limited when compared with our knowledge in that area today. SPMEI incorporates the state of art in project management. Most of the best practices inquired in a software project with SPMEI were not even known at the time. For example, SPMEI inquires whether earned value management is used in the project or not. When this project was being developed, earned value management was not introduced. Another example is level of automation used in the project management inquired in SPMEI in various project management areas. In 1974, the project team did not have the computer aided software engineering (CASE) tools used today. In addition, the development team was small and composed of graduate students and faculty. It is very likely that these people had other responsibilities unlike the people in various software development companies and organizations.

In addition, a detailed analysis of the responses in SPMEI will show why the metric is not applicable. There was no project plan in this effort, and the tasks and activities were identified as the project progressed. Project estimation techniques were not used and no project management data or metrics were gathered. There was no risk assessment and the risks were only identified as the project evolved. There were over twenty “Not Applicable” and “None” responses. This number is clearly higher than the projects for which the metric is applicable.

Timeframe of the Project Z	1974-1975
Location	U.S.A.
Actual Cost/ Cost Overrun	$80,000 / 60%
Actual Schedule/Schedule Overrun	12 Months / 34%
Functionality Delivered	95%
Size of the Product	N/A
Average Number of People Involved in the Project	4
Number of People Involved in Requirements Phase	4
Number of People Involved in Design Phase	4
Number of People Involved in Implementation Phase	4
Number of People Involved in Testing and Delivery Phase	4
Communication Area Score	4.6
Teamwork Area Score	4.9
Leadership Area Score	5.7
Organizational Commitment Area Score	6.2
Project Manager Area Score	5.7
Stakeholder Involvement Area Score	3.3
Staffing and Hiring Area Score	4.7
Requirements Management Area Score	4.8
Project Planning and Estimation Area Score	2.9
Project Monitoring and Control Area Score	2.2
Scope Management Area Score	3.0
Configuration Management Area Score	2.2
Quality Engineering Area Score	2.6
Risk Assessment Area Score	2.9
Risk Control Area Score	2.8
People Area Score	5.0
Process Area Score	3.2
Product Area Score	2.4
Risk Area Score	2.8
PME Score	3.6
Rounded PME Score	4
Project's Overall Success Rating	8

Table 37. Project Z Data in Tabular Form

D. DATA ANALYSIS

In the previous section, each project is presented in detail one-by-one. In this section, the data from survey studies will be analyzed as a dataset. In the rest of the section, "N/A" indicates "Not Available."

A total of twenty software projects were analyzed in this survey study. Sixteen of them were grouped together as a dataset, which includes Project A to Project P. It is observed that the metric is not applicable to three projects: Projects X, Y, and Z. In one study, the participant was not able to provide project data that would enable us to categorize the project. Therefore, this project, Project R, was excluded from the main dataset.

The projects in the dataset are a good mix of projects in many aspects. The dataset includes projects from every decade since the 1970s. In addition, most of the projects were developed in recent years. These projects provide an emphasis on the practices employed today in the software industry. The development length of the projects in the dataset varies from four months to three years. In the software industry, very few projects expand to more than three years of development time. Most of the study participants did not or could not report the cost of the projects. The study participants had privacy concerns. The rest of the projects show variability in cost. Almost all of the participants reported the percentage of delivered functionality compared to baseline. In most of the projects, more than 90% of the functionality from the initial baseline was delivered. Most of the projects were delivered on time. There were eight projects with a schedule overrun. All of them, except one, had less than 50% schedule overrun. The delivered systems or products include real-time systems, embedded systems, mission critical systems, information management systems, office automation systems, etc.

All of the projects in the dataset were developed in North America and Europe. The dataset does not include projects developed in Asia, South America and Australia. Today, a big portion of the software development efforts takes place in North America and Europe. However, China, India, Taiwan and some other countries have increased their share in the recent years. Future studies should include projects developed in these parts of the world.

Table 38 provides an overview of basic statistics gathered from the survey studies on software projects.

Project Identifier	**Time Frame**	**Projected/ Estimated Schedule (months)**	**Actual Schedule (months)**	**Schedule Overrun**	**Projected/ Planned Effort**	**Actual Effort**	**Projected/ Planned Budget**	**Actual Cost**	**Cost Overrun**	**Delivered Functionality**
Project A	2006	7	10	43%	N/A	N/A	$500K	$750K	50%	100%
Project B	2006	6	6	On Time	N/A	N/A	N/A	N/A	N/A	95%
Project C	2007-2009	12	17	42%	125	175	$3.5 M	$4.5 M	28.5%	100%
Project D	2006	6	4	On Time	24	16	$29K	$20K	None	100%
Project E	1993-1995	9	24	167%	180	360	N/A	N/A	N/A	70%
Project F	2007-2008	10	12	20%	220	275	N/A	N/A	N/A	95%
Project G	1982-1983	10	10	On Time	96	96	N/A	N/A	N/A	70%
Project H	2003-2005	24	24	On Time	200	230	$3.2 M	$3.2 M	0%	90%
Project I	1980-1983	36	36	On Time	1,000	1,000	N/A	$1 B	N/A	150%
Project J	1976-1977	12	12	On Time	N/A	N/A	$4.7 M	$4.5 M	None	100%
Project K	2006-2008	24	24	On Time	172	174	N/A	N/A	N/A	100%
Project L	2003-2005	24	30	25%	1,024	700	N/A	N/A	N/A	100%
Project M	2006	6	7	17%	48	50	N/A	N/A	N/A	95%
Project N	2000-2002	24	24	On Time	24	24	$16 M	$16 M	None	98%
Project O	2005-2007	24	30	25%	N/A	N/A	N/A	N/A	N/A	80%
Project P	1994-1995	12	14	17%	N/A	N/A	N/A	N/A	N/A	100%

Table 38. Overview of Projects in the Dataset

Table 39 shows an overview of data gathered from the studies in terms of the number of people involved in different phases of the project development, as well as the total and average number of people involved in the development effort. In most studies, the participants did not provide the total number of people involved in the project. On the other hand, almost all of the participants provided the average number of people involved in the project. Thus, it is possible to categorize the projects based on the average number of people involved.

Project Identifier	**Requirements Phase**	**Design Phase**	**Implementation Phase**	**Testing and Delivery Phase**	**Total Number of People Involved**	**Average Number of People Involved**
Project A	3	2	4	4	N/A	4
Project B	4	10	15	10	N/A	10
Project C	3	3	4	4	18	10
Project D	4	4	5	5	N/A	5
Project E	4	4	20	15	43	N/A
Project F	5	14	16	22	N/A	20
Project G	8	10	10	10	N/A	10
Project H	2	2	4	5	13	8
Project I	25	100	300	300	N/A	300
Project J	5	3	20	15	N/A	17
Project K	5	7	8	7	7	7
Project L	100	250	350	100	800	25
Project M	4	4	3	4	N/A	4
Project N	5	15	10	8	38	9
Project O	6	6	12	5	29	N/A
Project P	10	10	5	5	N/A	10

Table 39. Overview of Projects: Number of People Involved

Figure 37 presents the distribution of projects in terms of average number of people involved. The projects are divided into four size categories: small, medium, large and very large. A small size project involves 4-9 people on average during the development effort. A medium size project involves 10-19 people on average. A large size project involves 20-100 people on average. A very large project involves more than 100 people on average during the development. Almost half of the projects in the dataset are small size projects. Close to one-third of the projects are medium sized projects while close to one-fourth of the projects are large size projects. There is one project with more than 100 people involved on average.

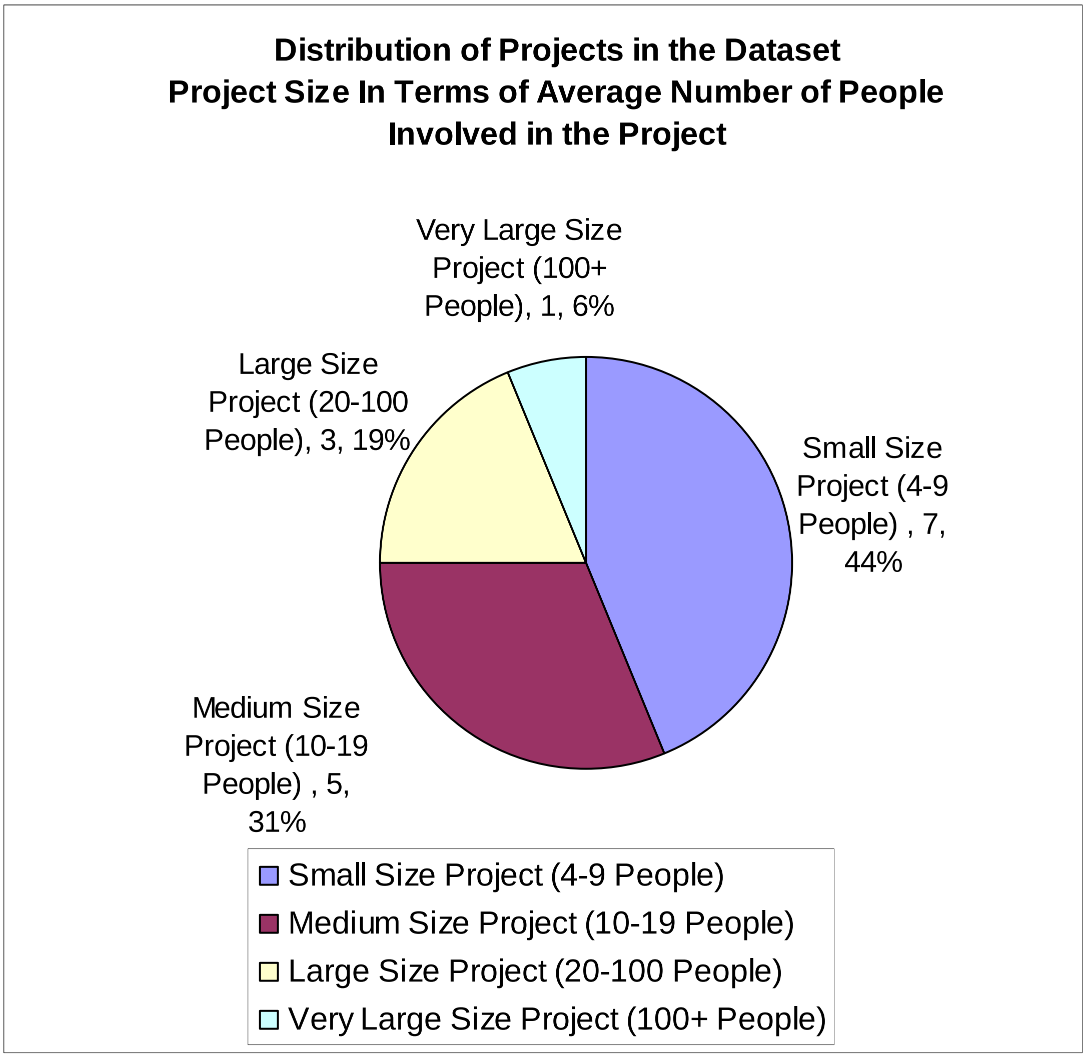

Figure 37. Distribution of Project Size in Terms of Average Number of People Involved

Table 40 provides the size of the products delivered at the end of the projects. Even though more than half of the study participants reported this data, most of these reports do not include exact numbers. During the interviews with the study participants, it was observed that the study participants are not very concerned about the final product size. They were more concerned with whether the project team delivered the functionality or not.

Project Identifier	**LOC (Number of Lines of Code)**	**Number of Function Points**
Project A	100,000 (Approximately)	N/A
Project B	N/A	N/A
Project C	100,000 (Approximately)	N/A
Project D	30,000	N/A
Project E	N/A	More than 30,000
Project F	N/A	N/A
Project G	16,000	N/A
Project H	10,000	50
Project I	N/A	N/A
Project J	N/A	N/A
Project K	215,400	N/A
Project L	440,000	N/A
Project M	115,000	N/A
Project N	N/A	N/A
Project O	N/A	N/A
Project P	N/A	N/A

Table 40. Product Size

Figures 38 and 39 present the timeframe of the projects in the dataset. Most of the projects in the dataset were developed after 2000. Thus, the dataset provides a focus to the project practices in the recent years. There are also sample projects from every decade since 1970s. The number of samples is not enough to identify trends in the project management practices employed at different timeframes.

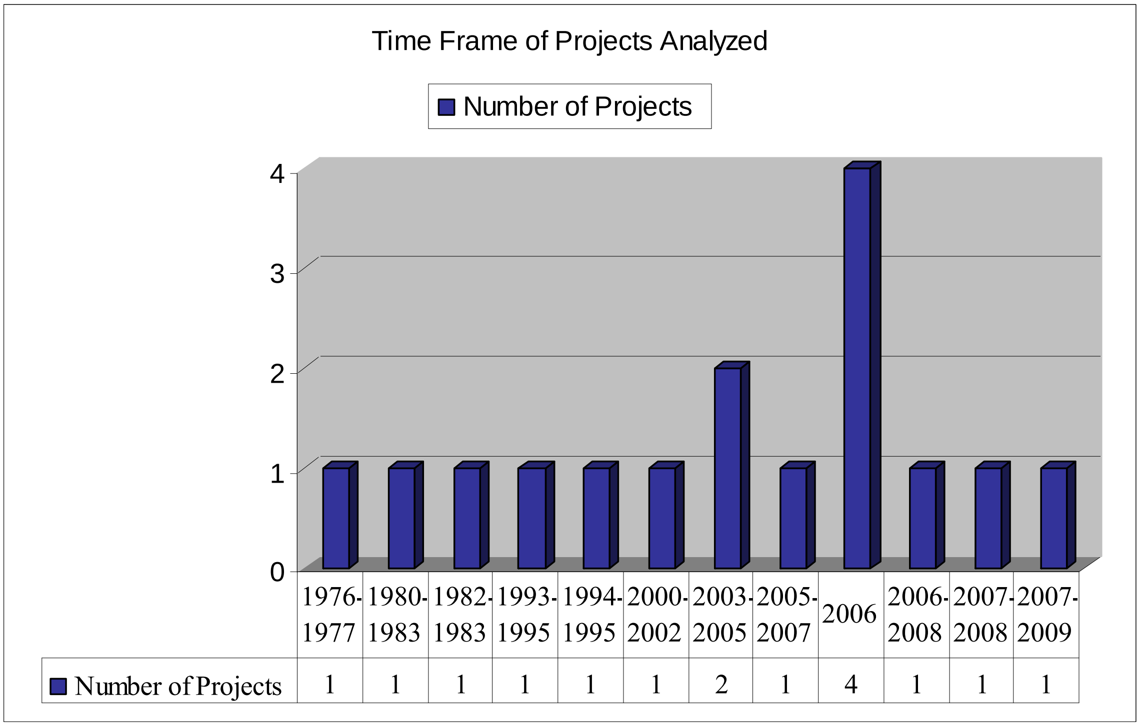

Figure 38. Time Frame of Projects Analyzed

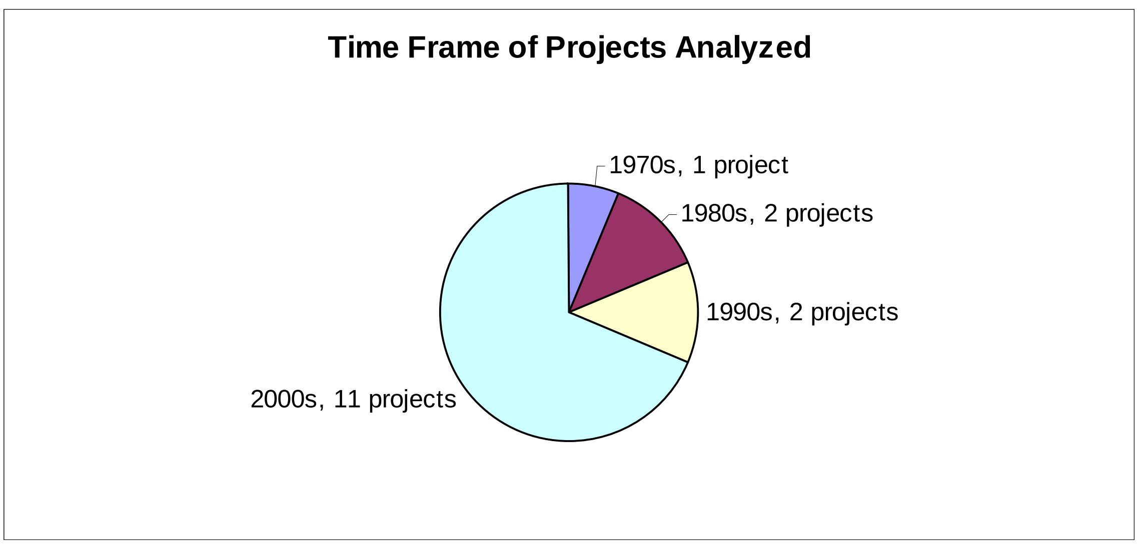

Figure 39. Time Frame of Projects in the Dataset Categorized by Decades

The actual schedules of projects in the dataset are presented in Figure 40. This data element is one of the few items reported by every participant in the study. The actual schedules vary from four months to thirty-six months. The average schedule of the projects in the dataset is eighteen months. Four of the projects took twenty-four months to complete. This is the largest category.

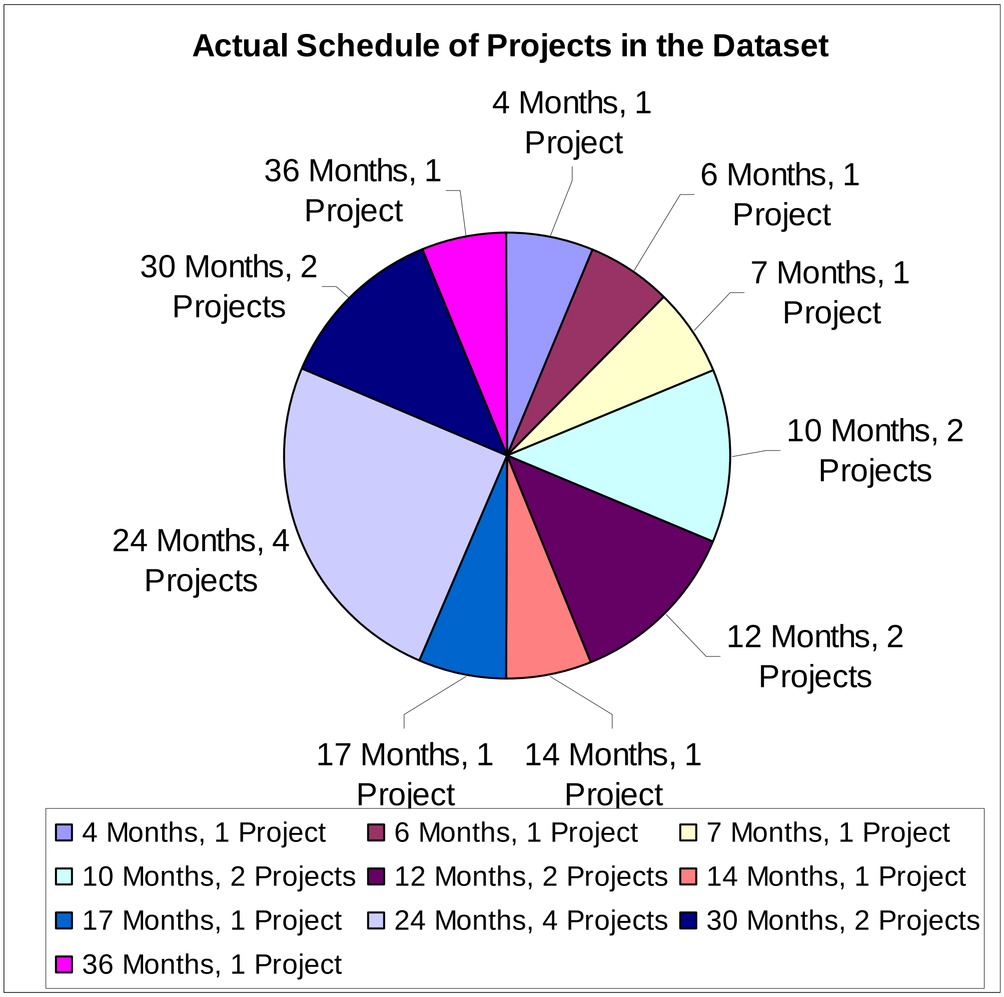

Figure 40. Actual Schedule of Projects in the Dataset

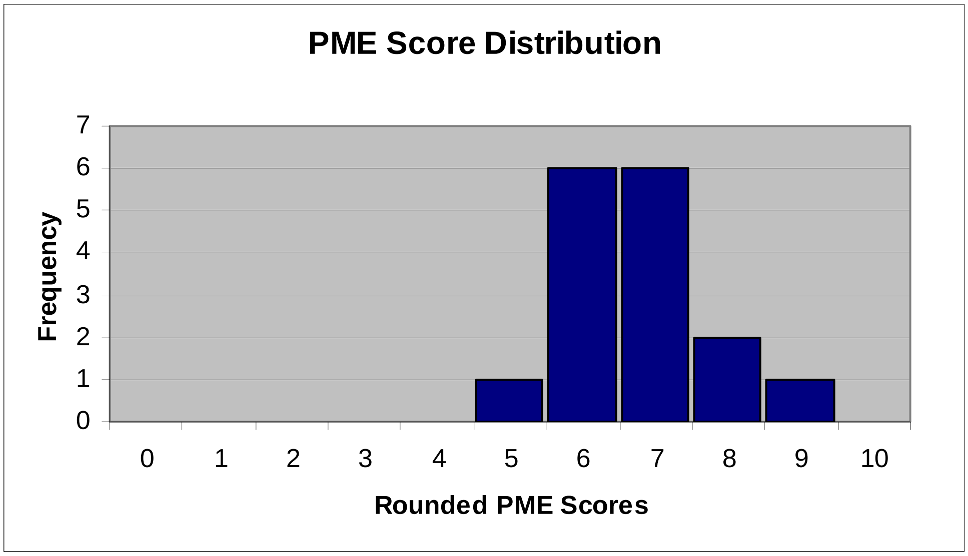

Figure 41. Distribution of PME Scores - Bar Chart

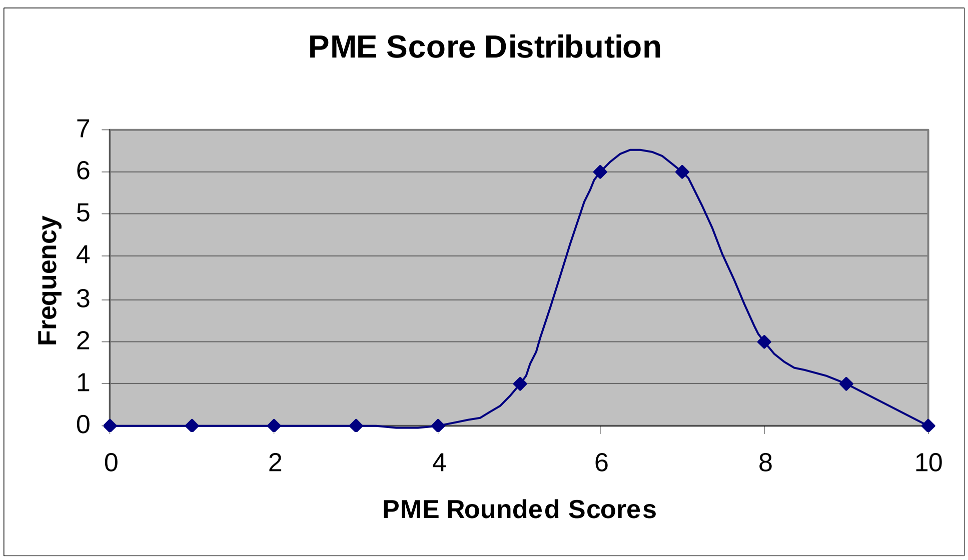

Figure 42. Distribution of PME Scores – Scatter Plot

Figures 41 and 42 present the distribution of PME scores in the dataset as a bar and scatter chart. From the figures, it is possible to speculate that the distribution of scores resembles a normal distribution. The lack of knowledge about the overall population of software projects limits our ability to test whether this sample distribution follows the statistical distribution of the overall population or not. Therefore, until there is evidence that this sample distribution of project management effectiveness (PME) scores of software projects is not a fair representation of the overall distribution, we will assume that it is.

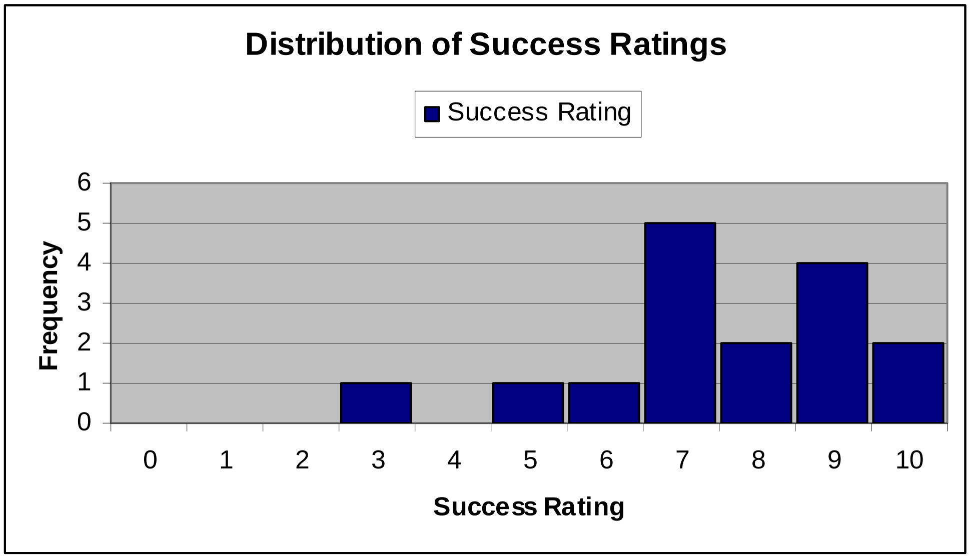

Figure 43. Distribution of Success Ratings – Bar Chart

Figure 43 presents the distribution of project success ratings provided by study participants for their projects. It is observed that most of the projects in the dataset are successful projects as indicated by the study participants. However, this does not necessarily mean that this data is not a fair representation of the population. Unfortunately, what percentage of software projects is a success is still an open question today. Therefore, such lack of knowledge limits our ability to conduct further analysis on this set of data.

Figure 44 shows the plot of project success scores and rounded project management effectiveness (PME) scores for each project. An analysis of the figure suggests that there is a close relationship with the success of a software project and project management effectiveness. The trend acquired by plotting the project success ratings for each project is similar to the trend acquired by plotting the project management effectiveness (PME) scores for each project. Figure 45 shows the same plot without rounding the PME scores. The higher the project success rating for a project, the higher the project management effectiveness score is for that project. Project management effectiveness is one of the factors affecting the project success. There are other factors to explain the differences between the scores and the ratings. Such factors include choosing the right problem to solve with the development effort, the user and customer satisfaction with the developed system after the delivery, other stakeholders' satisfaction with the result of development effort (whether the return of investment is satisfactory or not; whether it is a pleasant learning experience for the development team), the market share gained with the introduction of the product to the market, etc. Identifying the right problem to solve is very important. Every project development effort starts with a need to solve a problem. If this problem is not identified correctly, no matter how effective the project management is, the solution would not be successful. There are examples of this situation especially in government projects. The projects and developed systems are shelved without being deployed because the need is not adequately satisfied, or even just for political reasons.

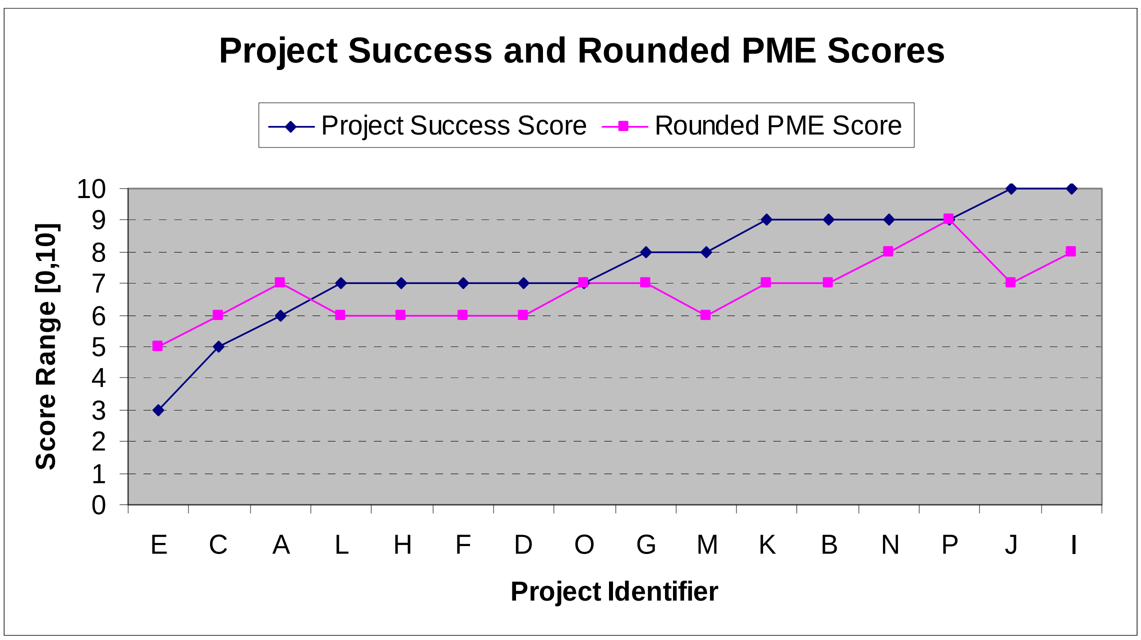

Figure 44. Project Success and Rounded PME Score for each Project in the Dataset

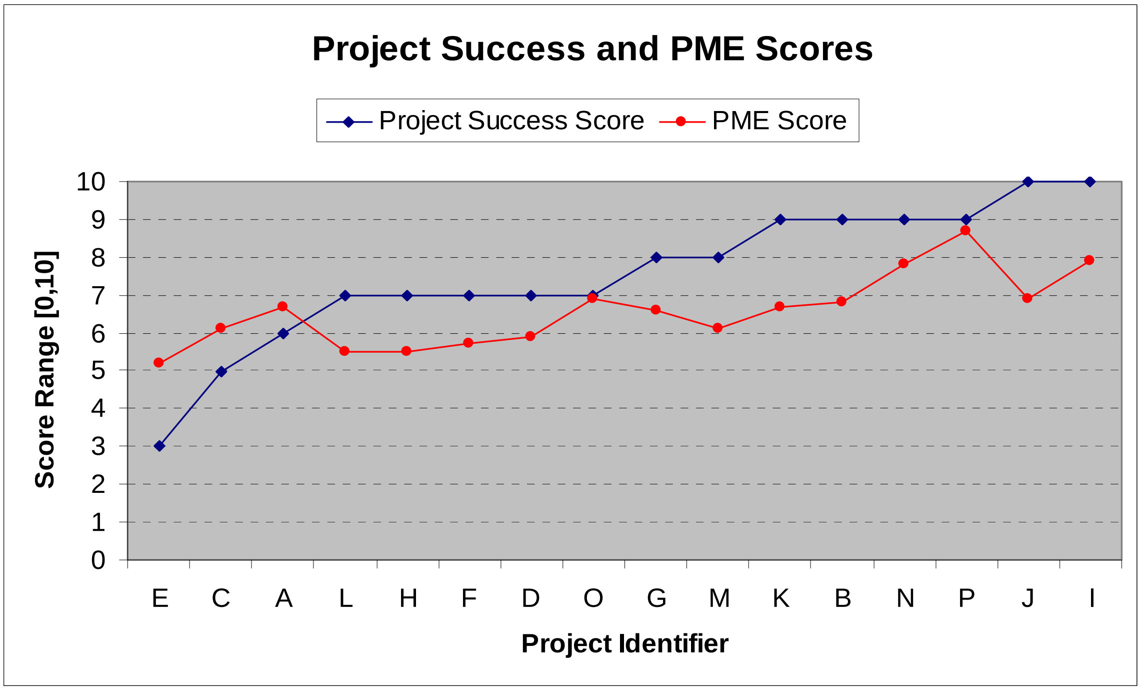

Figure 45. Project Success and PME Score for each Project in the Dataset

In the rest of the section, various tables show the project management area scores, project management effectiveness scores, and other basic statistics regarding the dataset. These basic statistics include minimum, maximum, range, mean, standard deviation and variation of scores.

Table 41 presents all the scores computed from the data gathered in the survey studies. In Table 42, the main project management area scores, project management effectiveness (PME) scores, success ratings gathered from study participants, and basic statistical data are presented.

The people area has the highest minimum and maximum scores among all the area scores. The lowest people area score is 5.7 and the highest people area score is 9.7. The mean of people area scores is also the highest in the dataset at 6.9. The standard deviation and the variance for people area scores are close to 1.

The minimum process area score is also high when compared to other area scores. The range of process area scores are close to the range of people area scores and project management effectiveness scores. Like the people area scores, the standard deviation and the variance are close to 1. It is important to note the similarities between the process area scores and project management effectiveness scores. Almost all of the statistical data is identical for these two sets of scores.

The set of product scores in the dataset have a higher variance. The range of product area scores are also the highest. On the other hand, the mean of product scores are close to the mean of project management effectiveness scores.

Risk scores are distinctly lower than the other area scores. The mean of product scores are 5.6. As indicated by the study participants during the interviews, risk management in software projects is not getting the necessary focus and attention it deserves. Therefore, many project development efforts have significant room for improvement in risk management.

The lowest PME score in this dataset is 5.2, while the highest PME score is 8.7. The mean of the project management effectiveness (PME) scores in the dataset is 6.6. It is fair to say that most of the projects in this dataset are successful projects with effective project management. The standard deviation is 0.96, which is very close to 1. The standard deviation and variance of PME scores are close to the standard deviation and variance of people and process scores.

Project management effectiveness (PME) scores are rounded because most executives are interested in simple but informative metrics. The difference between a PME score of 6.2 and a PME score of 6 is not very important for the purposes of overseeing a project for a high-level executive. That is why PME scores are rounded to provide a simpler metric. The set of scores obtained by rounding PME scores have similar statistics with PME scores. The mean of rounded PME (PME-R) scores are 6.8 while the mean of PME scores is 6.6. The standard deviation and variance of PME-R scores is 1.

The set of project success ratings was also analyzed. The mean of this set is 7.6, which is high. That is why it is concluded that most of the projects in this dataset are considered successful projects. It is possible that most of the study participants preferred to report a successful project for the survey study. That may be the reason for having such a high mean for this set of scores. There is only one project that has a lower success rating than 5 in this dataset. More survey studies with low success ratings may provide new insights in future studies.

Tables 43 through 46 all report the statistical data for project management area scores. They will not be discussed in detail here, since it is not within the scope of this research. It is only provided here for guiding future studies.

PROJECT IDENTIFIER	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
PEOPLE AREA																
Communication	6.5	7.2	6.4	7.1	6.0	6.1	5.0	6.2	7.8	8.8	6.8	5.1	6.3	9.2	6.3	8.8
Teamwork	6.1	7.8	6.1	7.1	7.1	6.4	5.9	5.7	8.0	7.8	6.9	5.7	7.6	7.6	6.5	9.6
Leadership	5.9	8.4	6.2	6.6	5.0	7.9	5.9	5.9	6.9	7.9	7.4	6.6	8.1	9.1	6.3	9.1
Organizational Commitment	5.4	7.3	7.6	6.7	8.1	6.4	5.7	5.3	7.5	8.0	6.9	6.5	7.4	6.6	7.9	9.8
Project Manager	7.1	8.0	5.2	8.1	7.1	7.7	6.6	6.4	9.1	8.6	7.4	6.3	7.8	9.2	8.1	9.5
Stakeholder Involvement	7.1	6.2	7.7	7.7	5.4	3.4	5.4	7.2	8.9	6.8	6.0	4.2	6.3	7.5	6.5	8.3
Staffing and Hiring	4.4	7.3	5.9	6.0	6.1	6.3	6.6	4.6	7.2	6.8	6.5	5.7	6.4	5.8	7.9	9.8
PEOPLE SCORE	**6.1**	**7.5**	**6.4**	**7.0**	**6.4**	**6.3**	**5.9**	**5.9**	**7.9**	**7.8**	**6.8**	**5.7**	**7.1**	**7.9**	**7.1**	**9.3**
PROCESS AREA																
Requirements Management	7.0	7.1	7.2	5.4	3.8	4.8	7.0	5.3	7.3	6.8	7.2	6.1	6.1	8.0	9.2	9.7
Project Monitoring and Control	7.6	5.5	6.2	6.9	5.2	6.2	7.0	5.1	7.9	7.0	6.2	5.6	6.4	8.1	5.8	8.1
Project Planning and Estimation	6.4	6.8	5.6	6.7	6.7	4.9	6.3	6.2	7.9	7.4	6.6	5.2	5.9	7.2	7.1	8.6
Scope Management	6.9	7.0	6.1	5.9	3.9	4.9	6.1	3.7	6.9	5.8	6.3	3.4	5.8	7.7	5.6	7.9
PROCESS SCORE	**7.0**	**6.6**	**6.3**	**6.2**	**4.9**	**5.2**	**6.6**	**5.1**	**7.5**	**6.7**	**6.6**	**5.1**	**6.0**	**7.8**	**6.9**	**8.6**
PRODUCT AREA																
Configuration Management	8.7	7.2	4.5	2.2	2.2	4.0	8.2	5.5	8.5	5.5	8.7	8.0	5.0	7.2	8.2	9.3
Quality Engineering	7.1	8.2	7.8	5.6	7.1	7.2	7.5	5.5	8.1	8.4	6.9	6.2	5.4	7.3	6.8	9.7
PRODUCT SCORE	**7.9**	**7.7**	**6.2**	**3.9**	**4.6**	**5.6**	**7.8**	**5.5**	**8.3**	**6.9**	**7.8**	**7.1**	**5.2**	**7.2**	**7.5**	**9.5**
RISK AREA																
Risk Assessment	6.4	5.6	5.5	5.5	3.7	5.6	6.8	5.0	7.6	4.9	6.4	3.8	6.2	8.1	6.2	8.5
Risk Control	6.3	5.5	4.4	5.7	3.7	5.4	5.9	6.3	8.1	6.1	4.6	3.7	5.0	8.0	5.0	5.6
RISK SCORE	**6.3**	**5.5**	**5.0**	**5.6**	**3.7**	**5.5**	**6.4**	**5.7**	**7.9**	**5.5**	**5.5**	**3.7**	**5.6**	**8.0**	**5.6**	**7.0**
PME SCORE	**6.7**	**6.9**	**6.1**	**5.9**	**5.1**	**5.7**	**6.6**	**5.5**	**7.9**	**6.9**	**6.7**	**5.5**	**6.1**	**7.7**	**6.9**	**8.7**
ROUNDED PME SCORE	**7**	**7**	**6**	**6**	**5**	**6**	**7**	**6**	**8**	**7**	**7**	**6**	**6**	**8**	**7**	**9**
PROJECT SUCCESS RATING	**6**	**9**	**5**	**7**	**3**	**7**	**8**	**7**	**10**	**10**	**9**	**7**	**8**	**9**	**7**	**9**

Table 41. Project Management Area Scores

	PEOPLE	PROCESS	PRODUCT	RISK	PME	PME-R	Success Rating
Project A	6.1	7.0	7.9	6.3	6.7	7	6
Project B	7.5	6.6	7.0	5.8	6.8	7	9
Project C	6.4	6.3	6.2	5.0	6.1	6	5
Project D	7.0	6.2	3.9	5.6	5.9	6	7
Project E	6.4	5.1	4.6	3.7	5.2	5	3
Project F	6.3	5.3	5.6	5.5	5.7	6	7
Project G	5.9	6.6	7.8	6.4	6.6	7	8
Project H	5.9	5.1	5.5	5.7	5.5	6	7
Project I	7.9	7.5	8.3	7.9	7.9	8	10
Project J	7.8	6.7	6.9	5.5	6.9	7	10
Project K	6.8	6.6	7.8	5.5	6.7	7	9
Project L	5.7	5.1	7.1	3.7	5.5	6	7
Project M	7.1	6.0	5.2	5.6	6.1	6	8
Project N	7.9	7.8	7.2	8.0	7.8	8	9
Project O	7.1	6.9	7.5	5.6	6.9	7	7
Project P	9.3	8.6	9.5	7.0	8.7	9	9
Min	**5.7**	**5.1**	**3.9**	**3.7**	**5.2**	**5.0**	**3.0**
Max	**9.3**	**8.6**	**9.5**	**8.0**	**8.7**	**9.0**	**10.0**
Range	**3.6**	**3.5**	**5.6**	**4.3**	**3.5**	**4.0**	**7.0**
Mean	**6.9**	**6.5**	**6.8**	**5.8**	**6.6**	**6.8**	**7.6**
Standard Deviation	**0.96**	**1.01**	**1.48**	**1.19**	**0.96**	**1.00**	**1.86**
Variance	**0.92**	**1.02**	**2.19**	**1.41**	**0.92**	**1.00**	**3.46**

Table 42. Data Analysis of Main Area Scores

	C	T	L	OC	PM	SI	S	People
Project A	6.5	6.1	5.9	5.4	7.1	7.1	4.4	6.1
Project B	7.2	7.8	8.4	7.3	7.9	6.6	7.3	7.5
Project C	6.4	6.1	6.2	7.6	5.2	7.7	5.9	6.4
Project D	7.1	7.1	6.6	6.7	8.1	7.7	5.9	7.0
Project E	6.3	7.1	5.0	8.1	6.7	5.7	6.1	6.4
Project F	6.1	6.4	7.9	6.4	7.7	3.4	6.3	6.3
Project G	5.0	5.9	5.9	5.7	6.6	5.4	6.6	5.9
Project H	6.2	5.7	5.9	5.3	6.4	7.2	4.6	5.9
Project I	7.8	8.0	6.9	7.5	9.1	8.9	7.2	7.9
Project J	8.8	7.8	7.9	8.0	8.6	6.8	6.8	7.8
Project K	6.8	6.9	7.4	6.9	7.4	6.0	6.5	6.8
Project L	5.1	5.7	6.6	6.5	6.3	4.2	5.7	5.7
Project M	6.3	7.6	8.1	7.4	7.8	6.3	6.4	7.1
Project N	9.2	7.6	9.1	6.6	9.2	7.5	5.8	7.9
Project O	6.3	6.5	6.3	7.9	8.1	6.5	7.9	7.1
Project P	8.8	9.6	9.1	9.8	9.5	8.3	9.8	9.3
Min	**5.0**	**5.7**	**5.0**	**5.3**	**5.2**	**3.4**	**4.4**	**5.7**
Max	**9.2**	**9.6**	**9.1**	**9.8**	**9.5**	**8.9**	**9.8**	**9.3**
Range	**4.2**	**3.9**	**4.1**	**4.6**	**4.3**	**5.5**	**5.4**	**3.6**
Mean	**6.9**	**7.0**	**7.1**	**7.1**	**7.6**	**6.6**	**6.5**	**6.9**
Standard Deviation	**1.24**	**1.05**	**1.24**	**1.15**	**1.19**	**1.44**	**1.28**	**0.96**
Variation	**1.55**	**1.11**	**1.53**	**1.33**	**1.41**	**2.07**	**1.63**	**0.92**

Table 43. Data Analysis of People Area Scores

	Requirements Management	**Project Monitoring and Control**	**Project Planning and Estimation**	**Scope Management**	**Process**
Project A	7.0	7.6	6.4	6.9	7.0
Project B	7.1	5.5	6.8	7.0	6.6
Project C	7.2	6.2	5.6	6.1	6.3
Project D	5.4	6.9	6.7	5.9	6.2
Project E	3.8	5.2	7.1	4.2	5.1
Project F	4.8	6.6	4.9	4.9	5.3
Project G	7.0	7.0	6.3	6.1	6.6
Project H	5.3	5.1	6.2	3.7	5.1
Project I	7.3	7.9	7.9	6.9	7.5
Project J	6.8	7.0	7.4	5.8	6.7
Project K	7.2	6.2	6.6	6.3	6.6
Project L	6.1	5.6	5.2	3.4	5.1
Project M	6.1	6.4	5.9	5.8	6.0
Project N	8.0	8.1	7.3	7.7	7.8
Project O	9.2	5.8	7.1	5.6	6.9
Project P	9.7	8.1	8.6	7.9	8.6
Min	**3.8**	**5.1**	**4.9**	**3.4**	**5.1**
Max	**9.7**	**8.1**	**8.6**	**7.9**	**8.6**
Range	**5.9**	**3.0**	**3.7**	**4.5**	**3.5**
Mean	**6.7**	**6.6**	**6.6**	**5.9**	**6.5**
Standard Deviation	**1.52**	**1.00**	**0.96**	**1.32**	**1.01**
Variation	**2.30**	**1.01**	**0.92**	**1.74**	**1.02**

Table 44. Data Analysis of Process Area Scores

	Configuration Management	Quality Engineering	Product
Project A	8.7	7.1	7.9
Project B	7.2	6.9	7.0
Project C	4.5	7.8	6.2
Project D	2.2	5.6	3.9
Project E	2.2	7.1	4.6
Project F	4.0	7.2	5.6
Project G	8.2	7.5	7.8
Project H	5.5	5.5	5.5
Project I	8.5	8.1	8.3
Project J	5.5	8.4	6.9
Project K	8.7	6.9	7.8
Project L	8.0	6.2	7.1
Project M	5.0	5.4	5.2
Project N	7.2	7.3	7.2
Project O	8.2	6.8	7.5
Project P	9.3	9.7	9.5
Min	**2.2**	**5.4**	**3.9**
Max	**9.3**	**9.7**	**9.5**
Range	**7.2**	**4.3**	**5.6**
Mean	**6.4**	**7.1**	**6.8**
Standard Deviation	**2.34**	**1.12**	**1.48**
Variation	**5.47**	**1.26**	**2.19**

Table 45. Data Analysis of Product Area Scores

	Risk Assessment	Risk Control	Risk
Project A	6.4	6.3	6.3
Project B	5.6	5.9	5.8
Project C	5.5	4.4	5.0
Project D	5.5	5.7	5.6
Project E	3.7	3.7	3.7
Project F	5.6	5.4	5.5
Project G	6.8	5.9	6.4
Project H	5.0	6.3	5.7
Project I	7.6	8.1	7.9
Project J	4.9	6.1	5.5
Project K	6.4	4.6	5.5
Project L	3.8	3.7	3.7
Project M	6.2	5.0	5.6
Project N	8.1	8.0	8.0
Project O	6.2	5.0	5.6
Project P	8.5	5.6	7.0
Min	**3.7**	**3.7**	**3.7**
Max	**8.5**	**8.1**	**8.0**
Range	**4.7**	**4.4**	**4.3**
Mean	**6.0**	**5.6**	**5.8**
Standard Deviation	**1.35**	**1.26**	**1.19**
Variation	**1.82**	**1.59**	**1.41**

Table 46. Data Analysis of Risk Area Scores

In order to understand the measure of association between project success ratings provided by the study participants and the project management effectiveness (PME) metric for the project, correlation analysis was conducted. The choice of analysis method was parametric bivariate correlation analysis. This choice was driven by the applicability and suitability of the assumptions rather than being a preference. This method was suitable for statistical association analysis in this particular study. The parametric correlation measure most often used is the Pearson product moment coefficient, r (Emory, 1980). This coefficient of correlation is the summary statistic that represents the linear relationship between two sets of variables of interest (Emory, 1980). In this research, that is exactly what we are looking for and this is what is needed to test the research hypothesis. Overall, the analysis showed that there is a strong positive correlation r, between the software project management effectiveness metric proposed in this research and the software project success rating provided by the study participants.

In statistics, the Pearson product-moment correlation coefficient is a commonly used measure to identify the linear relationship between the sets of variables. It is sometimes referred as MCV or PMCC. According to the usual convention, when the Pearson product-moment correlation coefficient is calculated for the entire population, the Greek letter rho (ρ) is used. When the correlation coefficient is calculated for a sample, then Latin letter r is used. The Pearson correlation coefficient, r, ranges from -1 to +1. The sign of the correlation coefficient indicates the direction of the linear relation. Correlation coefficient +1 indicates that there is a perfect positive correlation between two variables. If the correlation coefficient is -1, then there is a perfect negative relation between the variables of interest. Perfect relationships are rarely observed in social studies. In a positive correlation, when one variable goes up the other variable goes up as well. In a negative correlation, when one variable goes up, the other variable goes down. There is also one special case, and that is when the correlation coefficient is zero. In that case, there is no linear relationship between the variables. The absolute value of the correlation coefficient indicates the strength of the relationship. The higher the value of the correlation coefficient, the stronger the relationship between the variables are. What constitutes as a strong correlation depends strictly on the research being conducted. In social studies, as a rule of thumb, when the Pearson product-moment correlation coefficient is higher than 0.5, then it may be assumed that there is strong correlation between the variables.

In statistics, r^2, the square of coefficient correlation r, is called the coefficient of determination. The coefficient of determination, r^2, is the percentage of variance in one variable explained by the linear relationship with the other variable. This r^2 basically refers to the amount of variation in one variable explained by the relationship between variables.

Table 47 shows the correlation, r, between main area scores, project management effectiveness (PME) scores, and project success ratings. All scores have strong positive correlations between each other. Only the correlation between the people and product main area scores is 0.42. While the correlation between these two sets of scores may not be strong, there is certainly a relationship of interest between the people and product main area scores. In this research, our main interest is the relationship between project success and the project management effectiveness metric proposed with this research. It is observed that there is a strong positive correlation between project success and project management effectiveness. The Pearson product-moment correlation coefficient, *r*, between project success rating and rounded project management effectiveness (PME-R) is 0.73. The coefficient of determination, r^2, for these two sets of metrics is 0.53. In simple terms, this means that project management effectiveness accounts for half the variation in project success. This result supports the hypothesis stated in the beginning of this research.

It is also very important to note that there is no weak or strong negative correlation between the set of scores. Negative correlations between these scores were not expected and there were not any. Such a result supports the claim that this research is sound, especially from the point of construct validity.

All main area scores have strong correlation with the project success. Therefore, it is possible to suggest that effectiveness in each main area has an effect on project success.

The main people area scores have strong correlation with the main process area scores and project management effectiveness (PME) scores. The Pearson's correlation coefficient between people area scores and process area scores is 0.80. The correlation, *r*, between people area scores and PME scores is 0.83. The strength of these correlations is noteworthy.

One notable aspect of the process area scores is that they have very strong correlations with all other main areas. The correlation, *r*, between the people and process area scores is 0.80, while *r* between the process and product area scores is 0.72, and *r* between process and risk main area scores is 0.80. The correlation between process area scores and project management effectiveness (PME) scores is almost perfect at 0.97. This is extraordinary. This means that it is possible to predict the PME metric using process area scores. However, it does not mean that effectiveness in only the process area leads to effectiveness in project management because the Pearson correlation coefficient does not necessarily indicate causality. There may be other factors affecting the correlation. In this case, people, product and risk management effectiveness contribute the PME metric.

Positive strong correlations between all these metrics are indications of the soundness of this research. Table 48 presents the correlations between project management area scores, main area scores, PME scores, and project success ratings. All project management area scores have positive strong correlations with the project management effectiveness metric. The strong positive correlations between project management area scores and people main area scores are noteworthy. There is only one exception and that is configuration management scores.

All project management area scores except organizational commitment, stakeholder involvement, project planning and estimation, and quality engineering area scores have strong correlation with project success ratings. The exception in these areas does not necessarily mean that there is no relationship with project success because the Pearson product-moment correlation coefficient is about the linear relationship between two sets of variables. The relations between these metrics may be non-linear. Further research is required to identify the type of relationships between these sets of metrics.

	PEOPLE	PROCESS	PRODUCT	RISK	PME	PME-R	PROJECT SUCCESS RATING
PEOPLE	*	0.80	0.42	0.57	0.83	0.75	0.59
PROCESS		*	0.72	0.80	0.97	0.93	0.58
PRODUCT			*	0.53	0.79	0.85	0.54
RISK				*	0.82	0.82	0.64
PME					*	0.98	0.68
PME-R						*	0.73

Table 47. Correlation Coefficient of Main Project Management Areas (Project A to Project P)

	PEOPLE	PROCESS	PRODUCT	RISK	PME	PME-R	PROJECT SUCCESS RATING
Communication	0.87	0.72	0.30	0.61	0.74	0.66	0.53
Teamwork	0.96	0.68	0.33	0.47	0.73	0.63	0.52
Leadership	0.73	0.55	0.33	0.49	0.62	0.61	0.71
Organizational Commitment	0.76	0.44	0.23	0.00	0.46	0.34	0.13
Project Manager	0.85	0.71	0.36	0.68	0.76	0.72	0.69
Stakeholder Involvement	0.60	0.66	0.25	0.60	0.61	0.54	0.28
Staffing and Hiring	0.76	0.59	0.50	0.25	0.64	0.59	0.42
Requirements Management	0.61	0.85	0.81	0.58	0.84	0.84	0.52
Project Monitoring and Control	0.58	0.80	0.51	0.81	0.77	0.76	0.50
Project Planning and Estimation	0.81	0.76	0.46	0.55	0.77	0.70	0.40
Scope Management	0.71	0.92	0.56	0.78	0.86	0.80	0.52
Configuration Management	0.25	0.60	0.94	0.48	0.67	0.76	0.55
Quality Engineering	0.59	0.66	0.69	0.38	0.70	0.66	0.28
Risk Assessment	0.63	0.88	0.63	0.92	0.87	0.87	0.56
Risk Control	0.41	0.57	0.31	0.90	0.61	0.62	0.61

Table 48. Correlation Coefficient of Main Areas to Project Management Areas (Project A to Project P)

Table 50 presents the Pearson product moment correlation coefficients, *r*, between project management areas in the dataset. Any *r* values higher than 0.5 are indicated in bold letters. It was identified that many project management area scores are strongly correlated with each other. Such results show the soundness of this research study. For example, the correlation between communication and teamwork is 0.79. This is a strong positive correlation. Such a relation between communication and teamwork has already been established in studies conducted prior. The particular relationships between project management areas are not within the scope of this doctoral study. The relationships between two areas or a set of areas are potential doctoral research topics. The results in this table provide important guidance for future research. In addition, more studies on software projects using the software project management evaluation instrument (SPMEI) will help to investigate the relationships with more accuracy and precision.

Table 51 presents the correlations between project management areas based on the data from all survey studies. The projects data excluded from the dataset may be used in this table. The project management effectiveness (PME) metric may not be applicable to the excluded projects, but the relationships between project management area scores should still be applicable. It is observed that the strength of relationships *r* values is higher when data from all projects are included.

Project Management Area (PMA)	**Identifier**	**Project Management Area (PMA)**	**Identifier**
Communication	C	Project Monitoring and Control	PMC
Teamwork	T	Project Planning and Estimation	PPE
Leadership	L	Scope Management	SM
Organizational Commitment	OC	Configuration Management	CM
Project Manager	PM	Quality Engineering	QE
Stakeholder Involvement	SI	Risk Assessment	RA
Staffing and Hiring	S	Risk Control	RC
Requirements Management	RM		

Table 49. Identifiers for Project Management Areas

	C	T	L	OC	PM	SI	S	RM	PMC	PPE	SM	CM	QE	RA	RC
C	*	**0.79**	**0.67**	**0.51**	**0.78**	**0.64**	0.39	0.45	**0.62**	**0.75**	**0.68**	0.13	**0.54**	**0.53**	**0.57**
T		*	**0.70**	**0.78**	**0.82**	**0.51**	**0.74**	0.43	**0.51**	**0.79**	**0.64**	0.16	**0.54**	**0.53**	0.32
L			*	0.39	**0.71**	0.13	0.49	0.45	0.48	0.29	**0.58**	0.26	0.32	0.54	0.36
OC				*	0.45	0.31	**0.83**	0.41	0.16	**0.60**	0.32	0.01	**0.59**	0.19	-0.20
PM					*	0.40	**0.58**	0.46	**0.65**	**0.72**	**0.62**	0.27	0.37	**0.63**	**0.60**
SI						*	0.22	0.48	0.46	**0.72**	**0.60**	0.17	0.30	**0.54**	**0.56**
S							*	**0.62**	0.27	**0.60**	0.45	0.33	**0.62**	0.46	-0.02
RM								*	**0.50**	**0.54**	**0.69**	**0.76**	**0.55**	**0.73**	0.31
PMC									*	0.49	**0.75**	0.37	**0.57**	**0.80**	**0.66**
PPE										*	**0.61**	0.31	**0.57**	**0.55**	0.45
SM											*	0.45	**0.55**	**0.84**	**0.57**
CM												*	0.39	**0.57**	0.30
QE													*	0.47	0.21
RA														*	**0.65**
RC															*

Table 50. Correlation Coefficient of Project Management Areas (Project A to Project O)

	C	T	L	OC	PM	SI	S	RM	PMC	PPE	SM	CM	QE	RA	RC
C	*	**0.86**	**0.67**	**0.64**	**0.73**	**0.77**	**0.56**	**0.66**	**0.73**	**0.77**	**0.72**	0.42	**0.72**	**0.71**	**0.62**
T		*	**0.69**	**0.79**	**0.81**	**0.67**	**0.79**	**0.58**	**0.64**	**0.76**	**0.70**	0.39	**0.67**	**0.65**	**0.47**
L			*	0.48	**0.70**	0.23	0.49	0.46	0.38	0.28	0.43	0.28	0.33	0.41	0.25
OC				*	**0.52**	0.47	**0.84**	**0.57**	0.41	**0.61**	0.42	0.24	**0.62**	0.41	0.08
PM					*	0.47	**0.63**	**0.51**	**0.57**	**0.64**	**0.61**	0.39	0.47	**0.57**	**0.58**
SI						*	0.45	**0.67**	**0.74**	**0.83**	**0.75**	**0.50**	**0.68**	**0.77**	**0.71**
S							*	**0.70**	**0.52**	**0.68**	**0.59**	**0.51**	**0.68**	**0.60**	0.28
RM								*	**0.71**	**0.72**	**0.76**	**0.82**	**0.73**	**0.82**	**0.53**
PMC									*	**0.86**	**0.84**	**0.67**	**0.88**	**0.91**	**0.81**
PPE										*	**0.79**	**0.64**	**0.87**	**0.81**	**0.74**
SM											*	**0.66**	**0.76**	**0.89**	**0.76**
CM												*	**0.67**	**0.75**	**0.57**
QE													*	**0.79**	**0.63**
RA														*	**0.79**
RC															*

Table 51. Correlation Coefficient of Project Management Areas (All 20 Projects)

E. SOUNDNESS OF THE MEASUREMENT STUDY

In this section, the soundness of the measurement study will be discussed. First, the sources of errors and their implications on the study will be outlined. Then, validity, reliability and practicality of the measurement study will be discussed briefly.

According to Emory (1980), there are three major considerations for evaluating a measurement tool. They are validity, reliability and practicality. These terms may be described as follows:

> Validity refers to the extent to which a test measures what we actually wish to measure. Reliability has to do with the accuracy and precision of a measurement procedure…. Practicality is concerned with a wide range of factors of economy, convenience, and interpretability (Emory, 1980).

1. Sources of Measurement Differences

It is very hard to develop an ideal measurement tool without contamination from the sources of errors. Therefore, it is important to recognize these sources of errors. Whenever possible, these sources of errors should be identified, eliminated or neutralized. If elimination is not feasible or sometimes possible, then the sources of errors should at least be acknowledged so that the users of the measurement tool know how accurate and precise the measurement activity is.

According to Emory (1980), there are four major error sources that may contaminate the results. These sources are the respondent, the situation, the measurer and the instrument.

a. The Respondent as an Error Source

The study participants may be a source of errors for many reasons. These reasons include personal bias, social class, ethnic background, etc. In addition, the respondent may be affected by various conditions such as fatigue, boredom, anxiety, etc.

Every research is unique in various aspects. Common causes of errors introduced by participants observed in many other studies do not play a role in this research because of its nature. For example ethnic background, social class, etc.

One of most obvious characteristics of the study participants in this research is that they are highly educated. Most of the participants are quite experienced in the software field as well. Some of the study participants had more than twenty years of software and systems development experience. All of the study participants had at least a certain amount of management experience in their careers.

In this research, the most likely source of errors by the study respondents may be due to the bias resulting from personal views of software project management. However, the participation in the research was voluntary. The types of practitioners who volunteer in these research studies tend to be objective. Generally, they want to improve themselves, improve their work practices, and try to learn something new. So, they also try to be as objective as possible to get the most out of their participation.

The proposed metric with this research is designed to assess the project management effectiveness not the effectiveness of various people in the project organizations. The study participants are ensured of this particular point. This is to avoid any misunderstandings and contamination of results due to the bias that might occur because the participants think they are being evaluated. In order to eliminate or at least reduce any possible bias, the questions in the software project management evaluation instrument (SPMEI) are carefully crafted so that the wording clearly reflects what is being evaluated.

During the study, it was observed that the participants did not contribute as a significant source of error. SPMEI is designed in such a way that errors caused by participants can be identified. Many of the software project management evaluation instrument (SPMEI) questions are related. Discrepancies among the responses may be easily identified.

In this study, the study participants provided the project success ratings based on a scale from 0 to 10. With the current state-of-the-art in software project management, this is still one of the best ways to determine the success of a project. This method has been used in many other studies as well. As indicated earlier in previous sections, there is currently no established method to determine the success of a software project. At the beginning of the study, one of the concerns posed was the possibility of study participants rating their projects with high ratings. The same issue was a concern in a similar study conducted previously by Osmundson et al. (2003). In that study, the case that the study participants were rating the project success consistently higher was not observed. In this study, it was observed that study participants tried to rate the projects as objectively as possible.

b. The Measurer as an Error Source

Some research designs require the researcher or the measurer to be present during the study. In some cases, the study participants may get anxious because the measurer is present. They may try to impress the measurer or the researchers, or they may get nervous and behave differently than normal. Therefore, the researchers should be aware of these types of error sources in research designs requiring the researcher to be present during the study. In order to eliminate this type of contamination, the author was not with the study participants during the process. There was one exception to this: in one of the survey studies at the beginning of the research, the author was present when the study participants completed the SPMEI. This was done deliberately. The goal was to observe the study participant and identify any difficulties in the surveying protocol. It was observed that the study participant was able to complete the instrument without any difficulty. This was important to help understand the nature of the study protocol. It is important to note that this study participant was chosen carefully. The author and the study participant knew each other. This particular study participant was comfortable with the author. Therefore, any contamination due to the existence of researcher during the procedure was minimized in this particular survey study.

The SPMEI is designed as a self-evaluation tool. This was an important and deliberate decision made early in the research. There are two reasons for this. The first reason is that the bias due to the measurer as a source of error is eliminated. The second reason relates to practicality issues. In this research, a new project management measurement tool is introduced. This tool is designed to be used by practitioners. Thus, the tool is designed in such a way that the software managers are able to use it by their selves.

In this research, the study participants completed the SPMEI by themselves on their own time. The researcher was not present during the process. Sources of errors caused by the measurer or researcher being present during the studies are almost nonexistent.

c. Situational Factors

Any condition that may put a strain on the respondent may contaminate the study results. For instance, the room where the study participant is located during a research study may affect the study results. In some studies, the participants are brought to controlled environments for close observation. In these cases, if the study participant becomes uncomfortable with the environment, the results may be contaminated unless the researchers are not especially investigating that particular effect. There are many variants of situational factors and they are specific to the research design. The researchers have to be aware of such situational factors. If unwanted, the researchers should eliminate or at least account for these factors. In this research, no situational factors affecting the research results are observed.

d. The Instrument as an Error Source

It is very hard to design an ideal instrument in social studies. In most cases, social concepts are hard to capture and measure with an instrument. This research deals with the project management aspect of software projects. There are many social issues involved in managing a software project. Therefore, development of an instrument for measuring project management effectiveness was one of the most challenging aspects of this research. The software project management effectiveness metric uses the software project management evaluation instrument (SPMEI) and software project management evaluation model (SPMEM) to provide an overall effectiveness metric. A great deal of the effort in this research went to the development of this instrument. Extra effort was spent in order to minimize the errors in the design of the instrument and the evaluation model.

The SPMEI questions were carefully designed. They are worded as simple as possible. Most questions and statements are concise and clear. The terms used in the questions and statements were specially selected to minimize misunderstandings. The software project management evaluation instrument was tested for these issues during pilot studies. Study participants indicated that the questions in the instrument were clear and easily understandable. The analysis conducted after the survey studies showed that there were no significant errors caused by the instrument. On the other hand, the instrument surely has room for improvement. However, more research and more samples are required in order to identify the opportunities for improvement.

2. Validity of the Measurement

There are many concepts of validity in research literature. There are also many categorizations. Not all validity concepts or concerns are applicable to all research experiments. Most validity related concerns were already reported throughout the dissertation where they were pertinent. Here, external and internal validity issues related to this measurement activity will be discussed briefly.

Emory (1980) described external validity by stating that, “external validity of research findings refers to their generalizability across persons, settings and times.”

The software project management effectiveness (PME) metric has limitations. Even though the PME metric is applicable to most software projects, it is not applicable in some software projects as observed in the survey studies.

The software PME metric is applicable to software or software intensive projects. The metric is not tested in other types of projects. Adaptation of the PME to other types of projects may likely require modifications in the instrument and model.

The software PME metric is independent from the life cycle development model used in the projects. It is designed to be applicable with almost all life cycle development models. The projects in the survey studies employed different life cycle development models including agile development, waterfall development, incremental development, rapid prototyping development model, and variants of various other development models. No project employs a life cycle development model as stated in a textbook. They are customized based on many factors. This is one of the reasons to design the metric independent from life cycle development models.

The PME metric is designed to be used in many types of organizations. Survey studies showed that the metric is applicable to projects developed in government organizations as well as commercial organizations. There are cases in the study in which a combination of various types of organizations developed projects. These are among the basic types of organizations. It is observed that the PME metric is applicable to these environments. There are also other types of groups or organizations worth mentioning. One of them is open-source communities. The dataset does not include an open-source project. The author suspects that modifications may be required in the instrument and model to ensure the applicability of the metric to open-source projects. Therefore, currently the applicability of the metric to open-source projects is not known.

The PME metric is designed to be applicable to all types of product developments. The products developed with the projects in the dataset include mission critical defense systems, embedded systems, real time systems, office automation systems, information management systems, networking applications, prototypes, database applications, etc. The survey studies covered many of the product types.

The PME metric is applicable to almost all project team sizes. The only exception is very small teams consisting of 2-4 people. The survey studies showed that when the project team is very small and the project development is conducted in a highly informal manner, the metric is not applicable. There are three such examples. The average number of people involved in these developments is 2 to 4. None of these projects had a project plan. It is likely that formal or semi-formal project management would not contribute to these efforts significantly. On the other hand, it is observed that when there is a project plan and the development effort is conducted in a formal or semi-formal manner, the metric is applicable even to small teams. In two projects, the average number of the people involved in the project was four. The metric is found to be applicable to these projects. In one project, the project involved a team of 300 people. This is a very large project in terms of number of people involved.

The survey studies included projects developed in both North America and Europe. Projects developed in other parts of the world were not included in this study. More samples, especially projects developed in other geographical locations will be beneficial. Nevertheless, different results are not expected.

All the study participants in this study are managers at some level in the project organization or experts with a broad view of the project. The SPMEI requires the respondent to be a project team member who has a broad view of the project. The project members who assume a management role are likely candidates to participate in this measurement activity. The software project management evaluation instrument can not be completed by a team member or a stakeholder with access to only certain parts of the development effort.

The survey studies included examples from every decade since 1970s. As discussed earlier, the metric is not applicable to projects developed at all timeframes. It is mostly applicable to projects developed after the 1970s. The reasons are explained earlier in detail. There may be exceptions to this issue. It is observed that the metric is applicable to a project developed in 1976. It was applicable to this case because this project was developed by a major software company employing the best management practices at that time. Such effective project management is unlikely in other projects developed by many of the software development organizations during the 1970s.

Emory (1980) described internal validity as, “The ability of a research instrument to measure what it is purported to measure.” Establishing the internal validity of a study is not an easy task because the ideal way of understanding the internal validity is to compare the results of a measurement instrument with the absolute measures. In most cases, the real measure of what is being measured is not known. If it were known, there would not be a need to measure it in the first place. So, the way to overcome this challenge is to seek other relevant evidence confirming the answers found with measurement device (Emory, 1980). The key term here is relevant evidence. What is relevant or not depends on the nature of the study as well as the judgment of the researcher. There are three widely accepted classifications of internal validity. They are content, criterion-related and construct.

a. Content Validity

The content validity pertains to how well the measurement instrument covers the concepts of interest. Project management is a very broad concept. It is hard to achieve full coverage with an instrument. However, in this research a high coverage is achieved. The software project management evaluation instrument is designed with the guidance of the software project management framework proposed in this study. This framework is developed via an extensive literature search. Then, it is validated with a worldwide survey of software practitioners. In the survey, the survey participants were specifically asked about the coverage and sufficiency of the framework. A high percentage of the survey participants found the framework sufficient. Furthermore, the SPMEI coverage was discussed with survey study participants during the interviews. Almost all of the study participants indicated that the coverage achieved with SPMEI is good. Most of the study participants had years of experience in software development projects.

Emory (1980) indicated that the determination of content validity is judgmental. The researcher's judgment is important. In this research, in addition to the judgment of the researcher, many practitioners were also consulted in determining the content validity of measurement instrument.

b. Criterion-Related Validity

Criterion-related validity is concerned with the success of the measures used for empirical estimating purposes. As discussed earlier, a measurement activity is conducted for two purposes. These two purposes are assessment and prediction. The goal of this study is to develop a metric just for assessment purposes and not for prediction purposes. It is possible to extend the PME measurement to be used in a prediction or estimation model. However, that is outside the scope of this work. Most criterion-related validity concerns are not applicable in this study.

c. Construct Validity

Morisio et al. (2002) defined the construct validity as follows: "Construct validity considers whether the metrics and models used in a study are valid abstraction of the real world under study."

In very simple terms, trying to answer the following question leads the way to establish the construct validity: are you measuring what you intend to measure? The following is an example in which the construct validity is not satisfied. A researcher intends to measure the weight of a person but instead the researcher measures the height of the person. The given example was an extreme. Establishing construct validity in most studies is not easy. It mostly relies on the judgment of the researcher to provide relevant evidence. While evaluating construct validity, the correlation between the measurement results and another variable that is known to correlate with the measures is analyzed. There should be an expectance of theoretical background between the concept measured and the known variable. When the correlations are within the expectations, the researchers decide whether the construct validity concerns are satisfied or not.

In this research, software project management effectiveness is being measured. Then, the correlation between this set of metric and the set of success ratings of software projects are analyzed. The expectance derived from the literature on the subject is that effectiveness of project management is a factor in achieving project success. For example, Capers Jones (2004) expresses that effectiveness in many project management related areas, such as project planning, project estimating, change management, etc., is a success factor for large software projects, while ineffectiveness in these areas is a failure factor. The correlation between the software project management effectiveness (PME) metric and project success rating was found to be strong. This is one of the most important pieces of evidence in this research supporting the construct validity of the instrument. Furthermore, most project management areas measured with the instrument highly correlate with other areas as well as the PME metric. These high correlations provide evidence for the existence of construct validity in this measurement study.

3. Reliability of the Measurement

Reliability is about the consistency of the measurement results. Emory (1980) states that a measure is reliable to the degree that it provides consistent results. The expectance in a reliable measurement tool is that it is free from random or unstable errors. Reliability and validity are related. A valid tool is expected to be reliable as well. However, a reliable tool may not be valid. A reliable measurement may provide consistent results, but the validity concerns may not necessarily be satisfied for that measurement activity. For example, the measurement tool may not be measuring what it is intended to measure; but on the other hand, while it is measuring something else it may still produce reliable results.

Understanding reliability requires multiple measurements of the same thing that is being measured. If multiple measurements are taken using the same measurement instrument with the same study participant and the results are consistent, then the measurement is considered stable, which is one aspect of reliability. This is particularly hard in some surveys because of the test-retest concerns. The study participants will repeat the answers without thinking when the time intervals are short. In this research, stability of the measurement could not be investigated mainly because of this test-retest concern. Another aspect of reliability is the equivalence. Emory (1980) states that equivalence considers how much error may be introduced by different investigators or a different sample of items being studied. The errors resulting from using different investigators or observers are not a concern in this study because this measurement study is standardized in such a way that different investigators will make absolutely no difference. The study participants completed the SPMEI, and then the responses were fed into the software project management evaluation model (SPMEM). The result was the software project management effectiveness (PME) metric. Using different samples of items is another approach to determine the equivalence of the measurement activity. In order to achieve this, alternative or parallel tests should be administered. Then, the results of each test must be compared. The complexity of measuring project management effectiveness in software projects is so high that developing another instrument requires another doctoral study.

In this study, the reliability of the instrument is not analyzed in detail because of the difficulties in establishing it. However, the instrument is assumed reliable since its validity is established with relevant evidence. Furthermore, PME measures are rounded to integers because exact measures with high reliability are not a primary concern in this study.

4. Practicality of the Measurement

Practicality of the measurement is a natural and obvious requirement. Without achieving a certain level of practicality, a reliable and valid measurement tool will not be used. Therefore, ensuring the practicality of the measurement tool is important.

PME measurement is practical. SPMEI is designed as a self-administered tool. Thus, the measurement does not require a specialist or a researcher. During interviews, study participants indicated that SPMEI makes sense and it is easy to understand and respond to. In 2-3 hours, PME measurement can be completed. In comparison to hiring a consultant to do the same assessment, PME measurement using SPMEI and SPMEM is faster and cheaper.

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IX. FINDINGS

The most important finding of this research is the relationship between software project success and project management effectiveness with empirical evidence. There is a strong positive correlation between software project success and project management effectiveness. The Pearson product moment correlation coefficient between these two variables is 0.73. Project management effectiveness accounts for half of the variation in project success based on the data gathered from survey studies. When project management effectiveness is high, project success is likely.

As presented in this research, it is possible to develop a project management effectiveness metric using a questionnaire-based instrument and evaluation model. The instrument, SPMEI, is developed based on a theory of project management proposed in this research. The evaluation model is developed based on a theory of project management effectiveness measurement, which uses the theory of project management as a basis. The survey study results provide evidence for the applicability and viability of these proposed theories.

In this research, a software project management framework is developed. This framework is validated with a worldwide survey of software practitioners. Furthermore, this framework is used as a basis for the development of an evaluation instrument and the evaluation model. The results from the survey studies show that the framework is valid and feasible to be used in measurement studies.

Studies were conducted in the past to identify the relations between various project management areas or concepts. One widely researched topic is the relation between risk management and project success. There are also other studies that investigate the relationship between project success and project success factors such as communication, organizational commitment, project manager, project planning, project estimation, etc. Some of these studies are empirical. Others are based on the experiences of practitioners. For example, Capers Jones (2004) identified that effective project planning, effective project cost estimating, effective project change management, effective project quality control are success factors for large software projects. Verner and Evanco (2005) found that an above-average project manager is positively associated with software project success. Reel (1999) states the importance of building the right team, hence the importance of staffing and hiring. The relationship between teamwork and communication is widely researched in organizational behavior discipline. The findings indicate strong positive correlation between communication and teamwork. The correlation analysis of these project management areas was reported earlier in this study. The findings of this research are similar to the findings of prior literature on the subject. Thus, these similar findings support the validity of this research.

One interesting discovery of this study was finding an almost perfect positive correlation between process area scores and project management effectiveness scores. The Pearson correlation coefficient was 0.97. It is important to note that correlation does not necessarily indicate causation. Therefore, this strong positive correlation does not mean that being effective in process related project management areas is adequate for achieving project success. This high correlation only suggests that a shorter version of the measurement activity can be achieved with process area related sections in SPMEI.

The correlations between main project management area scores and project success ratings are all positively strong. The *r* values are also close to each other. This suggests that the viability of the framework as well as evaluation model. The process area scores are highly correlated with the other three main area scores. This may suggest that the process main area is the key area that binds all other areas. The correlations between other main area scores are not as strong as the correlations between process area scores and other main areas.

The mean scores of risk main area are lower than the means of other area scores. This suggests that in most software projects, there is room for improvement in applying better risk management practices. For example, in most of the projects critical team members do not have substitutes. Thus, when a critical team member leaves the project organization, development efforts suffer. In one case, it was observed that such a loss of a critical team member was one of the major causes of a significant schedule overrun.

Good risk management practices suggest contingency plans in case of such losses. During the interviews, some study participants also indicated the necessity of applying better risk management practices.

Different evaluation models with variations of different coefficients and project management main areas were tested based on the dataset. These different evaluations models did not provide better results. The conclusion from these investigations is that the current model is valid and adequate for measuring project management effectiveness in software projects.

One important finding was about the data collection challenges faced during this study. It was observed that getting participation from software managers requires a trust relationship between the researcher and study participants. A portion of the data gathered from projects is considered sensitive by some practitioners. The researchers have to be aware of this difficulty and be careful to satisfy the expected privacy concerns of the study participants.

The survey studies include projects developed in the U.S. and Europe. Only one project includes developers from India, the United Kingdom and the U.S. A brief analysis was conducted to identify possible differences among projects developed in different geographical regions. The analysis showed that there were no significant differences in terms of applying project management principles and activities. There may be two possible conclusions. First, the cultural issues in different geographical regions do no affect project management effectiveness as much as applying sound project management principles. Second, differences might exist, but these differences could not be identified due to the limited sample size in the dataset. More research is required to shed light on this issue. In addition, more samples are required including projects developed in other parts of the world.

The studies included projects from both public and private sector. An initial analysis showed that there are no significant differences between these two types of projects. The conclusion is that main project management principles are the same for both of these development environments. Open source development environments are quite different from commercial and government environments. The survey studies did not include open-source projects. Further research that includes open-source projects may bring new insight.

Interviews were conducted with study participants. The interviews revealed that the study participants were not generally concerned with the size of the application in terms of lines of code. They were concerned with whether the required system functionality was delivered or not. Many project estimations were based on the number of modules providing the required functionality. The author had the following observation during the studies: lines of code metrics may not be reliable for understanding the true development effort. In some projects, new technologies may need to be developed, or an existing technology may be imported to a new hardware platform, or a significant amount of user manuals and other types of documentation may need to be delivered with the project. All these efforts, which require a significant amount of work, are hard to capture with lines of code metrics. Therefore, these metrics may be misleading for understanding the development effort.

Another significant finding is about the importance of the communication. The projects that achieved high project management effectiveness conducted weekly or biweekly meetings with the inclusion of managers, developers and other stakeholders. In addition, it was possible to conduct these meetings even when the project team size is large. One project manager published a project newsletter in addition to these project meetings to inform the developers and other stakeholders about the status of the project. A new trend in project management is the use of wiki pages to facilitate communication among the project team and other stakeholders. In this research, a survey on the importance of project management areas was conducted with worldwide participation. The survey results indicate that communication is the most important project management area. The observation from the survey studies supports such a conclusion.

The study participants found the software project management evaluation instrument quite successful in capturing the essence of project management. Most of the study participants specifically indicated that the coverage with SPMEI was good. Some of the participants mentioned that they may also use this tool as a checklist to better manage their projects. The study participants were asked their thoughts on the length of the instrument. They indicated that the length of the instrument is what is necessary. They were also asked whether the instrument should be shortened. The study participants think that the instrument in its current version is good. It takes about 2-3 hours to complete the instrument. Most of the study participants completed the instrument within this time. In addition, they indicated that the instrument made sense to them. This is quite important. There are various tools used by software managers for different purposes. When these tools do not make sense to them or they do not understand the goal or the inner workings of the tool, they tend to ignore the results of the tool. The author attended a seminar on earned value management. In the seminar, the views and the beliefs of practitioners in using various project management tools came up as an interesting discussion topic. The presenter and various practitioners indicated when these tools do not make sense to the tool users, the findings of the tools are ignored and the benefit from these tools could not be gained. Therefore, it is important that the goal of the tool is clear and understandable by the practitioners. SPMEI seems to satisfy this criterion.

Most of the projects in the dataset were successful software projects. The mean project management effectiveness was high in this dataset. This result is not attributed to subjectivity of study participants in trying to present their projects more successful. It is observed that study participants were objective in responding to SPMEI. However, it seems that most study participants chose successful project for analysis.

The survey studies include a variety of software projects in many aspects. However, whether the dataset is a fair representation of the population or not is somewhat of an open question. Currently, it is not possible to identify how well the population is represented in the dataset because such identification requires knowledge about the state of the software industry. Many questions need to be answered about the software industry today. Some of these questions are:

- How do we decide whether a software project is successful or not?
- What percentage of software projects are successful?
- What kinds of projects are being developed today?
- What are the types of software projects?

- What is the number of software projects developed in the past and the number of projects being developed at the present moment?
- What is the average schedule of software projects?
- What are the trends?

Some software engineering scholars are calling for standardization across the software industry in collecting basic software project data. Without the necessary standardization and common understanding, it is hard to provide answers to these questions.

A traditional view of project success is insufficient. That traditional view of success is about completing the project on time, within budget and with the necessary functionality. A few study participants indicated that priorities are different from one project to another. For example, one study participant indicated that the cost was not an issue or a priority for the project he participated in. The main priority was on delivering the necessary functionality because the organization's continuity depended on the successful deployment of the system developed. When the cost of the project is not a priority, evaluating the success of the project based on cost performance may be misleading. During the interviews, one senior software practitioner who has more than thirty years of industry experience indicated an important point. The success of a project relies on successfully managing expectations. When the project satisfies the expectations, then it should be considered successful. The expectations on the outcome of a project should be negotiated with stakeholders. Even though a project is categorized as a success based on the traditional criteria, it may not be viewed as a success by all stakeholders. The opposite case is also possible.

Glass (1999) emphasizes the need for a new theory of project success. There are doctoral studies investigating new views of software project success. Some of them are discussed in prior sections. In the beginning of this research, the author considered the development of a project success metric using the traditional criteria. During the research, it became clear that these criteria are not sufficient to determine whether a project is a success or a failure. Therefore, the author chose to ask the study participants to rate the success of the project. This method is also used in prior studies. With the current state of art, it is one of the most reliable methods in determining project success. In determining project success, many questions may be asked on the outcome of project. Some of these are:

- Was the project developed on time, within budget and with the necessary functionality?
- Was the customer satisfied with the system?
- Did the project yield a good return on investment?
- Did the project team members learn new things?
- Did the organization developing the project gain an increased market share?
- Did the organization developing the project gain more reputation?
- Did the project become an innovation to the society?

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X. CONCLUSIONS AND FUTURE DIRECTIONS

A. CONCLUSIONS

In the recent years, society has seen enormous improvements in the computing field. Many devices that were dreams from the past have become common gadgets in our daily lives today. These devices include laptops, cell phones, electronic identification cards, thumb drives, GPS devices, small multimedia players, and many more. The computing power of CPUs has increased exponentially. The memory devices are small and cheap. Wireless networking enables connection among many devices. The software engineering discipline has also advanced with the introduction of new programming languages such as Java, new design languages such as UML, new automated tools such as automatic verification validation tools, etc. Even though there have been so many technical advances, software projects still suffer from significant failures when compared to other project based industries. In order to increase the rate of software project successes, we need to do better in software project management. The advances in software project management are slow. Most of the commonly used project management tools such as Gantt charts, Pert charts, CPM analysis, earned value management (EVM), and work breakdown structure (WBS) were developed decades ago. Gantt charts were developed back in 1910. Today, most of the automated project management tools include these classic tools. Advancements in software project management will help to increase the rate of software project successes.

In this research, a novel project management tool is introduced. That tool is a software project management effectiveness metric. This metric will be an important addition to the current set of project management tools. This tool measures the project management effectiveness in software projects. This measurement tool will help software development managers to evaluate, monitor and improve project management effectiveness in software projects. Without an understanding and assessment of the status, it is hard to justify the amount of improvement gained in any process improvement effort. This tool will help to improve project management practices in software projects. Thus, it will assist software development managers to achieve better outcomes in their projects.

Most of the literature on software project management is based on practitioner experience reports. Empirical studies are not nearly where they should be. Conducting project management research is challenging. Software companies are reluctant to provide project data for obvious reasons. In addition, the studies provide data that is hard to compare because of different research settings under various assumptions. Capers Jones calls for standardization in gathering and reporting software project data in his book titled "Software Assessments, Benchmarks, and Best Practices." Because of the nature of this study, a standard comprehensive software project data collection instrument is developed. An important contribution of this study is the introduction of this data collection instrument for other researchers to gather data on project management practices and areas. This will help other researchers in their studies.

One of the most important contributions of this research is the identification of the empirical relation between software project success and project management effectiveness. Prior studies established that effective project management is a success factor in software projects. However, a clear empirical relation was lacking. The findings of this study indicate that half of the variation in project success can be attributed to effective project management. Some of the other success factors are choosing the right problem to be solved, customer and user satisfaction, market share gain, and return on investment from the project.

In this research, a theory of project management was introduced. This theory is simple and provides a fresh view on the essence of project management. This theory was developed because of an obvious need. At the beginning of this research, the author struggled in capturing the essence of project management in a simple way. The theory of project management was the starting point for this research. The development of the theory contributed to further understanding and guidance toward the right direction. The existence of this research is evidence for the applicability of this theory. With the guidance of the theory of project management, this research was successfully completed. In addition, a theory of project management effectiveness measurement was developed based on the theory of project management. This shows that the theory of project management is capable of providing new insights for development of other theories and advancing the state of art.

The core concepts in the theory are activities and entities. In simple terms, measurement of project management effectiveness relies on determining the effectiveness of project management related activities and entities. The identification of what these activities and entities are is guided by the software project management framework proposed in this study. This framework is simple and inclusive. Achieving simplicity in the theory and the framework was important. Since the nature of project management is complex, development of an instrument to measure its effectiveness is a challenging task. Developing a simple theory and a simple framework significantly helped to reduce this complexity. This software project management framework was validated with a worldwide survey of software practitioners. The results of this survey also indicated that there has not been a change in the trend of the challenges faced in software development efforts. Software projects are still challenged in areas such as scope management, requirements management, project planning and estimation, communication, etc.

The main finding of this study indicates that it is possible to measure software project management effectiveness with the metric proposed in this research. Furthermore, during the interviews, the study participants indicated that software practitioners would benefit from this project management effectiveness metric and use it to guide their project development efforts.

Quality research enables researchers to ask many new questions while providing answers to the old ones. This research opens up many possibilities for future studies. Researchers will be able to analyze and possibly quantify the effects of software project management practices effectiveness to project success using the metric proposed here.

The contributions of this research are briefly outlined in Table 52.

Contribution	**Contributions to the Software Engineering Body of Knowledge**
1. Introduction of a theory of project management	- Provides a new perspective for program and project management with a focus on core concepts; activities and entities - Enables researchers to conduct further studies and develop other theories on software projects and software project management
2. Introduction of a theory of project management effectiveness measurement	Enables development of various project management metrics to guide process improvement efforts in software projects
3. Identification of approaches for measuring project management effectiveness	- Provides directions for the development of other project management effectiveness metrics - When other project management metrics are developed, it provides a framework for comparison
4. Development of a software project management framework	- Provides a simple view for project management - Helps to focus the improvement efforts on the necessary project management main areas - Identifies measurement model components for developing project management metrics
5. Development of a self-evaluation instrument for software project management	- Provides a standardized tool for collecting data from software projects for conducting project management research - This instrument may be used as a project management checklist by software managers

	- The instrument may be used for developing new industry standards and supplementing existing ones
6. Development of a metric for software project management effectiveness	- Enables quantification of project management effectiveness in software projects - Helps the software project managers to better manage their projects - Helps organizations to determine whether a project requires cancellation - Helps organizations to identify the project management effectiveness in comparison to industry - Helps to analyze effective and ineffective project management practices in software projects - May be used as an input for project estimation purposes - Provides a project monitoring tool to software project managers

Table 52. Contributions to Defense Community and Software Engineering Body of Knowledge

B. FUTURE DIRECTIONS

1. Development of an Automated Tool

Currently, the measurement activity is conducted manually. The software project management evaluation instrument, SPMEI, is provided to study participants as a Microsoft Word document. The study participants fill out the instrument. Then the author feeds the data into an Excel spreadsheet, which contains the evaluation model. The metric is also computed by hand to double-check the results. After all these tasks are completed, the responses are checked for consistency and validity. The overall process takes about 4-6 hours. An automated tool will significantly reduce the time to complete the process.

Development of an automated tool has additional benefits. It helps to store and compare the measurement results. When an organization uses the automated tool for measuring the project management effectiveness in its projects in a continuous fashion, the organization has a record of project management effectiveness history. The trends in project management effectiveness may be analyzed. The cost effective activities for achieving higher effectiveness in project management will be identified. Process improvement efforts may be initiated based on the results of these measurement activities. The results from the measurement activity will provide sound justifications, and these justifications guide better process improvement efforts.

This automated tool may evolve into an expert system. This system may help project managers in their decision-making in providing cost-effective solutions to their project management challenges. However, development of an expert system requires additional research and more data from projects.

The tool automates data collection efforts for researchers. Best project management practices will be researched easier with the help of the tool.

2. Increasing the Sample Size

The sample size in this study was limited. Conducting more studies provides further insight to the applicability and limitations of the proposed metric. The studies include projects from the U.S. and Europe. Studies on projects developed in other parts of the world may reveal new insights.

An important issue needs to be addressed here. While conducting more studies on software projects helps to understand the applicability and limitations of the metric, it will not help to identify whether the sample is a good representation of the population because many important data about the population of software projects is lacking.

Advanced statistical analysis methods could not be applied. These advanced statistical methods such as various tests of significance require established or at least estimated knowledge about the population. Software project management literature lacks the empirical data needed to establish sufficient knowledge about the overall population of software projects. Such knowledge includes the categorization of software project development efforts, the success and failure rates in these different categories, empirical data on the practices and methods applied in these efforts, the effectiveness and efficiency of these practices and efforts, and the different distributions of all these data. For example, one of the basic and most important data about software project management is the rate of software project successes and failures. Yet, we lack that data. Different studies yield different results, especially about the success or failure rates in IT software projects (The Standish Group, 1994; El Emam and Koru, 2008). Various authors discussed this topic in detail (Glass, 2002; Glass, 2005; Jorgensen and Molokken-Ostwold, 2006; Emam and Koru, 2008). El Emam and Koru (2008) indicate that, “So, the software community still needs a reliable global estimate of software project cancellation rates that will help us determine whether there is a software crisis.”

3. Conducting an In-depth Analysis of Project Management Areas based on the Data Gathered with SPMEI

The data gathered with SPMEI is quite extensive. SPMEI is one of the most comprehensive project management data collection tools developed. This instrument gathers data from fifteen project management areas and over 500 data points. This data is used to evaluate the project management effectiveness of a software project. This data may also be used to analyze the relationships of project management areas. It is possible to conduct research on the common, best or worst project management practices using the data collected with SPMEI.

The sections of the instrument may be used as a standard data collection tool. The strong positive correlations between various project management areas and the similar findings in literature indicate the high quality of the instrument. The sections in the instrument may be improved or adjusted for specific research goals.

SPMEI is designed as a modular instrument. SPMEM is a modular evaluation model as well. Future work may include improvement of specific portions of these tools.

APPENDIX A: GLOSSARY

Communication	It is the exchange of ideas, opinions and information through written or spoken words, symbols or actions.
Configuration Management	A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, (3) record and report change processing and implementation status, and (4) verify compliance with specified requirements.
Leadership	The ability to lead, including inspiring others in a shared vision. Leaders have clear visions and they communicate these visions to their employees. They foster an environment within their companies that encourages risk taking, recognition and rewards, and empowerment allowing other leaders to emerge.
Organizational Commitment	Organizational commitment is the employee's psychological attachment to the organization and organizational goals.
Process	A sequence of steps performed for a given purpose; for example the software development process (IEEE, 1990).
Project Monitoring & Control	Project monitoring is the process of keeping the project and project related factors under observation. Project control is to ensure that project goes according to what is planned and deviations from the plan kept under control.

Project Planning/Estimation	Project planning is the process to quantify the amount of time and budget a project will cost. The purpose of project planning is creating a project plan that a project manager can use to track the progress of his team. Estimation includes creating estimates of project cost and schedule using various tools and techniques.
Quality Engineering	In engineering, quality control and quality engineering are involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. It involves all activities and commitment towards development of a high quality product to meet or increase the customer/user satisfaction.
Requirements Management	The management of all requirements received by or generated by the project, including both technical and nontechnical requirements as well as those requirements levied on the project by the organization.
Risk Assessment	A process or a set of activities that involves measurement of risks to determine priorities and to enable identification of appropriate level of risk treatment.
Risk Control	That part of risk management which involves the implementation of policies, standards, procedures and physical changes to eliminate or minimize adverse risks.
Scope Management	Scope management is the process of keeping track of scope changes and limiting the changes to the point that they are not disruptive to the success of the project.

Software Project Management Effectiveness Metric (Software PME Metric)	This metric is a measure of the project management effectiveness in a software project. It captures the effectiveness of the project management from the start of the project to the customer delivery.
Staffing & Hiring	Staffing is the practice of finding, evaluating, and establishing a working relationship with future colleagues on a project and firing them when they are no longer needed. Staffing involves finding people, who may be hired or already working for the company (organization) or may be working for competing companies.
Stakeholder Involvement	Stakeholder involvement is the early and extensive engagement of stakeholders in the process of planning, decision making, and implementation of a project.
Supplementary Activities	Supplementary activities are activities conducted which are not directly related to the project outcome. However, these activities indirectly increase the success probability of the project. Such activities include use of project management, development, testing and other types of tools, training of the personnel, logistics, increasing the satisfaction of the work environment etc.
Teamwork	Teamwork is the concept of people working together towards a common goal set as a team.
Technical Complexity	Technical complexity refers to the complexity of the design, product, project deliverables and technologies used in the development of the product.

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APPENDIX B: PILOT SURVEY STUDY: SELF-ADMINISTERED QUESTIONNARE

Dear Colleague,

Your participation in this survey will help improve the body of knowledge to better manage software projects. You will remain anonymous. If you have questions about the survey or the research, or if you want to have the results and the analysis of the survey, please send an e-mail to kdemir@nps.edu. We sincerely appreciate your participation in this survey.

The Purpose of the Survey: The goal of this survey is to analyze software project management practices and principles. The survey results will help to determine the rankings between various concepts in software project management. The survey takes about 10-15 minutes to complete.

Contact Information:
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Email: kdemir@nps.edu
Web: http://www.nps.navy.mil/cs/kadirdemir/

PARTICIPANT CONSENT FORM & MINIMAL RISK CONSENT STATEMENT

Introduction: You are invited to participate in a study of software project management practices. With information gathered from you and other participants, we hope to discover insight on the importance of certain practices. We ask you to read this form and clicking 'yes' to the question below indicates that you agree to be in the study.

Procedures: If you agree to participate in this study, you will be asked to complete a survey instrumentation composed of a set of questions.

Risks and Benefits: I understand that this project does not involve greater than minimal risk and involves no known reasonably foreseeable risks or hazards greater than those encountered in everyday life. I have also been informed of any benefits to myself or to others that may reasonably be expected as a result of this research.

Compensation: I understand that no tangible reward will be given. I understand that a copy of the research results will be available at the conclusion of the survey research upon my request.

Confidentiality & Privacy Act: The records of this study will be kept confidential. No information will be publicly accessible which could identify you as a participant.

Voluntary Nature of the Study: I understand that my participation is strictly voluntary, and if I agree to participate, I am free to withdraw at any time without prejudice. A copy of this form will be provided upon request for your records.

Points of Contact: If you have any further questions or comments after the completion of the study, you may contact the research supervisor, James Bret Michael (831) 656-2655, bmichael@nps.edu, or the researcher, Kadir Alpaslan Demir (831) 394-3199, kdemir@nps.edu.

Statement of Consent: By entering my name and my signature to this form, I am acknowledging that **I have read and understood this information and agree to voluntarily participate in this survey. I also understand that I may stop at any time upon my request.**

Name:

Signature:

Software Project Management Survey Part 1

1. Please indicate your roles and corresponding experience in software projects. (in Years)

Project Manager	: ___	Project Team Leader	: ___
Requirement Engineer	: ___	Software Architect	: ___
Software Designer	: ___	Software Tester	: ___
Software Maintenance	: ___	Software Code Developer	: ___
Software System Engineer	: ___	Researcher/Scientist	: ___
Other	: ___		

Software Project Management Survey Part 2

2. How would you rate the importance of a particular concept, practice or role within software project management?

Risk Control	0	1	2	3	4	5	6	N/O
Project Monitoring / Control	0	1	2	3	4	5	6	N/O
Communication	0	1	2	3	4	5	6	N/O
Requirements Management	0	1	2	3	4	5	6	N/O
Project Planning/Estimation	0	1	2	3	4	5	6	N/O
Leadership	0	1	2	3	4	5	6	N/O
Teamwork	0	1	2	3	4	5	6	N/O
Staffing/Hiring	0	1	2	3	4	5	6	N/O
Stakeholder Involvement	0	1	2	3	4	5	6	N/O
Organizational Commitment	0	1	2	3	4	5	6	N/O
Scope/Configuration Man.	0	1	2	3	4	5	6	N/O
Quality Engineering	0	1	2	3	4	5	6	N/O
Project Manager	0	1	2	3	4	5	6	N/O
Risk Assessment	0	1	2	3	4	5	6	N/O
Support Activities (Tools, Training, Work Environment etc.)	0	1	2	3	4	5	6	N/O

Software Project Management Survey Part 3

Four different areas have been identified for project management. In this section, we want you to rate these areas with a percentage regarding their importance within software project management. These are people, product, process and risk.

3. The total rating should add up to %100.

* People related concepts and practices (Project Manager, Staffing/Hiring, Leadership, Communication, Teamwork, Stakeholder Involvement, Organizational Commitment)

* Product related concepts and practices (Quality Engineering, Requirement Engineering)

*Process related concepts and practices (Project Planning/Estimation, Scope/Configuration Management, Project Monitoring and Control, Support Activities (training, tools etc.)

* Risk related concepts and practices (Risk Assessment, Risk Control)

Please use (0,10,20…,100)

People related concepts and practices	….%
Process related concepts and practices	….%
Product related concepts and practices	….%
Risk related concepts and practices	….%
	Total = 100%

Software Project Management Survey Part 4

This section is about your views and ideas about the importance of software project management principles and practices. It is open-ended.

4. According to you, what are the most important principles and practices in software project management?

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5. According to you, is there an area, activity, concern or dimension that is left out in this survey?

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6. How can this survey be improved?

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Thank you!!!

If you have questions about the survey or the research, or if you want to have the results and the analysis of the survey, please send an e-mail to kdemir@nps.edu.

Research Contact Information:
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Fax: 1-831-394-3199
Email: kdemir@nps.edu Web: http://www.nps.navy.mil/cs/kadirdemir/
THANK YOU FOR YOUR CONSIDERATION/PARTICIPATION.

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APPENDIX C: SURVEY INSTRUMENT: SELF-ADMINISTERED QUESTIONNARE

Dear Colleague,

Your participation in this survey will help improve the body of knowledge to better manage software projects. You will remain anonymous. If you have questions about the survey or the research, or if you would like the results and the analysis of the survey, please send an e-mail to kdemir@nps.edu.

We sincerely appreciate your participation in this survey.

The Purpose of the Survey: The goal of this survey is to analyze software project management concepts. The survey results will help to determine what constitutes as crucial concepts in software project management. The survey takes about 15 minutes to complete.

Contact Information:
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Web: http://www.nps.navy.mil/cs/kadirdemir/

PARTICIPANT CONSENT FORM & MINIMAL RISK CONSENT STATEMENT

Introduction: You are invited to participate in a study of software project management practices. With information gathered from you and other participants, we hope to discover insight on the importance of certain practices. We ask you to read this form and click 'yes' to the question below to indicate that you agree to be in the study.

Procedures: If you agree to participate in this study, you will be asked to complete a survey instrumentation composed of a set of questions.

Risks and Benefits: I understand that this project does not involve greater than minimal risk and involves no known reasonably foreseeable risks or hazards greater than those encountered in everyday life. I have also been informed of any benefits to myself or to others that may reasonably be expected as a result of this research.

Compensation: I understand that no tangible reward will be given. I understand that a copy of the research results will be available at the conclusion of the survey research upon my request.

Confidentiality & Privacy Act: The records of this study will be kept confidential. No information will be publicly accessible which could identify you as a participant.

Voluntary Nature of the Study: I understand that my participation is **strictly voluntary**, and if I agree to participate, I am free to withdraw at any time without prejudice. A copy of this form will be provided upon request for your records.

Points of Contact: If you have any further questions or comments after the completion of the study, you may contact the research supervisor, James Bret Michael (831) 656-2655, bmichael@nps.edu, or the researcher, Kadir Alpaslan Demir (831) 394-3199, kdemir@nps.edu.

Statement of Consent: By entering my name and my signature to this form, I am acknowledging that **I have read and understood this information and agree to voluntarily participate in this survey. I also understand that I may stop at any time upon my request.**

Name:

Signature:

3. Please indicate your roles and corresponding experience in software projects. (in Years)

Project Manager	: ___	Project Team Leader	: ___
Requirement Engineer	: ___	Software Architect	: ___
Software Designer	: ___	Software Tester	: ___
Software Maintenance	: ___	Software Code Developer	: ___
Software System Engineer	: ___	Researcher/Scientist	: ___
Other	: ___		

4. What is the number of the projects you participated? _____

5. How would you rate the importance of a particular concept, practice or role within software project management

0 = very unimportant   1 = unimportant   2 = somewhat unimportant
3 = neither important nor unimportant   4 = somewhat important   5 = important
6 = very important   N/O = No Opinion

Risk Control	0	1	2	3	4	5	6	N/O
Project Monitoring / Control	0	1	2	3	4	5	6	N/O
Communication	0	1	2	3	4	5	6	N/O
Requirements Management	0	1	2	3	4	5	6	N/O
Technical Complexity	0	1	2	3	4	5	6	N/O
Project Planning/Estimation	0	1	2	3	4	5	6	N/O
Leadership	0	1	2	3	4	5	6	N/O
Teamwork	0	1	2	3	4	5	6	N/O
Staffing/Hiring	0	1	2	3	4	5	6	N/O
Stakeholder Involvement	0	1	2	3	4	5	6	N/O
Organizational Commitment	0	1	2	3	4	5	6	N/O
Scope Management	0	1	2	3	4	5	6	N/O
Quality Engineering	0	1	2	3	4	5	6	N/O
Project Manager	0	1	2	3	4	5	6	N/O
Risk Assessment	0	1	2	3	4	5	6	N/O
Configuration Management	0	1	2	3	4	5	6	N/O
Support Activities (Tools, Training, Work Environment etc.)	0	1	2	3	4	5	6	N/O

6. How many people were working in your LAST software project?

☐ 1-10   ☐ 11-100   ☐ 101- or more

7. What was the size of your LAST software project in terms of SLOC? (SLOC : Source Lines of Code)

☐ (small) <20,000 SLOC
☐ (middle) 20,000 SLOC - 2 Millions SLOC
☐ (large) >2 Millions SLOC

8. What was the type of your organization in your LAST project?

☐ Government   ☐ Commercial   ☐ Government-Contract

9. What kind of an application was developed in your LAST project? (real-time system, web-based, database, office-type application, operating system etc.)

____

10. In your LAST project, in which of these areas did you face challenges? (Please select one or more.)

- ☐ Risk Control
- ☐ Project Monitoring/Control
- ☐ Communication
- ☐ Requirements Management
- ☐ Technical Complexity
- ☐ Project Planning/Estimation
- ☐ Leadership
- ☐ Teamwork
- ☐ Staffing/Hiring
- ☐ Stakeholder Involvement
- ☐ Organizational Commitment
- ☐ Scope Management
- ☐ Quality Engineering
- ☐ Project Manager
- ☐ Risk Assessment
- ☐ Configuration Management
- ☐ Support Activities (Tools, Training etc.)
- ☐ The last project was smooth in every way.
- ☐ Other (Please specify) ______________________________

11. In this section, you are requested to consider ALL of your PAST PROJECT EXPERIENCES.

Four different areas have been identified for software project management. We want you to rate these areas with a percentage regarding their importance within software project management. These are people, product, process and risk.

The total rating should add up to %100.

* People related concepts and practices (Project Manager, Staffing/Hiring, Leadership, Communication, Teamwork, Stakeholder Involvement, and Organizational Commitment)

* Product related concepts and practices (Quality Engineering, Technical Complexity, and Configuration Management)

* Process related concepts and practices (Project Planning/Estimation, Scope Management, Project Monitoring and Control, Support Activities (training, tools etc.), Requirements Management)

* Risk related concepts and practices (Risk Assessment, Risk Control)

Please use (0,5,10,15…95,100)

People related concepts and practices	….%
Process related concepts and practices	….%
Product related concepts and practices	….%
Risk related concepts and practices	….%
	Total = 100%

This section is about your views and ideas about the importance of software project management principles and practices. It is open-ended to provide you the unbounded freedom to express your views.

12. According to you, what are the most important concepts, principles, or practices in software project management?

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13. According to you, is there an area, activity, concept or dimension that is left out in this survey? Or anything you would you like to add?

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DEFINITIONS (Alphabetical)

COMMUNICATION: It is the exchange of ideas, opinions and information through written or spoken words, symbols or actions.

CONFIGURATION MANAGEMENT: A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, (3) record and report change processing and implementation status, and (4) verify compliance with specified requirements.

LEADERSHIP: The ability to lead, including inspiring others in a shared vision. Leaders have clear visions and they communicate these visions to their employees. They foster an environment within their companies that encourages risk taking, recognition and rewards, and empowerment allowing other leaders to emerge.

ORGANIZATIONAL COMMITMENT: Organizational commitment is the employee's psychological attachment to the organization and organizational goals.

PROJECT MANAGER: The person responsible for planning, directing, controlling, structuring, and motivating the project. The project manager is responsible for satisfying the customer. In this survey, project manager is considered as a role and authority as well as incorporating the personal traits within the role.

PROJECT MONITORING/CONTROL: Project monitoring is the process of keeping the project and project related factors under observation. Project control is to ensure that project goes according to what is planned and deviations from the plan kept under control.

PROJECT PLANNING/ESTIMATION: Project planning is the process to quantify the amount of time and budget a project will cost. The purpose of project planning is creating a project plan that a project manager can use to track the progress of his team. Estimation includes creating estimates of project cost, schedule and necessary resources using various tools and techniques.

QUALITY ENGINEERING: In engineering, quality control and quality engineering are involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. It involves all activities and commitment towards development of a high quality product to meet or increase the customer/user satisfaction.

REQUIREMENTS MANAGEMENT: The management of all requirements received by or generated by the project, including both technical and nontechnical requirements as well as those requirements levied on the project by the organization.

RISK ASSESSMENT: A process that involves measurement of risk to determine priorities and to enable identification of appropriate level of risk treatment. In this survey, risk assessment includes the identification of risks.

RISK CONTROL: That part of risk management which involves the implementation of policies, standards, procedures and physical changes to eliminate or minimize adverse risks.

SCOPE MANAGEMENT: Scope management is the process of keeping track of scope changes and limiting the changes to the point that they are not disruptive to the success of the project.

STAFFING/HIRING: Staffing is the practice of finding, evaluating, and establishing a working relationship with future colleagues on a project and firing them when they are no longer needed. Staffing involves finding people, who may be hired or already working for the company (organization) or may be working for competing companies.

STAKEHOLDER INVOLVEMENT: Stakeholder involvement is the early and extensive engagement of stakeholders in the process of planning, decision making, and implementation of a project.

SUPPLEMENTARY ACTIVITIES: Supplementary activities are the type of activities which are not directly related to the project outcome. However, these activities indirectly increase the success probability of the project. Such activities include use of project management, development, testing and other types of tools, training of the personnel, logistics, increasing the satisfaction of the work environment etc.

TEAMWORK: Teamwork is the concept of people working together towards a common goal set as a team.

TECHNICAL COMPLEXITY: Technical complexity refers to the complexity of the design, product, project deliverables and technologies used in the development of the product.

APPENDIX D: SURVEY QUESTION #5 FURTHER ANALYSIS

This appendix provides the further analysis on the responses to the survey question #5.

This question is worded as follows:

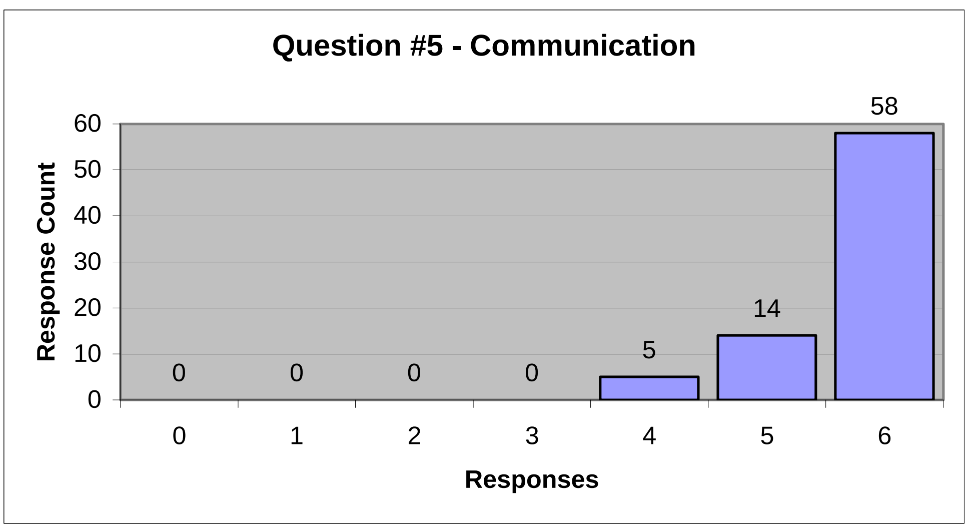
How would you rate the importance of a particular concept, practice or role within software project management?

The scale for the responses are:

0 = very unimportant	1 = unimportant
2 = somewhat unimportant	3 = neither important nor unimportant
4 = somewhat important	5 = important
6 = very important	N/O = No Opinion

1. COMMUNICATION

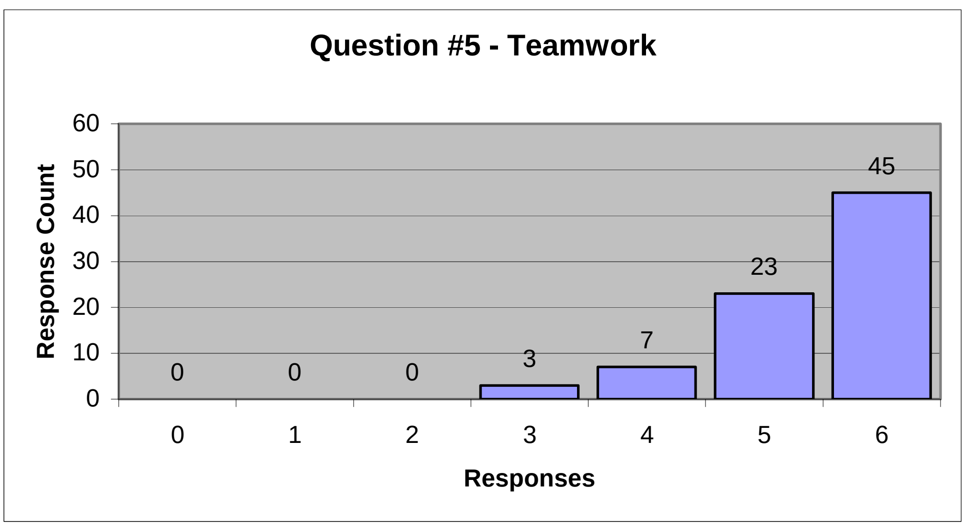
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	0
4 (Somewhat Important)	5
5 (Important)	14
6 (Very Important)	58
N/O (No Opinion)	1
Total Number of Responses	78



Mean	5.688311688	Median	6
Standard Deviation	0.590711887	Mode	6
T-Value	39.93459393	P-Value	9.3328535E-53
Statistically Significant	YES	Critical Test Value	1.991672579

2. TEAMWORK

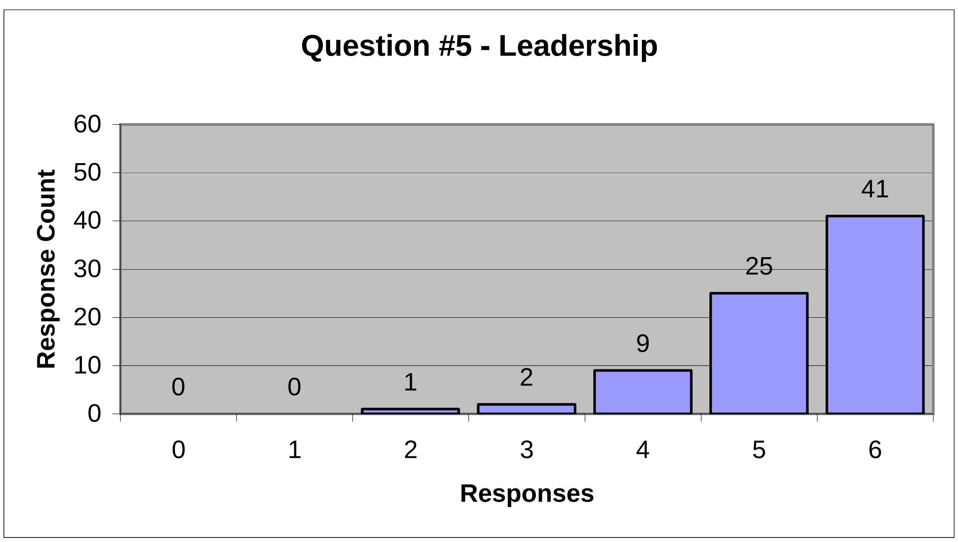
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	3
4 (Somewhat Important)	7
5 (Important)	23
6 (Very Important)	45
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.41025641	Median	6
Standard Deviation	0.812817729	Mode	6
T-Value	26.1889074	P-Value	4.3208136E-40
Statistically Significant	YES	Critical Test Value	1.991254363

3. LEADERSHIP

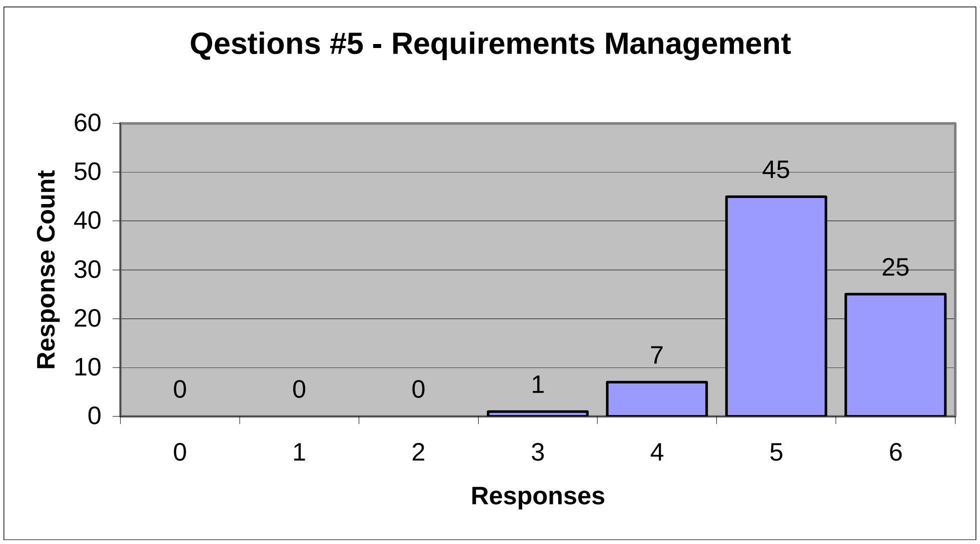
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	1
3 (Neither Important Nor Unimportant)	2
4 (Somewhat Important)	9
5 (Important)	25
6 (Very Important)	41
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.320512821	Median	6
Standard Deviation	0.875252687	Mode	6
T-Value	23.41519726	P-Value	9.2534552E-37
Statistically Significant	YES	Critical Test Value	1.991254363

4. REQUIREMENTS MANAGEMENT

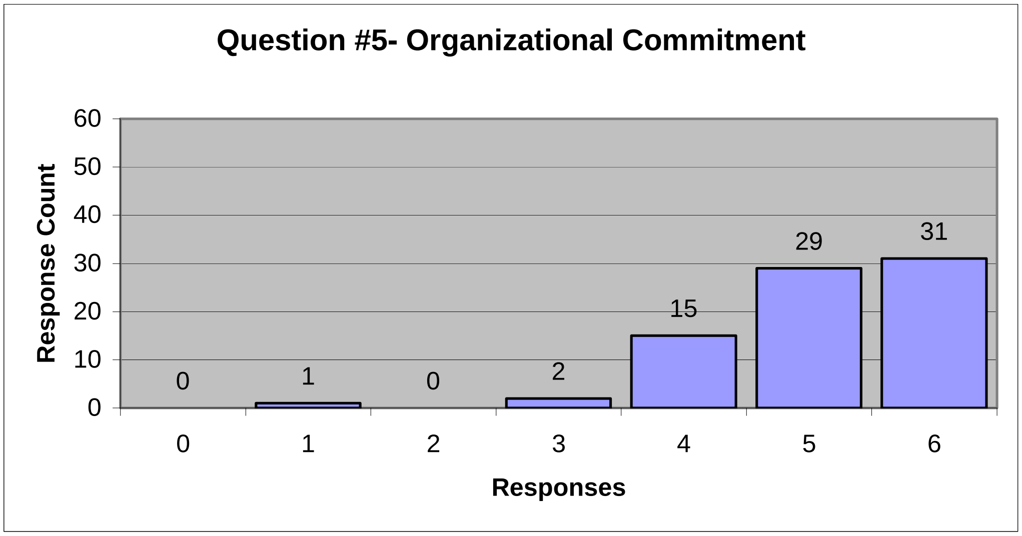
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	1
4 (Somewhat Important)	7
5 (Important)	45
6 (Very Important)	25
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.205128205	Median	5
Standard Deviation	0.651850002	Mode	5
T-Value	29.87675835	P-Value	4.17349559E-44
Statistically Significant	YES	Critical Test Value	1.991254363

5. ORGANIZATIONAL COMMITMENT

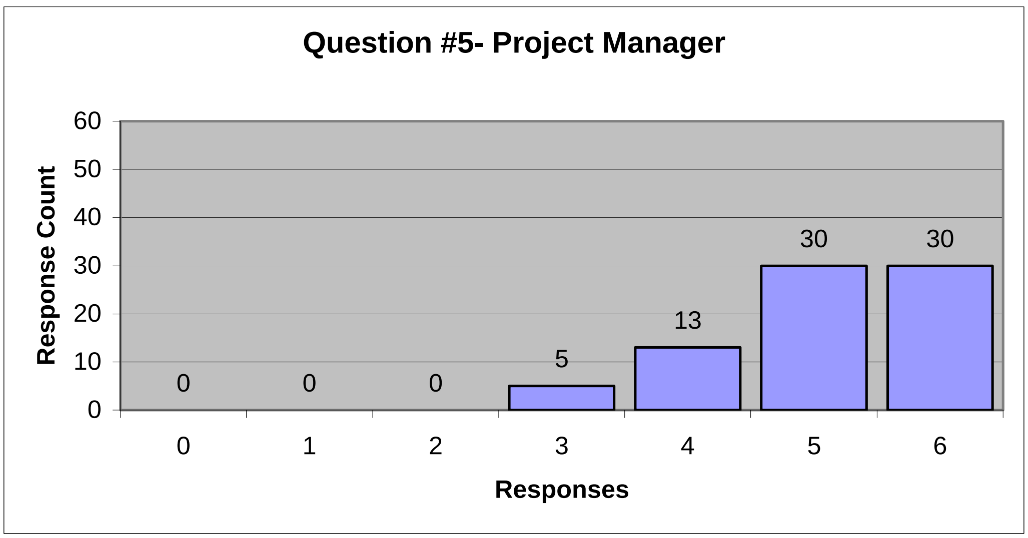
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	2
4 (Somewhat Important)	15
5 (Important)	29
6 (Very Important)	31
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.102564103	Median	5
Standard Deviation	0.947858058	Mode	6
T-Value	19.59084823	P-Value	1.2036674E-31
Statistically Significant	YES	Critical Test Value	1.991254363

6. PROJECT MANAGER

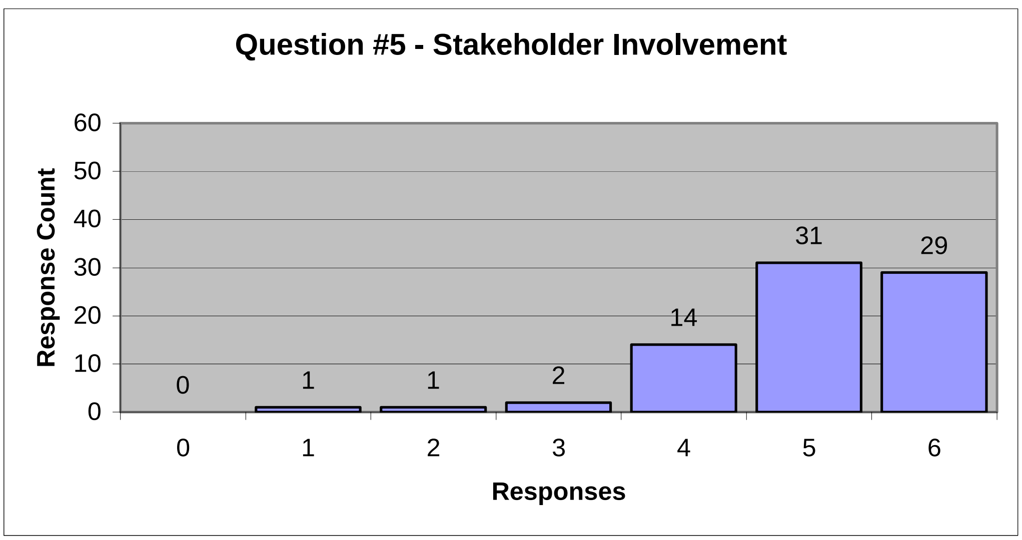
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	5
4 (Somewhat Important)	13
5 (Important)	30
6 (Very Important)	30
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.102564103	Median	5
Standard Deviation	0.947858058	Mode	6
T-Value	19.59084823	P-Value	1.2036674E-31
Statistically Significant	YES	Critical Test Value	1.991254363

7. STAKEHOLDER INVOLVEMENT

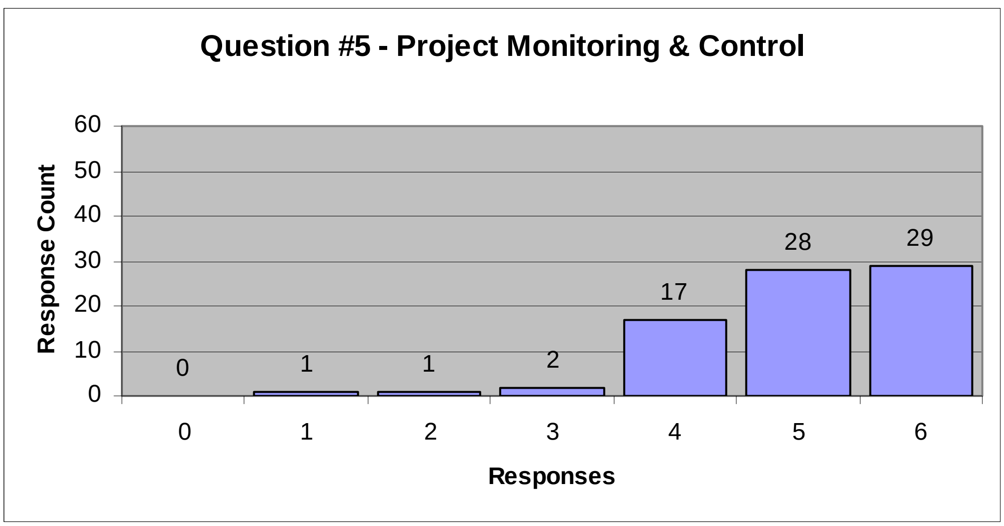
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	1
3 (Neither Important Nor Unimportant)	2
4 (Somewhat Important)	14
5 (Important)	31
6 (Very Important)	29
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.051282051	Median	5
Standard Deviation	0.992143631	Mode	5
T-Value	18.25988897	P-Value	1.0509756E-29
Statistically Significant	YES	Critical Test Value	1.991254363

8. PROJECT MONITORING AND CONTROL

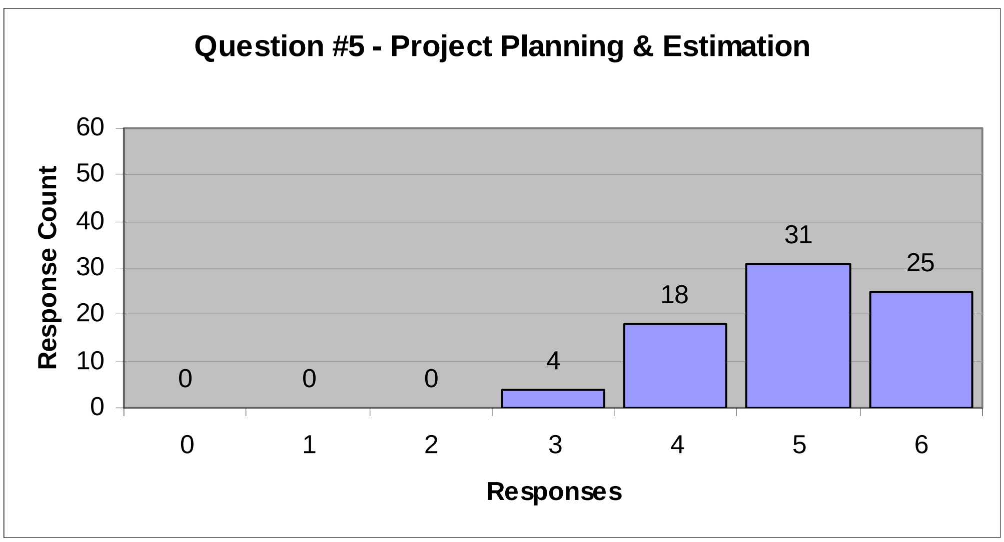
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	1
3 (Neither Important Nor Unimportant)	2
4 (Somewhat Important)	17
5 (Important)	28
6 (Very Important)	29
N/O (No Opinion)	0
Total Number of Responses	78



Mean	5.012820513	Median	5
Standard Deviation	1.012821567	Mode	6
T-Value	17.55170903	P-Value	1.23398069E-28
Statistically Significant	YES	Critical Test Value	1.991254363

9. PROJECT PLANNING AND ESTIMATION

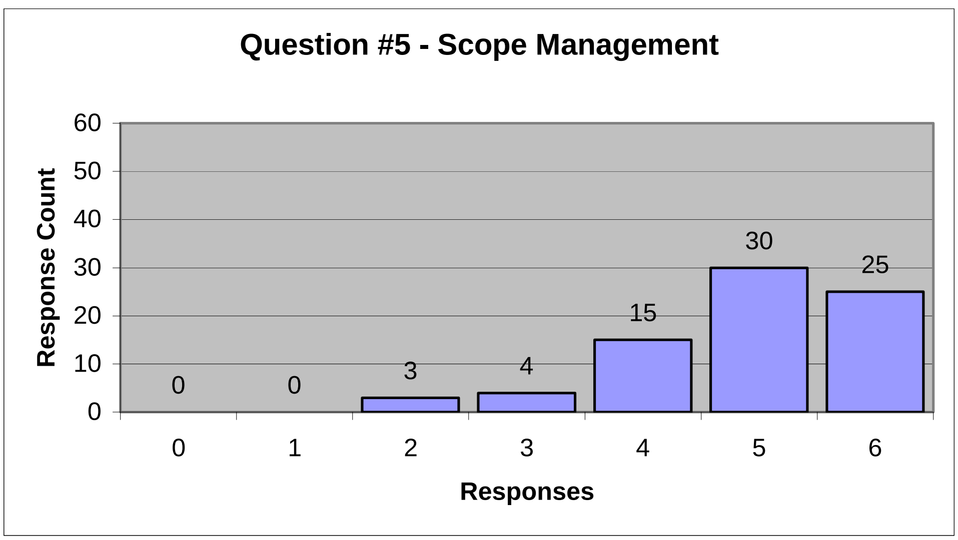
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	4
4 (Somewhat Important)	18
5 (Important)	31
6 (Very Important)	25
N/O (No Opinion)	0
Total Number of Responses	78



Mean	4.987179487	Median	5
Standard Deviation	0.875252687	Mode	5
T-Value	20.05168826	P-Value	2.6841819E-32
Statistically Significant	YES	Critical Test Value	1.991254363

10. SCOPE MANAGEMENT

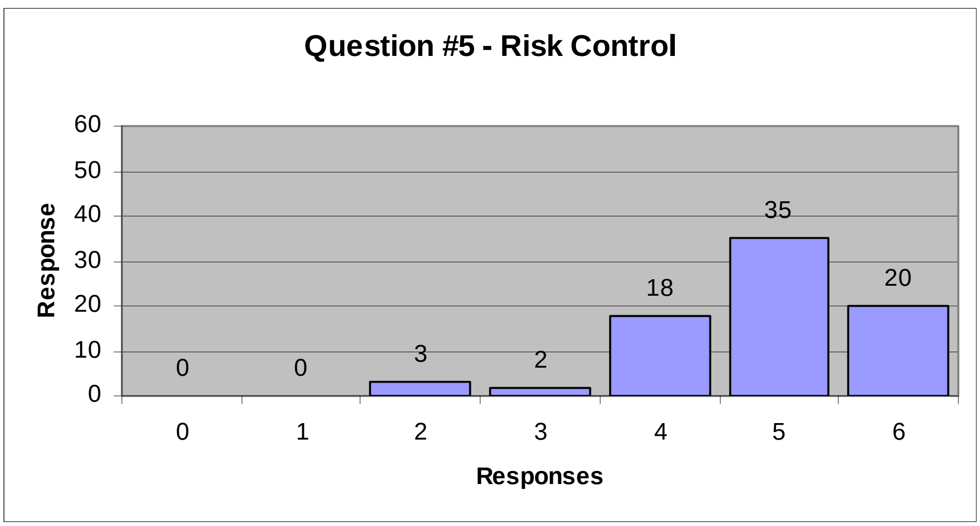
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	3
3 (Neither Important Nor Unimportant)	4
4 (Somewhat Important)	15
5 (Important)	30
6 (Very Important)	25
N/O (No Opinion)	1
Total Number of Responses	78



Mean	4.909090909	Median	5
Standard Deviation	1.041024523	Mode	5
T-Value	16.09203661	P-Value	3.4345063E-26
Statistically Significant	YES	Critical Test Value	1.991672579

11. RISK CONTROL

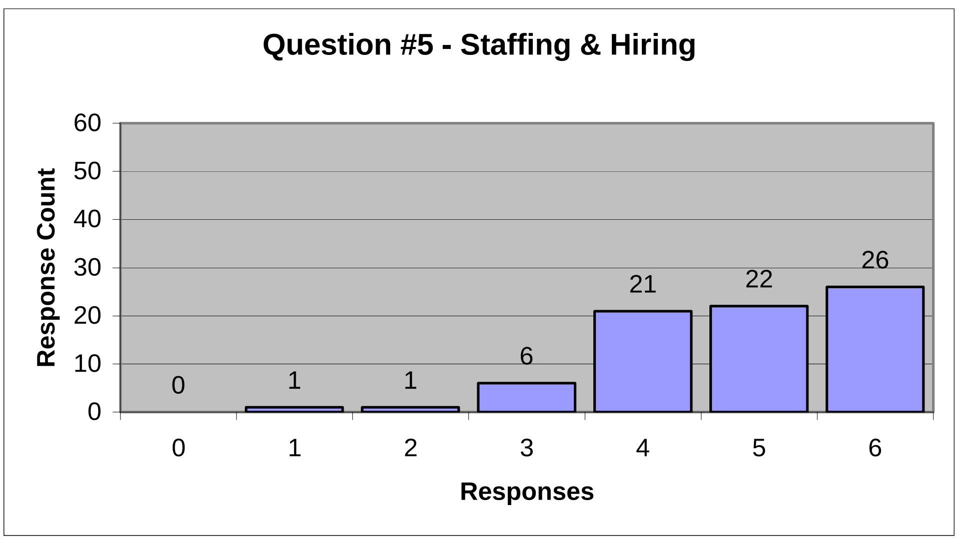
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	3
3 (Neither Important Nor Unimportant)	2
4 (Somewhat Important)	18
5 (Important)	35
6 (Very Important)	20
N/O (No Opinion)	0
Total Number of Responses	78



Mean	4.858974359	Median	5
Standard Deviation	0.963278479	Mode	5
T-Value	17.04389474	P-Value	7.4926949E-28
Statistically Significant	YES	Critical Test Value	1.991254363

12. STAFFING AND HIRING

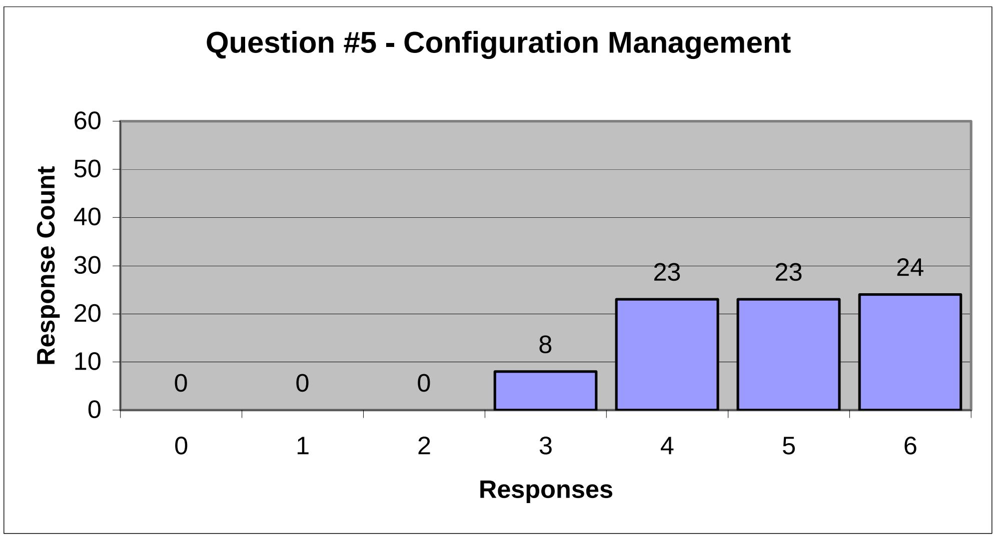
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	1
3 (Neither Important Nor Unimportant)	6
4 (Somewhat Important)	21
5 (Important)	22
6 (Very Important)	26
N/O (No Opinion)	1
Total Number of Responses	78



Mean	4.818181818	Median	5
Standard Deviation	1.108902643	Mode	6
T-Value	14.38762979	P-Value	2.1320399E-23
Statistically Significant	YES	Critical Test Value	1.991672579

13. CONFIGURATION MANAGEMENT

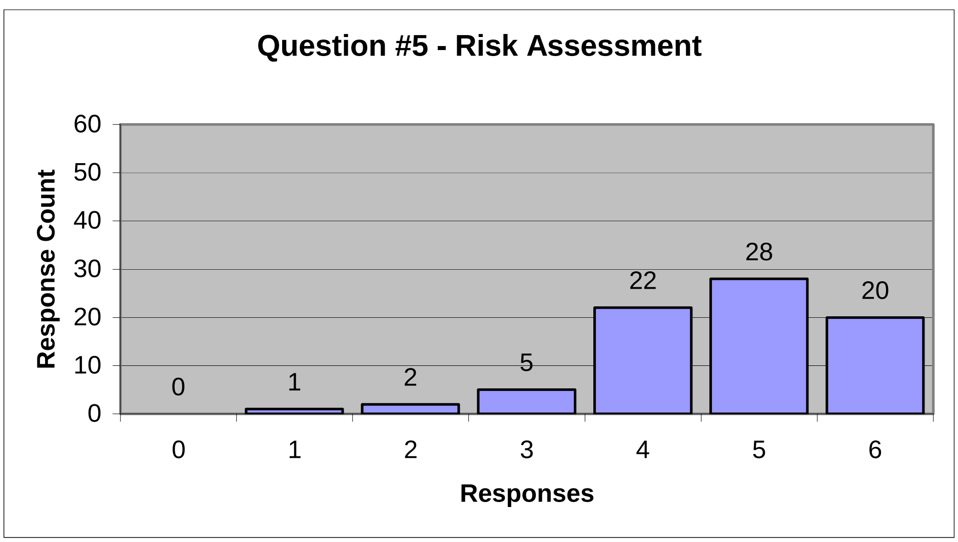
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	0
2 (Somewhat Unimportant)	0
3 (Neither Important Nor Unimportant)	8
4 (Somewhat Important)	23
5 (Important)	23
6 (Very Important)	24
N/O (No Opinion)	0
Total Number of Responses	78



Mean	4.807692308	Median	5
Standard Deviation	0.994239151	Mode	6
T-Value	16.05761166	P-Value	2.7271650E-26
Statistically Significant	YES	Critical Test Value	1.991254363

14. RISK ASSESSMENT

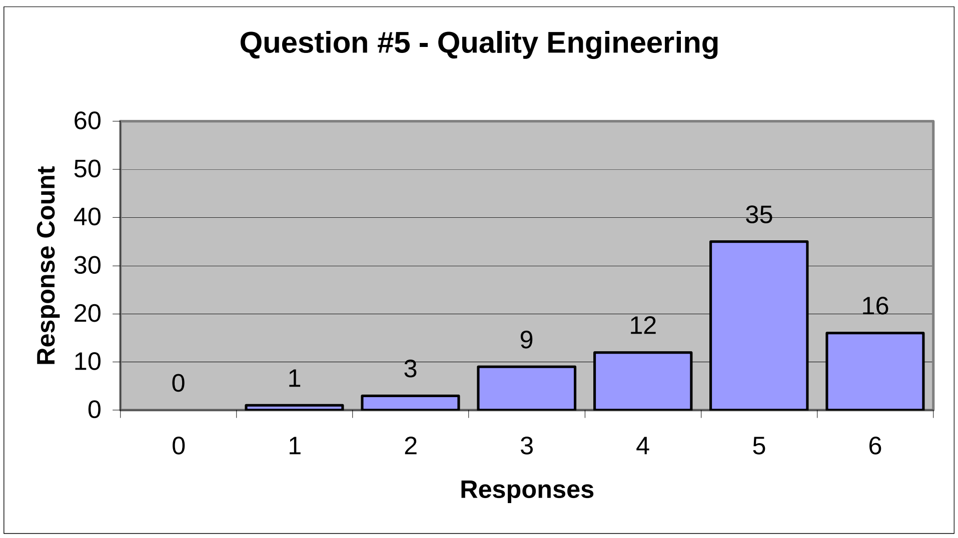
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	2
3 (Neither Important Nor Unimportant)	5
4 (Somewhat Important)	22
5 (Important)	28
6 (Very Important)	20
N/O (No Opinion)	0
Total Number of Responses	78



Mean	4.717948718	Median	5
Standard Deviation	1.079892201	Mode	5
T-Value	14.05002485	P-Value	6.0061044E-23
Statistically Significant	YES	Critical Test Value	1.991254363

15. QUALITY ENGINEERING

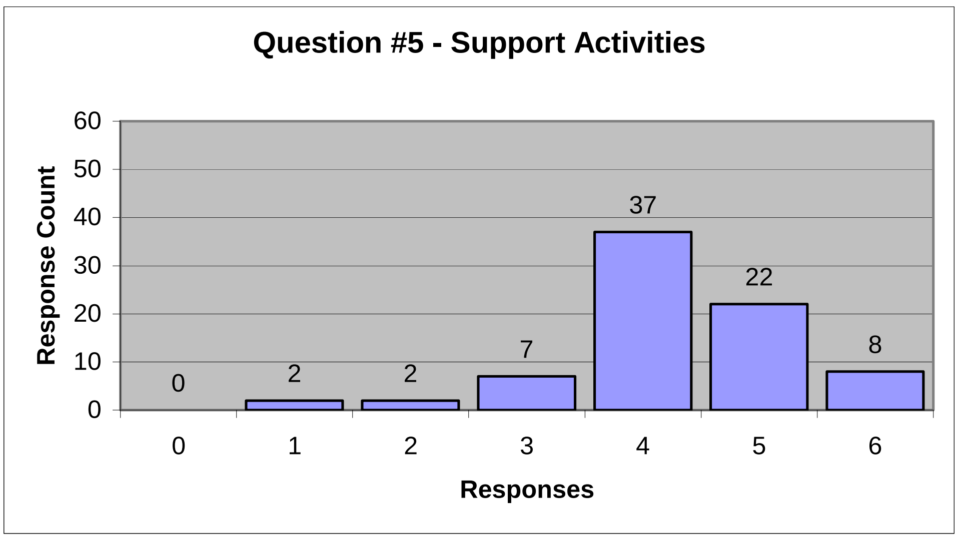
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	3
3 (Neither Important Nor Unimportant)	9
4 (Somewhat Important)	12
5 (Important)	35
6 (Very Important)	16
N/O (No Opinion)	2
Total Number of Responses	78



Mean	4.644736842	Median	5
Standard Deviation	1.139636753	Mode	5
T-Value	12.58162596	P-Value	3.6536650E-20
Statistically Significant	YES	Critical Test Value	1.992102124

16. SUPPORT ACTIVITIES

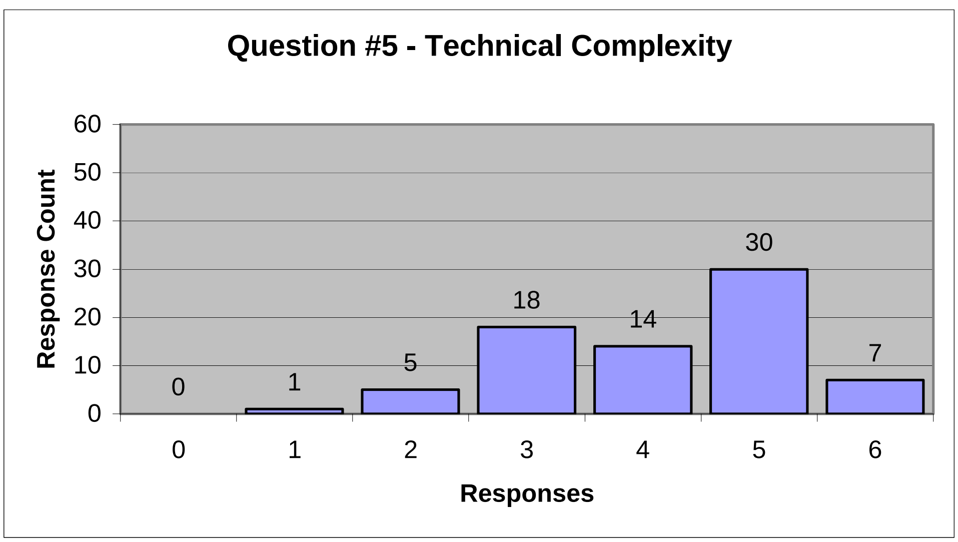
	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	2
2 (Somewhat Unimportant)	2
3 (Neither Important Nor Unimportant)	7
4 (Somewhat Important)	13
5 (Important)	37
6 (Very Important)	22
N/O (No Opinion)	0
Total Number of Responses	78



Mean	4.269230769	Median	4
Standard Deviation	1.027834401	Mode	4
T-Value	10.90598118	P-Value	2.7880999E-17
Statistically Significant	YES	Critical Test Value	1.991254363

17. TECHNICAL COMPLEXITY

	Response Count
0 (Very Unimportant)	0
1 (Unimportant)	1
2 (Somewhat Unimportant)	5
3 (Neither Important Nor Unimportant)	18
4 (Somewhat Important)	14
5 (Important)	30
6 (Very Important)	7
N/O (No Opinion)	3
Total Number of Responses	78



Mean	4.173333333	Median	4
Standard Deviation	1.178332919	Mode	5
T-Value	8.623509173	P-Value	8.5633121E-13
Statistically Significant	YES	Critical Test Value	1.992543466

APPENDIX E: MAPPING OF THE PROJECT MANAGEMENT PROCESSES TO THE PROJECT MANAGEMENT PROCESS GROUPS AND THE KNOWLEDGE AREAS [FROM (PMI, 2004)]

Knowledge Area Processes	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Management Integration	Develop Project Charter 3.2.1.1 (4.1) Develop Preliminary Project Scope Statement 3.2.1.2 (4.2)	Develop Project Management Plan 3.2.2.1 (4.3)	Direct and Manage Project Execution 3.2.3.1 (4.4)	Monitor and Control Project Work 3.2.4.1 (4.5) Integrated Change Control 3.2.4.2 (4.6)	Close Project 3.2.5.1 (4.7)
5. Project Scope Management		Scope Planning 3.2.2.2 (5.1) Scope Definition 3.2.2.3 (5.2) Create WBS 3.2.2.4 (5.3)		Scope Verification 3.2.4.3 (5.4) Scope Control 3.2.4.4 (5.5)	
6. Project Time Management		Activity Definition 3.2.2.5 (6.1) Activity Sequencing 3.2.2.6 (6.2) Activity Resource Estimating 3.2.2.7 (6.3) Activity Duration Estimating 3.2.2.8 (6.4) Schedule Development 3.2.2.9 (6.5)		Schedule Control 3.2.4.5 (6.6)	
7. Project Cost Management		Cost Estimating 3.2.2.10 (7.1) Cost Budgeting 3.2.2.11 (7.2)		Cost Control 3.2.4.6 (7.3)	
8. Project Quality Management		Quality Planning 3.2.2.12 (8.1)	Perform Quality Assurance 3.2.3.2 (8.2)	Perform Quality Control 3.2.4.7 (8.3)	
9. Project Human Resource Management		Human Resource Planning 3.2.2.13 (9.1)	Acquire Project Team 3.2.3.3 (9.2) Develop Project Team 3.2.3.4 (9.3)	Manage Project Team 3.2.4.8 (9.4)	
10. Project Communications Management		Communications Planning 3.2.2.14 (10.1)	Information Distribution 3.2.3.5 (10.2)	Performance Reporting 3.2.4.9 (10.3) Manage Stakeholders 3.2.4.10 (10.4)	
11. Project Risk Management		Risk Management Planning 3.2.2.15 (11.1) Risk Identification 3.2.2.16 (11.2) Qualitative Risk Analysis 3.2.2.17 (11.3) Quantative Risk Analysis 3.2.2.18 (11.4) Risk Response Planning 3.2.2.19 (11.5)		Risk Monitoring and Control 3.2.4.11 (11.6)	
12. Project Procurement Management		Plan Purchases and Acquisitions 3.2.2.20 (12.1) Plan Contracting 3.2.2.21 (12.2)	Request Seller Responses 3.2.3.6 (12.3) Select Sellers 3.2.3.7 (12.4)	Contract Administration 3.2.4.12 (12.5)	Contract Closure 3.2.5.2 (12.6)

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APPENDIX F: SOFTWARE PROJECT MANAGEMENT EVALUATION INSTRUMENT (SPMEI)

Dear Fellow Colleague,

I sincerely appreciate for taking time to participate in this study. This study is conducted as part of my PhD research. I am testing the applicability of a self-evaluation instrument for software project management. We would like you to apply the instrument on a software project you have managed. Your participation will be anonymous. (Please get the 3-digit code by sending an e-mail to kdemir@nps.edu - if you do not already have one.)

The benefits of your participation:

It will result in a tool for YOU to monitor, evaluate and improve YOUR projects.

You will have private third party evaluation of your software project.

You will have first-hand access to research results. It will result in the development of project management metrics and improve the body of knowledge to better manage and evaluate software projects.

The only requirement to participate is:

You are a software development project manager.

You are a software development technical manager.

Or you have worked as one in the past.

The study will be conducted with discretion in complete privacy. And neither will it possible to trace the results back to a particular person, organization or any entity.

This questionnaire investigates what happened during a particular project development. Any other use will definitely be incorrect and misleading.

This is NOT an evaluation of the project manager, the management team, or any other person. This instrument is not designed for that purpose. Any inference derived for such a purpose will definitely be incorrect and misleading.

This is NOT an evaluation of the organization. It focuses on the project, not the organization.

If you have questions about the study or the research, please send an e-mail to kdemir@nps.edu.

Contact Information:

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Software Engineering PhD Candidate,

Computer Science Department,

Naval Postgraduate School,

Monterey, CA, 93943

Tel: 1-831-333-9277

Fax: 1-831-333-9277

Email: kdemir@nps.edu

Web: http://faculty.nps.edu/kdemir/

Informed Consent Form (Naval Postgraduate School)

Introduction. You are invited to participate in a study entitled Software Project Management Effectiveness Evaluation.

Procedures. The goal of this study is to test an evaluation tool to aid practitioners assess their software project managements. You will be asked to fill out a questionnaire. The process takes 1,5-3 hours depending on the participant.

Risks and Benefits. I understand that this project does not involve greater than minimal risk and involves no known reasonably foreseeable risks or hazards greater than those encountered in everyday life. I have also been informed of any benefits to myself or to others that may reasonably be expected as a result of this research.

Compensation. I understand that no tangible compensation will be given. I understand that a copy of the research results will be available at the conclusion of the experiment. It will be delivered to you in the method you find appropriate.

Confidentiality & Privacy Act. I understand that all records of this study will be kept confidential and that my privacy will be safeguarded. No information will be publicly accessible which could identify me as a participant. I will be identified only as a code number on all research forms/data bases. My name on any signed document will not be paired with my code number in order to protect my identity. I understand that records of my participation will be maintained by NPS for three years, after which they will be destroyed.

Voluntary Nature of the Study. I understand that my participation is strictly voluntary, and if I agree to participate, I am free to withdraw at any time without prejudice.

Points of Contact. I understand that if I have any questions or comments regarding this project upon the completion of my participation, I should contact the Principal Investigator, Dr. John Osmundson. (831)656-3775, josmundson@nps.edu or Co-PI Mr. Kadir Alpaslan Demir (831) 333-9277, kdemir@nps.edu . Any medical questions should be addressed to LTC Eric Morgan, MC, USA, (CO, POM Medical Clinic), (831) 242-7550, eric.morgan@nw.amedd.army.mil. Any other questions or concerns may be addressed to the IRB Chair, LT Brent Olde, 656-3807, baolde@nps.edu.

Statement of Consent. I have been provided with a full explanation of the purpose, procedures, and duration of my participation in this research project. I understand how my identification will be safeguarded and have had all my questions answered. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights. Sending the completed questionnaire instrument to Co-PI (Kadir Alpaslan Demir), shows my agreement to participate in the study.

____ ___________________

Participant's Signature Date

*SIGNED XXX*_____________________________ 4/20/2008_________

Researcher's Signature Date

DIRECTIONS FOR FILLING OUT THE QUESTIONNAIRE:

There are 16 sections in the questionnaire. The first section covers some basic statistics regarding the project. The rest 15 sections are organized under various titles. It takes about 1,5 to 3 hours depending on the participant.

- Think of a project you participated and have extensive knowledge. The questionnaire examines from the start of the project (from the point it is decided that the project will be undertaken) to the point it is delivered to the customer for the first time (or it is cancelled).
- The project you chose does not have to be a successful or a good example. Our interest is testing whether the instrument works or not. We are trying to provide a tool for you that you may benefit in your future projects.
- You may respond in any order you like.
- The questions are straightforward and designed to be simple and easy to understand.
- There are two main types of questions.

In the first type, we simply would like you to check one or more statements that apply to the project.

Check the STATEMENT that applies to the project. (CHECK ONLY ONE)

☐ X
☒ Y
☐ None

Check the STATEMENT/S that applies to the project. (CHECK ALL THAT APPLY)

☒ X
☐ Y
☒ Z
☐ None

In the second type, we would like to get your opinion whether you agree or not on a particular statement.

SI1	STATEMENT	Completely Agree ☐	Agree ☐	Neutral ☒	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

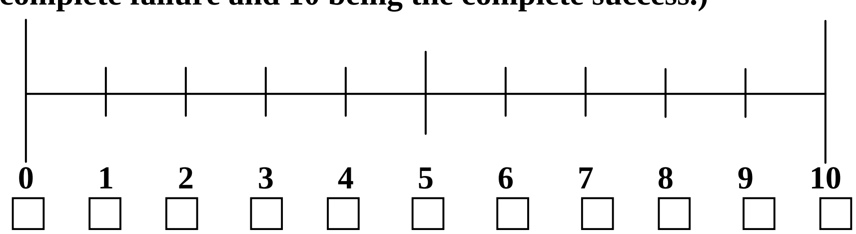
- When there are combined statements, consider them as one concept and respond as is, or take an average of the ratings for each of the statement.
- The questionnaire is designed as a whole. Trying to infer results from just one or more sections will be misleading.
- Please respond to all questions. Partial responses will prevent getting a successful evaluation.

A. GENERAL PROJECT RELATED QUESTIONS (17 QUESTIONS – ABOUT 5 MINUTES)

Directions: Please provide responses to the following questions to the best of your knowledge.

ENTER THE CODE PROVIDED:

PR1.	**What was the goal of the project? What kind of an application was developed? What were the deliverables? Please briefly state.**	
PR2.	**What was the title of the project (if there is one)?**	
PR3.	**What was the projected/planned effort for the project? (in terms of man-month)**	**Man-month**
PR4.	**What was the actual effort for the project? (in terms of man-month)**	**Man-month**
PR5.	**What was the actual cost of the project?**	**Dollars**
PR6.	**What was the projected/planned budget for the project?**	**Dollars**
PR7.	**How long did the project take?** ***From start (or contract) date to delivery date**	**Months**
PR8.	**What was the projected/planned schedule for the project?**	**Months**
PR9.	**What was the start date of the project? (Month/Year)**	**/**
PR10.	**What was the delivery date of the project? (Month/Year)**	**/**

PR11.	**How much of the functionality (or number of features) are delivered to the customer? (Between the initial baseline and the delivered product)**	**%**
PR12.	**How many people did work on the project? (Including the management, consultants/contractors etc.)** **Requirements Phase :** **Design Phase :** **Implementation Phase :** **Testing and Delivery Phase :** **Total :** **Or** **Average number of people during from start to end :**	
PR13.	**What is the size of the project? (in terms of Lines of Code (KLOC) or function points (FP))**	**KLOC** **FP**
PR14.	**Where was the project developed? Which state, country or countries?**	
PR15.	**What kind of an organization did develop the project? (Such as government, commercial, open source community, government contract etc.) Organization name?**	
PR16.	**How would you rate the overall success of the project?** **(0 being complete failure and 10 being the complete success.)** 	
PR17.	**What is/was your role in the project?**	

B. COMMUNICATION SECTION (23 QUESTIONS – ABOUT 7-12 MINUTES)

C1. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ A common glossary/terminology for the project is created.
☐ Communication procedures adapts due to changing project environment.
☐ Communication procedures are always followed as stated in the communication planning documentation (or similar document).
☐ There is a project information distribution list (or a similar document) and it is maintained.
☐ The project budget includes resources for communication and project information distribution efforts.
☐ None

C2. Who are generally present in the project status meetings? (Check all that apply.)

☐ Project manager
☐ Project team leaders
☐ Project team members
☐ Customer/s and/or user representatives
☐ Various stakeholders or stakeholder representatives
☐ Executive management / Project sponsor

C3. Which of the following/s is/are discussion items in project status meetings? (Check all that apply.)

☐ Project schedule
☐ Project budget
☐ Project risks
☐ Project staff problems
☐ Important development events and/or accomplished project deliverables
☐ Requirements
☐ None

C4. Which of the following/s does the project information distribution plan/list (or similar document) contain? (Check all that apply.)

☐ Project information type/context (What will be communicated)
☐ Recipients of various communication items (Stakeholders- who should receive the information)
☐ Project related information distribution frequency
☐ Timeframe of the relevant communication
☐ Communication format and medium (How the communication will be conducted- reports, meetings, teleconferencing etc.)
☐ Responsible project staff for communication
☐ Not available

		(5)	(4)	(3)	(2)	(1)	N/A
C5	**The importance of communication is understood and established between stakeholders and project team members. There is commitment to good**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C6	**Stakeholders including project team members' needs for various project data and information are analyzed and identified.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C7	**There have been communication problems due to various reasons.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C8	**Communication is used as a means to resolve conflicts.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C9	**There are designated project team members and representatives of stakeholders responsible for conducting communication.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C10	**Communication procedures are documented and distributed to stakeholders and project team members.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C11	**Communication and coordination for activities are planned in the project plan.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable
C12	**The response and acknowledgement procedures are planned and documented in the communication procedures.**	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Not Applicable

C13	**The information needs of stakeholders and project team members are satisfied in a timely manner through appropriate use of communications media.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C14	**As a project manager or a project team member, I can easily communicate my messages and I can be understood.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C15	**A communications and project information/data management system with essential capabilities are in place. (Such as databases, mail servers, or teleconferencing etc.)**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C16	**The project environment facilitates horizontal communication that is between peers.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C17	**The project team operates in a virtual environment rather than on a face-to-face basis.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C18	**The project status is visible to every stakeholder and project team member.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C19	**The project manager, management team, and team leaders are always accessible to project team members in a timely manner.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C20	**When I report a project problem, I get timely acknowledgement that my message has been received and understood.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

C21	**Informal communications within the team and stakeholders are also an important part of project development environment.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C22	**The project environment facilitates free-format meetings for various purposes.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
C23	**The project environment facilitates freedom in reporting of project problems.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

C. TEAMWORK SECTION (30 QUESTIONS – ABOUT 10 MINUTES)

T1. Which of the following/s are clearly documented in the project plan for each team member? (Check all that apply.)

☐ Responsibility of the team member
☐ Accountability of the team member
☐ Authority of the project manager and team members
☐ Reporting structure
☐ Interfaces and/or communication channels
☐ None

T2. How many project team members stayed with the project until the end according to the project staffing plan? (Check only one.)

☐ All
☐ Most
☐ Some
☐ None

T3. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ Notable project accomplishments/milestones/deliverables are celebrated with social events or parties.
☐ There are problem-solving meetings with the attendance of relevant project team members and stakeholders.
☐ Organizational culture encourages problem solving sessions with the attendance of project members.
☐ When a project team member left the team or the member is removed, the rest of the team has understood the reasoning.
☐ None

T4. Which of the following activities are carried out throughout the project? (Check all that apply.)

☐ Social events/parties
☐ Team building training
☐ Introduction meetings and parties
☐ Reward and other types of ceremonies
☐ Brainstorming and problem solving meetings and sessions
☐ Meetings for self-assessment of team performance
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
T5	**The project is adequately staffed during the project development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

T6	**The organization structure and responsibility/task matrix are clearly documented and provided to project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T7	**There are regular status meetings to self-assess the project team's performance and morale.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T8	**There is an accepted shared vision for the project within team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T9	**Team members are involved in the project planning effort.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T10	**Team members are involved in decision-making process during project development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T11	**The project status is visible to team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T12	**In order to do the work effectively, all necessary project data and information is easily accessible to project members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T13	**Training opportunities are created and made available upon need or at the request of team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

T14	**There are more experienced project team members than inexperienced team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T15	**The project environment facilitates teaming up inexperienced team members with the experienced team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T16	**Rewards for achievements are handed out justifiably and made the project team happy.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T17	**There is trust and respect among team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T18	**The project team is empowered with adequate resources to do their tasks.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T19	**The support from upper management or project sponsor is visible to the project team.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T20	**The project offers stimulating and challenging work to project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T21	**The project environment offers professional growth potential for team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

T22	**The project suffers from not having enough experienced or qualified team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T23	**Team members are tasked based on their skills, capabilities, ambitions and interests.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T24	**The team members are clear about how their job performance will be evaluated.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T25	**The project team members believe that they have enough resources to accomplish their jobs successfully.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T26	**The orientation procedures and the sponsors are documented and the procedures are followed for the team members joining the team later.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T27	**Project priorities are always made clear via meetings, presentations and memos; priorities are not constantly changing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T28	**The project suffers from lack of communication and coordination.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
T29	**The project suffers from lack of leadership at various levels.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

T30	**The project team consists of people who has worked together before.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

D. LEADERSHIP SECTION (17 QUESTIONS – ABOUT 3-6 MINUTES)

		(5)	(4)	(3)	(2)	(1)	N/A
L1	**The leaders at various levels promote competition rather than coordination within the project organization.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L2	**The leaders at various levels sets example for others.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L3	**After the creation of the shared vision for the project, the leaders at various levels maintain the vision.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L4	**The leaders at various levels are effective problem-solvers in technical and social issues.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L5	**The management protects the team from outside interference.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L6	**The leaders at various levels clearly state their leadership styles upfront with reasons for the style.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L7	**The leaders at various levels assign correct tasks to correct people.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L8	**The leaders at various levels are respected by the team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

L9	**The leaders at various levels easily delegates authority when necessary.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L10	**The leaders at various levels observe the morale of the staff and takes proactive action to boost the morale.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L11	**The project team suffers from coordination problems.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L12	**The project team suffers from communication problems.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L13	**The leaders at various levels welcome communication of project problems at any time.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L14	**The leaders at various levels clearly define what is expected from project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L15	**The project team members freely share their desires, wishes, and concerns with their leaders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
L16	**The leaders at various handle project politics well.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

<u>* Provide response to either L17 or L18.</u>

L17. (Answer only if the project team mostly consists of inexperienced staff) Check the <u>statement</u> that applies to the project. (Check only one.)

☐ The leaders at various levels have to make most decisions and direct the staff.
☐ The leaders at various levels make most decisions with the consultation of team members and coach the staff.
☐ The leaders at various levels and the team members make decisions together.
☐ The leaders at various levels mostly oversee the decisions made by the staff and delegate the tasks.

L18. (Answer only if the project team mostly consists of experienced staff) Check the <u>statement</u> that applies to the project. (Check only one.)

☐ The leaders at various levels have to make most decisions and direct the staff.
☐ The leaders at various levels make most decisions with the consultation of team members and coach the staff.
☐ The leaders at various levels and the team members make decisions together.
☐ The leaders at various levels mostly oversee the decisions made by the staff and delegate the tasks.

E. ORGANIZATIONAL COMMITMENT SECTION (27 QUESTIONS – ABOUT 7-12 MINUTES)

		(5)	(4)	(3)	(2)	(1)	N/A
OC1	**The executive management is committed to providing necessary financial support.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC2	**The executive management is committed to providing necessary flexibility on the project schedule.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC3	**The executive management is committed to providing necessary flexibility on the project functionality and quality.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC4	**The executive management and project organization is open to change/adaptation.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC5	**There is encouragement for organizational and personal certifications such as CMMI, PMI, PMP, ISO etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC6	**There is commitment to quality by executive management, team members and other stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC7	**Adequate resources are set aside for the success of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC8	**There is support for bringing in expertise when needed (Such as technical, legal, contracting etc.)**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

OC9	**There is support for quality subcontracting when needed.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC10	**The executive management supports / empowers / enables the project manager to do his job.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC11	**There is continuous and observable support from executive management.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC12	**Leaders at various levels are committed to the success of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC13	**Leaders at various levels are committed to their team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC14	**The project manager and leaders at various levels are committed to providing continuous support in enabling the team members to do their work.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC15	**The project team members are committed to the accomplishment of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC16	**The project team members show their commitment to staying with the project until the end.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

OC17	**The project team members put extra effort for the success of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC18	**The project team members lack motivation due to various reasons including external factors.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC19	**The project manager and the team members don't consider the project as a pleasant challenge.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC20	**The project manager and the team members consider the project as a valuable learning experience.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC21	**There is a friendly-work environment.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC22	**The project team members publicly and explicitly indicate their job satisfaction.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC23	**There is commitment from various stakeholders including project team members, customer, marketing and sales department(if applicable) etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
OC24	**Executive management, project manager and project team members are committed to establishing effective project management and control mechanisms.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

OC25. Which of the following <u>item/s</u> does the executive management show commitment to providing support? (Check all that apply.)

☐ Human resources
☐ Training needs
☐ Supplementary needs such as office space, tools, computer systems etc.
☐ None

0C26. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ The executive management clearly defines the authority and responsibility of the project manager.
☐ The executive management allows for realistic budget and schedule.
☐ Training is made available to all team members.
☐ There are some resignations in the project organization.
☐ The project organization allows for career development.
☐ None

F. PROJECT MANAGER SECTION (27 QUESTIONS – ABOUT 5-9 MINUTES)

PM1. How many project managers have changed during the project (Turnover)? (Check only one.)

☐ None
☐ 1
☐ 2
☐ 3 or more

PM2. How many years of experience does the project manager have? (Check only one.)

☐ Less Than 5
☐ 5-10
☐ 10-15
☐ 15-20
☐ More Than 20

PM3. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ The project manager has certification related to project management such as PMP etc.
☐ The project manager has worked on similar projects.
☐ The project manager has worked as a project manager before.
☐ The project manager has worked as a practitioner/developer before, therefore has technical background.
☐ The project manager has worked on different types of projects.
☐ None

PM4. Which of the <u>following/s</u> the project manager has control over? (Check all that apply.)

☐ Budget
☐ Schedule
☐ Product Quality
☐ Process Quality
☐ Hiring and letting go
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
PM5	**The project manager's role, accountability, and responsibilities are clearly defined and communicated to stakeholders including project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PM6	**The project manager was given adequate authority and control over the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM7	**The project manager has adequate project management education, training and experience.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM8	**As a project manager, I have goals and a clear vision related to the project. /As a team member, I observe that the project manager has goals and a clear vision related to the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM9	**As a project manager, I am able to maintain the continuity of the project vision. / As a team member, I observe that the project manager is able to maintain the continuity of the project vision.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM10	**As a project manager, I am deeply committed to the project./As a team member, I observe the deep commitment in the project manager.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PM11	**As a project manager, I am communicative and always accessible to team./As a team member, I observe that the project manager is communicative and always accessible to the team.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM12	**As a project manager, I motivate staff and other people well./As a team member, I observe that the project manager motivates the staff and other people well.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM13	**As a project manager, I am a good planner and organizer./As a team member, I observe that the project manager is a good planner and organizer.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM14	**As a project manager, I am an effective problem solver./As a team member, I observe that the project manager is an effective problem solver.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM15	**As a project manager, I consult to and get advice from stakeholders and project team members. / I observe that the project manager consults to and gets advice from stakeholders and project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PM16	**As a project manager, I delegate easily when necessary./As a team member, I observe that the project manager delegates easily when necessary.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM17	**As a project manager, I use rewarding and punishment mechanisms effectively. /As a team member, I observe that the project manager uses rewarding and punishment mechanisms effectively.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM18	**As a project manager, I am a people person./As a team member, I observe that the project manager is a people person.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM19	**As a project manager, I am an effective team builder and player./As a team member, I observe that the project manager is an effective team builder and player.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM20	**As a project manager, I support my team members in various aspects./As a team member, I observe that the project manager supports the team members in various aspects.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PM21	**As a project manager, I monitor every aspect of the project./As a team member, I observe that the project manager monitors every aspect of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM22	**As a project manager, I inform the stakeholders and my team members well./As a team member, I observe that the project manager informs the stakeholders and the team members well.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM23	**As a project manager, I clarify when the stakeholders and the team members are confused about an aspect of the project./As a team member, I observe that the project manager clarifies when the stakeholders and the team members are confused about an aspect of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM24	**As a project manager, I am able to see the project as a whole./As a team member, I observe that the project manager sees the project as a whole.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM25	**As a project manager, I understand the domain of the project./As a team member, I observe that the project manager understands the domain of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PM26	**As a project manager, I protect my team members so that their work don't get disrupted./As a team member, I observe that the project manager protects us so that our work don't get disrupted.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PM27	**As a project manager, I understand and foresee the project risks./As a team member, I observe that the project manager understands and foresees the project risks.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

G. REQUIREMENTS MANAGEMENT SECTION (27 QUESTIONS – ABOUT 5-9 MINUTES)

RM1. Check the statement/s that applies to the project. (Check all that apply.)

☐ There is a requirements development document (how they are gathered and developed).
☐ There is a requirements management document (how they are handled).
☐ There is an agreed/negotiated requirements baseline.
☐ There is a requirements baseline document and it is managed.
☐ None

RM2. Check the statement/s that applies to the project. (Check all that apply.)

☐ Oral requirements are used.
☐ Written requirements are used.
☐ Requirements are formal – a standard guides the development; have identifiers and traceability matrix etc.
☐ Requirements are informal – requirements are just identified and listed.
☐ None

RM3. Which of the following activities are conducted in the project? (Check all that apply.)

☐ Market surveys
☐ Customer/User interviews
☐ Prototyping
☐ Scenarios/ use cases
☐ Observation of the user in operation
☐ None

RM4. Check the statement/s that applies to the project. (Check all that apply.)

☐ Stakeholders are identified prior to requirements development activities.
☐ Requirements related documents have versions.
☐ There is a requirements traceability matrix (or a similar document to trace the requirements during all the development activities).
☐ Requirements volatility (number of requirements change/ percent of number of requirements change etc.) metrics are collected and used.
☐ Testing team is involved in the requirement development activities.
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
RM5	**Requirements prioritization is conducted and used for development decisions.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

RM6	**All stakeholders are involved in the requirements development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM7	**Users or user representatives are involved in the requirements development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM8	**Stakeholders show commitment to requirements stability during the project development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM9	**Automated requirements development and management tools are used.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 10	**All requirements are traceable.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 11	**Product components and project deliverables can be mapped to specific requirements.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 12	**Requirements are clear / unambiguous.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 13	**Requirements are complete.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

RM 14	**There are no inconsistencies among requirements.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 15	**During the project development, requirements related issues are resolved with the negotiation with the customers.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 16	**Requirements are validated with the user, customer and necessary stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 17	**There are designated points of contact (people) representing various stakeholders to resolve requirements related issues.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 18	**The procedures are formal for requirements validation (what the customer want).**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 19	**The procedures are formal for requirements verification (the system does what requirements state).**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 20	**There is a formal requirements change procedure and document.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 21	**Requirements history and rationale for requirements changes are recorded.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

RM 22	**Requirements are worded simple and each requirement consists of only one concept.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 23	**Extra effort is spent to make the requirements testable.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 24	**There are testing plans to check if the requirements are implemented as intended.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 25	**User/customer profiles are identified and documented.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 26	**Requirements are constantly changing and all changes are being implemented.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RM 27	**Requirements are kept stable at some point.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

H. STAKEHOLDER INVOLVEMENT SECTION (12-16 QUESTIONS – ABOUT 3-7 MINUTES)

		(5)	(4)	(3)	(2)	(1)	N/A
SI1	**Various users and/or customers are involved in the requirements development and functionality/feature identification process.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI2	**Various user and/or customer concerns are specified and documented for the project and the product.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI3	**Various user and/or customer profiles are identified and documented.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI4	**Prototypes/user stories/paper mock-ups/use cases etc. are prepared with the involvement of users.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI5	**Executive/upper management is involved in the decision making process regarding the project baselines, cost and schedule variations etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI6	**All stakeholders are identified and documented.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI7	**There are regular meetings with various stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI8	**There is an information gathering activity to identify stakeholders and their stakes/concerns.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

SI9	**All stakeholders show commitment to the successful outcome of the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

SI10. Check the statement/s that applies to the project. (Check all that apply.)
☐ There is a document guiding the management of stakeholders.
☐ The stakeholder management plan/document lists the primary and secondary stakeholders.
☐ The stakeholder management plan/document lists the concerns and stakes of the primary and secondary stakeholders.
☐ The stakeholder management plan/document provides specific strategies for dealing with various stakeholders.
☐ The users and/or customers participated in the testing phase of the project.
☐ There is a documented procedure for the acceptance of the project deliverables.
☐ None

* **Respond the following questions(SI11-SI12) only if the project is developed for the market without a specific contract.**

SI11	**The marketing department and necessary functional managers are involved in the decision making process during development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI12	**The marketing department provides timely information regarding users and other competing products.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

* **Respond the following questions (SI13-SI18) only if the project is developed under a contract with a specific customer.**

SI13	**There are communication and coordination problems between project team members and other stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

SI14	**When there is a change in the baseline, the cost, schedule, and functionality/features are renegotiated with the customer.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI15	**Regular updates regarding project variables such as cost, schedule and progress on functionality are provided to the stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI16	**When there is an increase in cost or delay in schedule, the news and the consequences are shared with the stakeholders in a timely manner.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SI17	**Project milestones are considered reached when there is consensus from stakeholders for advancing to the next phase.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

SI18. Check the statement that applies to the project. (Check only one.)

☐ Project team members are allowed to have direct communication with the customers and/or users.

☐ All communication with the stakeholders is conducted via the project manager and/or management.

I. PROJECT MONITORING AND CONTROL SECTION(19 QUESTIONS – ABOUT 4-8 MINUTES)

PMC1. Check the <u>statement</u> that applies to the project. (Check only one.)
☐ There is a documented project plan.
☐ There is no project plan.

PMC2. Which of the following data and/or metric/s are regularly monitored and documented? (Check all that apply.)
☐ Team/developer performance
☐ Cost and earned value
☐ Risk items and their impacts
☐ Schedule performance
☐ Number of requirements changes
☐ Necessary staff and skill requirements
☐ None

PMC3. Check the <u>statement</u> that applies to the project. (Check only one.)
☐ There are specific project team members assigned for controlling activities such as configuration management, requirement changes etc.
☐ All control activities are handled by the project manager.

PMC4. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ There are project progress or milestone review meetings.
☐ Key project problems are identified and being monitored.
☐ Key project problems and project progress status is visible to the stakeholders including project team members.
☐ None

PMC5. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ There is an established requirements change and control process.
☐ There is an established risk management and control process.
☐ There is an established configuration management process.
☐ There is an established baseline tracking and scope change control process.
☐ There is an established project management data and metrics collection and monitoring process.
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
PMC 6	**The project problems are generally proactively addressed (before they happen).**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PMC 7	**The project problems are generally reactively addressed (when they happen).**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 8	**The project resources are closely monitored.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 9	**There is an established project monitoring and control procedure with the acceptance of project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 10	**There are established methods/criteria to determine deviations from the project plan.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 11	**In case of deviations from the plan, corrective action is taken immediately.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 12	**Project management metrics are effectively collected and used in decision-making. (such as planned versus actual cost, requirements changes, schedule performance etc.)**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 13	**A project management automated software tool is used to manage project management data and metrics.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 14	**Earned value management is effectively used.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PMC 15	**There is communication between management and project staff regarding the project progress data.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 16	**The commitment and concerns of various stakeholders is being monitored through regular meetings and communication.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 17	**The subcontractor performance is monitored regularly.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 18	**There are checklists for critical tasks such testing, version control, requirements change requests etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PMC 19	**Corrective actions for problems are timely and effective.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

J. PROJECT PLANNING AND ESTIMATION SECTION (35 QUESTIONS – ABOUT 10-18 MINUTES)

PPE1. Check the statement/s that applies to the project. (Check all that apply.)

☐ There is a formal documented project plan.
☐ There is an informal project plan.
☐ There project plan and schedule is made visual via diagrams, charts etc.
☐ There is no project plan.

PPE2. Check the statement that applies to the project. (Check only one.)

☐ The project plan is developed as needed during the project.
☐ The project plan is developed up front before any development effort.

PPE3. Check the statement that applies to the project. (Check only one.)

☐ The project budget, schedule, and staff requirements are strictly enforced by the executive/upper management or customer.
☐ The project budget, schedule, and staff requirements are identified via analysis and negotiation.

PPE4. Check the statement that applies to the project. (Check only one.)

☐ The project plan is approved by the stakeholders such as customers, users, project team members, executive management etc.
☐ There is no approval process.

PPE5. Which of the following/s is/are involved in the project planning? (Check all that apply.)

☐ Senior/executive/upper management
☐ Experts and consultants
☐ Project manager and/or management team
☐ Project team members
☐ Customer/user/marketing department
☐ Other relevant stakeholders
☐ None

PPE6. Which of the following/s is/are included in the project plan? (Check all that apply.)

☐ Project scope
☐ Deliverables or products list
☐ Detailed schedule and milestones / various product version delivery dates
☐ Detailed budget and cost analysis
☐ Staffing/personnel/developer requirements
☐ Task responsibility matrix or similar assignment matrix
☐ Required functionality/features of the products or deliverables
☐ Validation and verification plan
☐ Acquisition plan / Subcontracting planning
☐ Deployment or Installation plan/ Marketing plan
☐ Quality requirements / Quality assurance plan
☐ Risk management planning
☐ Project glossary
☐ Project communications planning
☐ Project organization charts
☐ Staff responsibilities and responsibility definitions
☐ Necessary facility, equipment, and component requirements
☐ None

PPE7. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ There is a statement of work (or a similar document) stating what needs to be accomplished/done.
☐ There is a work breakdown structure or a feature/functionality list (or a similar document) that details the project tasks/activities.
☐ The tasks and activities are identified as the project progresses.
☐ None

PPE8. What kinds of effort, schedule or cost estimation techniques are used? (Check all that apply.)

☐ Experiences of project manager/management team
☐ Inputs from project team members
☐ Expert or consultant judgment
☐ Analogy to similar projects
☐ Historical data
☐ Automated cost estimation tools
☐ None

PPE9. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ No estimation is needed.
☐ Only one type of estimation technique is used.
☐ Two or more estimation techniques are used.
☐ Estimates from various techniques are compared and analyzed for discrepancies.
☐ None

PPE10. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ Lines of code (LOC) are used in estimation.
☐ Function points are used in estimation.
☐ Number of functionality/features are used in estimation.
☐ Number of modules and deliverables are used in estimation.
☐ Other advanced metrics used in estimation.
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
PPE 11	**The project schedule is feasible.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 12	**The funding for the project is adequate.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 13	**The project is adequately staffed.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 14	**Extra funding for unprecedented issues is set aside.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 15	**Slack or buffer time exists in the schedule for unprecedented or extra activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 16	**Alternative staff to accomplish critical tasks/activities are considered and incorporated in the project plan.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 17	**All relevant stakeholders are identified before planning activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PPE 18	**A certain level of requirements analysis is conducted before planning and estimation.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 19	**All external dependencies are identified and incorporated to the planning. (Such as acquisition of various products and services from outside vendors, required permissions**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 20	**The project plan is updated throughout the project development.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 21	**The project plan is visible/available to project team members and other relevant stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 22	**Various automated project management tools are used in planning the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 23	**The project team members are consulted in planning and estimation efforts.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 24	**The managers at various levels have project planning and estimation training.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 25	**Each task/activities/work packages are assigned to specific project team member or members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PPE 26	**Critical activities are identified and/or critical path analysis is conducted.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 27	**Various standards, guidelines or checklists are used in planning and estimation.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 28	**Formal analysis is conducted for cost, schedule and effort estimation such as PERT, CPM etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 29	**Factors such as staff turnover or loss of key personnel are considered during planning.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 30	**Realistic estimates guide the project planning.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 31	**Testing is carefully incorporated to project plan.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 32	**Effort estimations are provided by those performing the tasks.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 33	**Project risks are carefully analyzed and contingencies are included in the planning.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

PPE 34	**A suitable project development approach and process is identified with rationale in the project plan.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
PPE 35	**All necessary skills and expertise needed in the project are identified.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

K. SCOPE MANAGEMENT SECTION (16 QUESTIONS – ABOUT 3-8 MINUTES)

SM1. Check the statement that applies to the project. (Check only one.)
☐ Project scope never changed.
☐ Project scope frequently changed.
☐ Project scope somewhat changed.

SM2. Check the statement that applies to the project. (Check only one.)
☐ Project scope is ambiguous at first and it becomes clear during the project.
☐ Project scope is ambiguous at first and stays ambiguous due to various reasons.
☐ Project scope is defined and clear at the beginning of the project and it stays clear.
☐ Project scope is defined and clear at the beginning of the project and it become ambiguous due to various reasons.

SM3. Check the statement that applies to the project. (Check only one.)
☐ There is a project scope document and it stayed the same from the project start.
☐ There is a project scope document and it is updated when it is necessary.
☐ There isn't a project scope document.

SM4. What is the effect of project scope changes on the project schedule? (Check only one.)
☐ None
☐ On time without scope change/s
☐ On time with scope change/s
☐ Late without scope change/s
☐ Late with scope change/s

SM5. What is the effect of project scope changes on the project budget? (Check only one.)
☐ None
☐ Within budget without scope change/s
☐ Within budget with scope change/s
☐ Cost overrun without scope change/s
☐ Cost overrun with scope change/s

SM6. What is the effect of project scope changes on the functionality of the deliverables? (Check only one.)
☐ None
☐ Full functionality without scope change/s
☐ Full functionality with scope change/s
☐ Less than planned functionality without scope change/s
☐ Less than planned functionality with scope change/s

SM7. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ Project scope changes are handled only by the management.
☐ Project scope changes have to follow a formal defined process.
☐ Project scope changes follow a decision-making process that includes management, stakeholders, and team members.
☐ Project scope changes handled informally by the management.

SM8. Which of the following <u>statement/s</u> is/are included in the project scope document, if there is one. (Check all that apply.)
☐ The problem statement
☐ The work to be done or work breakdown structure
☐ The constraints
☐ The resources
☐ Preliminary or detailed schedule and cost analysis
☐ The project deliverables
☐ Clear definition of performance to meet contractual and legal obligations
☐ Glossary
☐ Not Available

SM9. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)
☐ The project scope is defined after stakeholders are identified.
☐ There is at least one project scope identification/definition meeting at the beginning of the project.
☐ There is a project scope change board.

SM10. Who are included while defining and updating the project scope? (Check all that apply.)
☐ Project management team
☐ Project manager
☐ All stakeholders
☐ Some stakeholders
☐ Project team members
☐ Subcontractor representatives if there is subcontracting
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
SM11	**Before defining the project scope, there is a rigorous information gathering activity about the problem that is to be solved, the resources, the constraints, the deliverables**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SM12	**Project scope is not clearly defined due to various reasons.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SM13	**The project has a documented project scope definition and a formal scope change process.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SM14	**Project scope is always visible and clear to stakeholders, project team members, and management.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SM15	**Project scope changes have to go through an extensive decision-making process.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
SM16	**The project scope document is reviewed and approved by all stakeholders.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

L. RISK CONTROL SECTION (17 QUESTIONS – ABOUT 3-8 MINUTES)

RC1. What is the overall risk level of the project? (Check only one.)
☐ High
☐ Medium
☐ Low
☐ None

RC2. What is the effect of risks on the project budget? (Check only one.)
☐ High cost overrun
☐ Medium cost overrun
☐ Low cost overrun
☐ None

RC3. What is the effect of risks on the project schedule? (Check only one.)
☐ The project delivery is on time.
☐ The project delivery is slightly late.
☐ The project delivery is significantly late.

RC4. What is the effect of risks on the project functionality? (Check only one.)
☐ High
☐ Medium
☐ Low
☐ None

RC5. What is the level of funding and resources set aside for risk management? (Check only one.)
☐ More than enough
☐ Enough
☐ Hardly enough
☐ No funding and resources

RC6. Check the statement/s that applies to the project. (Check only one.)
☐ Adequate slack time is planned in the schedule for consequences due to risks.
☐ There is not any slack time planned for consequences due to risks.
☐ Not enough slack time is planned in the schedule for consequences due to risks.

RC7. Check the statement that applies to the project. (Check only one.)
☐ Risks are handled when they occur.
☐ Risks are addressed before they occur.
☐ Both

RC8. Check the statement/s that applies to the project. (Check all that apply.)
☐ Informal project risk management procedures are in place.
☐ Project risk management is based on formal procedures.
☐ There is not any project risk management and planning.

RC9. Check the statement/s that applies to the project. (Check all that apply.)
☐ Risks are generally avoided. (Risk Avoidance)
☐ Risks are transferred to third parties for example contracting risky development items to consultants or experts. (Risk Transfer)
☐ Risks are managed as they occur.
☐ Risk mitigation (actions reducing the severity/impact of a risk) is the most used option in risk management of the project. (Risk Mitigation)
☐ None

RC10. Check the <u>statement</u> that applies to the project. (Check only one.)

☐ Experts are consulted in the risk management of the project.
☐ Project management handles all the risks.
☐ Project team members and stakeholders are involved in the risk management.

		(5)	(4)	(3)	(2)	(1)	N/A
RC11	**For each identified risk item, there is an information gathering activity.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC12	**Contingencies and alternative solutions are planned for the critical tasks and portions of the development exposed to high risks.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC13	**Top risk items list is closely monitored and periodically updated.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC14	**Risk monitoring is an important activity in the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC15	**Risk avoidance is primary method of risk control activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC16	**There are regular project risk monitoring meetings or project risk monitoring is handled through project status meetings etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RC17	**There is a risk management plan and course of action for each high-risk items.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

M. STAFFING/HIRING SECTION(29 QUESTIONS – ABOUT 7-13 MINUTES)

S1. Which of the followings are clearly identified, documented and communicated? (Check all that apply.)

☐ Project Roles
☐ Project Positions
☐ Necessary Qualifications for the project
☐ None

S2. Which of the documents or similar documents exist for the project? (Check all that apply.)

☐ Project staffing management plan
☐ Project responsibility/accountability/interfaces/assignment matrix
☐ Project work breakdown structure
☐ None

S3. What is the experienced-to-inexperienced project team member ratio? (experienced: inexperienced) (Check only one.)

☐ Smaller than 1:2
☐ 1:2
☐ 1:1
☐ 2:1
☐ Greater than 2:1

S4. Which of the followings for team members are clearly identified, documented and communicated? (Check all that apply.)

☐ Responsibility
☐ Job Interfaces
☐ Reporting Structure
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
S5	**The work breakdown structure (WBS) or similar document is completed before hiring/staffing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S6	**The analysis of the required work and resources is conducted rigorously.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S7	**Significant project risks are identified before the hiring/staffing the team.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

S8	**There is adequate funding and resources for hiring/staffing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S9	**There are adequate work force and experts with the necessary skills and expertise available for hiring and/or staffing on this project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S10	**Expertise on human resources is acquired for staffing and hiring activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S11	**Project open positions are made attractive to qualified candidates through incentives etc. The position is made desirable.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S12	**The skills and expertise needed for the project success are acquired with the timely recruitment of team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S13	**The necessary interpersonal skills for the roles are identified and the project team members are recruited also based on their interpersonal skills.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S14	**The ambitions and goals of the project team members are aligned with the project mission and goals.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S15	**The project team members have the necessary educational background.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

S16	**The project team members have similar project work experience.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S17	**The productivity of the project team members are within the expectations.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S18	**Project team members are familiar and comfortable with the organizational culture.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S19	**Project team members have difficulties with the organizational procedures.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S20	**Project team members are happy with their roles, positions and career advancement opportunities in the project organization.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S21	**Project team members stay with the project according to the project staffing management plan. Turn-over rate is at minimum.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S22	**Resignations are at minimum.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S23	**Project team members acquire the necessary skills and expertise needed for the project through training and coaching.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

S24	**There are alternative team members with the necessary skills and knowledge to take over some other team member's work for critical tasks in case of team member**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S25	**Project positions are filled with qualified individuals.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S26	**Work and task assignments are fair and based on qualifications of the project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S27	**Removing of project team members for unsatisfactory work performance and/or other reasons are conducted fairly and according to the organizational procedures.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S28	**Orientation or transition activities for the new team members are conducted properly.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
S29	**When necessary, consultants and contractors are used effectively.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

N. CONFIGURATION MANAGEMENT SECTION (13 QUESTIONS – ABOUT 3-7 MINUTES)

* In some organizations configuration management is referred as version control.

CM1. Check the statement that applies to the project. (Check only one.)

☐ Configuration management is conducted informally.
☐ Configuration management is a formal and documented activity and it has well-defined procedures.

CM2. Check the statement/s that applies to the project. (Check all that apply.)

☐ There is a configuration management document.
☐ There is a configuration or change control board, committee or team.
☐ There is a configuration items list.
☐ None

CM3. Check the statement/s that applies to the project. (Check all that apply.)

☐ Baselines and configuration items are identified at the beginning of the project and updated as necessary.
☐ The owner or responsible staff is identified for each configuration item.
☐ Every configuration item has a unique identifier.
☐ Important characteristics for each configuration item are identified such as author, type, date, version number etc.
☐ None

CM4. Check the statement/s that applies to the project. (Check all that apply.)

☐ The configuration management procedures includes a detailed change and change request protocols.
☐ The configuration management system has various levels of control (such as only author may release the item, restricted write access etc).
☐ There is not a configuration management system and configuration management is only the responsibility of project team members or developers.
☐ None

CM5. Check the statement that applies to the project. (Check only one.)

☐ The change requests have to go through the change control board or responsible staff.
☐ The change requests are only handled by the developer or the owner of the configuration item.

		(5)	(4)	(3)	(2)	(1)	N/A
CM6	**The project suffers from configuration/version management problems.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM7	**An automated configuration management system is used and adequate for the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM8	**The configuration management procedures are strictly followed. Project team members do not try to bypass them.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM9	**The integrity, security and privacy of configuration items are satisfactory.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM 10	**The changes and change requests are controlled, and documented in such a way that it enables audit.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM 11	**Every change request is controlled and extensively reviewed.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM 12	**Records of configuration management activities, changes to baselines, work products, and change requests are well-maintained.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
CM 13	**There is an established and reliable configuration management system including automated tools, databases, protocols etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

O. RISK ASSESSMENT SECTION (20 QUESTIONS – ABOUT 5-10 MINUTES)

RA1. Which of the following does best characterize the risk assessment activities in the project? (Check only one.)

☐ Formal
☐ Informal
☐ Semiformal
☐ Not available

RA2. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ Risks are assessed as they are identified during the project.
☐ Risks are assessed early and incorporated into a risk management document.
☐ The risk management document is periodically updated.
☐ There is staff specifically assigned to risk assessment activities.
☐ Lessons learned are visited prior to risk assessment activities.
☐ None

RA3. In which of the following categories the risks are assessed and documented? (Check all that apply.)

☐ People
☐ Schedule
☐ Budget and Funding
☐ Technology
☐ Requirements
☐ Subcontractor
☐ None

RA4. There are common objective criteria to assess risks. (Check only one.)

☐ Yes
☐ No
☐ Partially
☐ Not Available

RA5. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ There is a project risk management plan.
☐ The project risk management plan includes objective criteria for risk identification, analysis and prioritization.
☐ Project risk document is updated frequently along the project.
☐ None

RA6. Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ Experts or consultants are used for risk assessment.
☐ Experienced project staff is used for risk assessment.
☐ Project manager conducted the risk assessment.
☐ There is not any risk assessment activity.

RA7. Check the statement/s that applies to the project. (Check all that apply.)

☐ Risks are identified.
☐ Risks are analyzed.
☐ Risks are categorized.
☐ Risks are prioritized.
☐ None

RA8. Check the statement that applies to the project. (Check only one.)

☐ Risk assessment is based on qualitative methods.
☐ Risk assessment is based on quantitative methods.
☐ Risk assessment is based on the judgment of the management.
☐ Risk assessment is based on both qualitative and quantitative methods.
☐ There is no need for any risk assessment activity.

		(5)	(4)	(3)	(2)	(1)	N/A
RA9	**The projects risks are documented early with details related to their impact on the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA10	**Risk assessment has a clear impact on project planning and decisions.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA11	**Sufficient reserve resources and funding are planned and set aside for risk assessment activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA12	**Top risk items list or a similar list is maintained.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA13	**Risks are assessed with the broad inclusion of stakeholders and project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

RA14	**Project environment facilitates and encourages open and free discussions on project risks.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA15	**Risks are identified using risk identification tools such as checklists, databases, risk taxonomy, decision-driver analysis etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA16	**Risks are analyzed based on their probability of occurrence and impact on the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA17	**Risks are prioritized based on their probability of occurrence and impact on the project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA18	**Risk assessment information is always visible and they are shared with stakeholders and project team members.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
RA19	**Any stakeholder or project team member may report a risk at any time and there is a mechanism allowing such reports.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

RA20. (Answer only if a portion of the system is subcontracted.) Check the <u>statement/s</u> that applies to the project. (Check all that apply.)

☐ Subcontractor/s is/are free in their risk management decision and activities.
☐ Subcontractor/s is/are contractually responsible to have formal risk assessment procedures.
☐ Subcontractor/s is/are contractually responsible to deliver risk assessment reports.
☐ Subcontractor/s has/have a representative for project risk management meetings.

P. QUALITY ENGINEERING SECTION (20 QUESTIONS – ABOUT 4-10 MINUTES)

QE1. Check the statement/s that applies to the project. (Check all that apply.)

☐ There is a quality policy.
☐ Quality is not a high priority in this project due to various reasons.
☐ There is a quality planning activity.

QE2. Check the statement/s that applies to the project. (Check all that apply.)

☐ Quality expectations of various stakeholders are identified and documented.
☐ The quality standards and guidelines related to the project are identified. (Such as aviation standards etc.)
☐ Objective quality criteria for the project and its deliverables are identified.
☐ None

QE3. Which of the following quality attribute/s are considered achieved in the project? (Check all that apply.)

☐ Maintainability
☐ Safety
☐ Security
☐ Reliability
☐ Usability
☐ Other
☐ None

QE4. What is the amount of testing conducted during the project development? (Check only one.)

☐ Extensive
☐ Fair
☐ Some
☐ None

		(5)	(4)	(3)	(2)	(1)	N/A
QE5	**Quality is considered a high priority in this project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE6	**There is support for and commitment to quality from executive management.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

QE7	**High quality is planned from the start in this project.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE8	**Various quality metrics are identified.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE9	**Quality assurance procedures are adequate.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE10	**Quality assurance procedures are documented.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE11	**Adequate amount of resources are set aside for quality engineering activities.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE12	**The requirements are defined with the guidance of quality expectations.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE13	**The project team culture encourages commitment to high quality.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE14	**Project team members are trained in quality assurance.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

QE15	**There are quality thresholds and expectations for various work products such as system architecture, requirements definitions, designs, testing etc.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE16	**Quality considerations are limited to testing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE17	**High testing coverage for the product is achieved.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE18	**There are adequate tools, equipment and resources for testing.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐
QE19	**There are specifically assigned team members for quality related issues.**	Completely Agree ☐	Agree ☐	Neutral ☐	Disagree ☐	Completely Disagree ☐	Not Applicable ☐

QE20. Which of the following activity or activities are conducted during the project development? (Check all that apply.)

☐ Design reviews
☐ Code reviews/inspections
☐ Performance testing
☐ Independent verification and validation
☐ Quality assurance activities
☐ Requirements tracing
☐ Various types of testing
☐ Defect identification and prevention
☐ Simulations and/or prototyping
☐ None

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APPENDIX G: SOFTWARE PROJECT MANAGEMENT EVALUATION MODEL SHEET BY SECTION

A. COMMUNICATION SECTION

	Choices						
Question Number	**A**	**B**	**C**	**D**	**E**	**F**	**G**
C1	2	2	2	2	2	0	
C2	1	1	1	1	1	1	
C3	1	1	1	1	1	1	0
C4	1	1	1	1	1	1	0
	Choices						
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**	
C5	2	1	0	-1	-2	0	
C6	2	1	0	-1	-2	0	
C7	-2	-1	0	1	2	0	
C8	2	1	0	-1	-2	0	
C9	2	1	0	-1	-2	0	
C10	2	1	0	-1	-2	0	
C11	2	1	0	-1	-2	0	
C12	2	1	0	-1	-2	0	
C13	2	1	0	-1	-2	0	
C14	2	1	0	-1	-2	0	
C15	2	1	0	-1	-2	0	
C16	2	1	0	-1	-2	0	
C17	-2	-1	0	1	2	0	
C18	2	1	0	-1	-2	0	
C19	2	1	0	-1	-2	0	
C20	2	1	0	-1	-2	0	
C21	2	1	0	-1	-2	0	
C22	2	1	0	-1	-2	0	
C23	2	1	0	-1	-2	0	

B. TEAMWORK SECTION

Question Number	Choices					
	A	**B**	**C**	**D**	**E**	**F**	**G**
T1	1	1	1	1	1	0	
T2	2	0	-1	-2			
T3	2	2	2	2	0		
T4	1	1	1	1	1	1	0
	Choices						
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**	
T5	2	1	0	-1	-2	0	
T6	2	1	0	-1	-2	0	
T7	2	1	0	-1	-2	0	
T8	2	1	0	-1	-2	0	
T9	2	1	0	-1	-2	0	
T10	2	1	0	-1	-2	0	
T11	2	1	0	-1	-2	0	
T12	2	1	0	-1	-2	0	
T13	2	1	0	-1	-2	0	
T14	2	1	0	-1	-2	0	
T15	2	1	0	-1	-2	0	
T16	2	1	0	-1	-2	0	
T17	2	1	0	-1	-2	0	
T18	2	1	0	-1	-2	0	
T19	2	1	0	-1	-2	0	
T20	2	1	0	-1	-2	0	
T21	2	1	0	-1	-2	0	
T22	-2	-1	0	1	2	0	
T23	2	1	0	-1	-2	0	
T24	2	1	0	-1	-2	0	
T25	2	1	0	-1	-2	0	
T26	2	1	0	-1	-2	0	
T27	2	1	0	-1	-2	0	
T28	-2	-1	0	1	2	0	
T29	-2	-1	0	1	2	0	
T30	2	1	0	-1	-2	0	

C. LEADERSHIP SECTION

	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
L1	-2	-1	0	1	2	0
L2	2	1	0	-1	-2	0
L3	2	1	0	-1	-2	0
L4	2	1	0	-1	-2	0
L5	2	1	0	-1	-2	0
L6	2	1	0	-1	-2	0
L7	2	1	0	-1	-2	0
L8	2	1	0	-1	-2	0
L9	2	1	0	-1	-2	0
L10	2	1	0	-1	-2	0
L11	-2	-1	0	1	2	0
L12	-2	-1	0	1	2	0
L13	2	1	0	-1	-2	0
L14	2	1	0	-1	-2	0
L15	2	1	0	-1	-2	0
L16	2	1	0	-1	-2	0
Question Number	**Choices**					
	A	**B**	**C**	**D**		
L17*	2	2	1	-2		
L18*	-2	1	2	2		

***Either provide responses to L17 or L18**

D. ORGANIZATIONAL COMMITMENT SECTION

	Choices					
Question Number	5	4	3	2	1	N/A
OC1	2	1	0	-1	-2	0
OC2	2	1	0	-1	-2	0
OC3	2	1	0	-1	-2	0
OC4	2	1	0	-1	-2	0
OC5	2	1	0	-1	-2	0
OC6	2	1	0	-1	-2	0
OC7	2	1	0	-1	-2	0
OC8	2	1	0	-1	-2	0
OC9	2	1	0	-1	-2	0
OC10	2	1	0	-1	-2	0
OC11	2	1	0	-1	-2	0
OC12	2	1	0	-1	-2	0
OC13	2	1	0	-1	-2	0
OC14	2	1	0	-1	-2	0
OC15	2	1	0	-1	-2	0
OC16	2	1	0	-1	-2	0
OC17	2	1	0	-1	-2	0
OC18	-2	1	0	-1	-2	0
OC19	-2	1	0	-1	-2	0
OC20	2	1	0	-1	-2	0
OC21	2	1	0	-1	-2	0
OC22	2	1	0	-1	-2	0
OC23	2	1	0	-1	-2	0
OC24	2	1	0	-1	-2	0
Question Number	Choices					
	A	B	C	D	E	F
OC25	2	2	2	0		
OC26	2	2	2	-2	2	0

E. PROJECT MANAGER SECTION

Question Number	Choices					
	A	B	C	D	E	F
PM1	0	-2	-4	-6		
PM2	0	1	2	3	4	
PM3	1	1	1	1	1	0
PM4	1	1	1	1	1	0
	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
PM5	2	1	0	-1	-2	0
PM6	2	1	0	-1	-2	0
PM7	2	1	0	-1	-2	0
PM8	2	1	0	-1	-2	0
PM9	2	1	0	-1	-2	0
PM10	2	1	0	-1	-2	0
PM11	2	1	0	-1	-2	0
PM12	2	1	0	-1	-2	0
PM13	2	1	0	-1	-2	0
PM14	2	1	0	-1	-2	0
PM15	2	1	0	-1	-2	0
PM16	2	1	0	-1	-2	0
PM17	2	1	0	-1	-2	0
PM18	2	1	0	-1	-2	0
PM19	2	1	0	-1	-2	0
PM20	2	1	0	-1	-2	0
PM21	2	1	0	-1	-2	0
PM22	2	1	0	-1	-2	0
PM23	2	1	0	-1	-2	0
PM24	2	1	0	-1	-2	0
PM25	2	1	0	-1	-2	0
PM26	2	1	0	-1	-2	0
PM27	2	1	0	-1	-2	0

F. REQUIREMENTS MANAGEMENT SECTION

Question Number	Choices					
	A	**B**	**C**	**D**	**E**	**F**
RM1	2	2	2	2	0	
RM2	-2	2	2	-2	0	
RM3	1	1	1	1	1	0
RM4	2	2	2	2	2	0
	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
RM5	2	1	0	-1	-2	0
RM6	2	1	0	-1	-2	0
RM7	2	1	0	-1	-2	0
RM8	2	1	0	-1	-2	0
RM9	2	1	0	-1	-2	0
RM10	2	1	0	-1	-2	0
RM11	2	1	0	-1	-2	0
RM12	2	1	0	-1	-2	0
RM13	2	1	0	-1	-2	0
RM14	2	1	0	-1	-2	0
RM15	2	1	0	-1	-2	0
RM16	2	1	0	-1	-2	0
RM17	2	1	0	-1	-2	0
RM18	2	1	0	-1	-2	0
RM19	2	1	0	-1	-2	0
RM20	2	1	0	-1	-2	0
RM21	2	1	0	-1	-2	0
RM22	2	1	0	-1	-2	0
RM23	2	1	0	-1	-2	0
RM24	2	1	0	-1	-2	0
RM25	2	1	0	-1	-2	0
RM26	-2	1	0	-1	-2	0
RM27	2	1	0	-1	-2	0

G. STAKEHOLDER INVOLVEMENT SECTION

	Choices						
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**	
SI1	2	1	0	-1	-2	0	
SI2	2	1	0	-1	-2	0	
SI3	2	1	0	-1	-2	0	
SI4	2	1	0	-1	-2	0	
SI5	2	1	0	-1	-2	0	
SI6	2	1	0	-1	-2	0	
SI7	2	1	0	-1	-2	0	
SI8	2	1	0	-1	-2	0	
SI9	2	1	0	-1	-2	0	
Question Number	**Choices**						
	A	B	C	D	E	F	G
SI10	2	2	2	2	2	2	0

SI11 and SI12 are to be answered if the project is developed for the market without a specific contract.

Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
SI11	2	1	0	-1	-2	0
SI12	2	1	0	-1	-2	0

SI13-SI18 are to be answered if the project is developed under a contract with a specific customer.

	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
SI13	-2	-1	0	1	2	0
SI14	2	1	0	-1	-2	0
SI15	2	1	0	-1	-2	0
SI16	2	1	0	-1	-2	0
SI17	2	1	0	-1	-2	0

Question Number	**Choices**	
	A	**B**
SI18	2	-2

H. PROJECT MONITORING AND CONTROL SECTION

Question Number	Choices					
	A	**B**	**C**	**D**	**E**	**F**	**G**
PMC1	2	-2					
PMC2	1	1	1	1	1	1	0
PMC3	2	-2					
PMC4	2	2	2	0			
PMC5	2	2	2	2	2	0	
	Choices						
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**	
PMC6	2	1	0	-1	-2	0	
PMC7	-2	1	0	-1	-2	0	
PMC8	2	1	0	-1	-2	0	
PMC9	2	1	0	-1	-2	0	
PMC10	2	1	0	-1	-2	0	
PMC11	2	1	0	-1	-2	0	
PMC12	2	1	0	-1	-2	0	
PMC13	2	1	0	-1	-2	0	
PMC14	2	1	0	-1	-2	0	
PMC15	2	1	0	-1	-2	0	
PMC16	2	1	0	-1	-2	0	
PMC17	2	1	0	-1	-2	0	
PMC18	2	1	0	-1	-2	0	
PMC19	2	1	0	-1	-2	0	

I. PROJECT PLANNING AND ESTIMATION SECTION

Question Number	Choices																	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
PPE1	2	-2	2	-4														
PPE2	-2	2																
PPE3	-2	2																
PPE4	2	-2																
PPE5	1	1	1	1	1	1	0											
PPE6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
PPE7	2	2	-4															
PPE8	1	1	1	1	1	1	0											
PPE9	-4	0	2	4	0													
PPE10	1	1	1	1	1	0												

	Choices					
Question Number	5	4	3	2	1	N/A
PPE11	2	1	0	-1	-2	0
PPE12	2	1	0	-1	-2	0
PPE13	2	1	0	-1	-2	0
PPE14	2	1	0	-1	-2	0
PPE15	2	1	0	-1	-2	0
PPE16	2	1	0	-1	-2	0
PPE17	2	1	0	-1	-2	0
PPE18	2	1	0	-1	-2	0
PPE19	2	1	0	-1	-2	0
PPE20	2	1	0	-1	-2	0
PPE21	2	1	0	-1	-2	0
PPE22	2	1	0	-1	-2	0
PPE23	2	1	0	-1	-2	0
PPE24	2	1	0	-1	-2	0
PPE25	2	1	0	-1	-2	0
PPE26	2	1	0	-1	-2	0
PPE27	2	1	0	-1	-2	0
PPE28	2	1	0	-1	-2	0
PPE29	2	1	0	-1	-2	0
PPE30	2	1	0	-1	-2	0
PPE31	2	1	0	-1	-2	0
PPE32	2	1	0	-1	-2	0
PPE33	2	1	0	-1	-2	0
PPE34	2	1	0	-1	-2	0
PPE35	2	1	0	-1	-2	0

J. SCOPE MANAGEMENT SECTION

Question Number	Choices								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
SM1	2	-2	0						
SM2	-2	-4	2	-2					
SM3	0	2	-2						
SM4	Not Included in the Model								
SM5	Not Included in the Model								
SM6	Not Included in the Model								
SM7	-2	2	4	-4					
SM8	1	1	1	1	1	1	1	1	0
SM9	2	2	2						
SM10	1	1	2	1	1	1	0		
	Choices								
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**			
SM11	2	1	0	-1	-2	0			
SM12	-2	-1	0	1	2	0			
SM13	2	1	0	-1	-2	0			
SM14	2	1	0	-1	-2	0			
SM15	2	1	0	-1	-2	0			
SM16	2	1	0	-1	-2	0			

K. RISK CONTROL SECTION

Question Number	Choices					
	A	**B**	**C**	**D**	**E**	
RC1	Not Included in the Model					
RC2	Not Included in the Model					
RC3	Not Included in the Model					
RC4	Not Included in the Model					
RC5	2	1	-1	-2		
RC6	2	-2	-1			
RC7	-1	1	0			
RC8	0	2	-2			
RC9	1	1	-2	1	0	
RC10	2	-2	2			
	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
RC11	2	1	0	-1	-2	0
RC12	2	1	0	-1	-2	0
RC13	2	1	0	-1	-2	0
RC14	2	1	0	-1	-2	0
RC15	2	1	0	-1	-2	0
RC16	2	1	0	-1	-2	0

L. STAFFING AND HIRING SECTION

Question Number	Choices					
	A	B	C	D	E	
S1	1	1	1	0		
S2	2	2	2	0		
S3	-2	-1	0	1	2	
S4	1	1	1	0		
	Choices					
Question Number	5	4	3	2	1	N/A
S5	2	1	0	-1	-2	0
S6	2	1	0	-1	-2	0
S7	2	1	0	-1	-2	0
S8	2	1	0	-1	-2	0
S9	2	1	0	-1	-2	0
S10	2	1	0	-1	-2	0
S11	2	1	0	-1	-2	0
S12	2	1	0	-1	-2	0
S13	2	1	0	-1	-2	0
S14	2	1	0	-1	-2	0
S15	2	1	0	-1	-2	0
S16	2	1	0	-1	-2	0
S17	2	1	0	-1	-2	0
S18	2	1	0	-1	-2	0
S19	-2	-1	0	1	2	0
S20	2	1	0	-1	-2	0
S21	2	1	0	-1	-2	0
S22	2	1	0	-1	-2	0
S23	2	1	0	-1	-2	0
S24	2	1	0	-1	-2	0
S25	2	1	0	-1	-2	0
S26	2	1	0	-1	-2	0
S27	2	1	0	-1	-2	0
S28	2	1	0	-1	-2	0
S29	2	1	0	-1	-2	0

M. CONFIGURATION MANAGEMENT SECTION

Question Number	Choices					
	A	**B**	**C**	**D**	**E**	
CM1	-2	2				
CM2	2	2	2	0		
CM3	2	2	2	2	0	
CM4	2	2	-2	0		
CM5	2	-2				
	Choices					
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**
CM6	-2	-1	0	1	2	0
CM7	2	1	0	-1	-2	0
CM8	2	1	0	-1	-2	0
CM9	2	1	0	-1	-2	0
CM10	2	1	0	-1	-2	0
CM11	2	1	0	-1	-2	0
CM12	2	1	0	-1	-2	0
CM13	2	1	0	-1	-2	0

N. RISK ASSESSMENT SECTION

Question Number	Choices						
	A	**B**	**C**	**D**	**E**	**F**	**G**
RA1	2	-2	0	0			
RA2	-2	2	2	2	2	0	
RA3	1	1	1	1	1	1	0
RA4	2	-2	0	0			
RA5	2	2	2	0			
RA6	2	1	1	-2			
RA7	1	1	1	1	0		
RA8	0	1	0	2	-4		
	Choices						
Question Number	**5**	**4**	**3**	**2**	**1**	**N/A**	
RA9	2	1	0	-1	-2	0	
RA10	2	1	0	-1	-2	0	
RA11	2	1	0	-1	-2	0	
RA12	2	1	0	-1	-2	0	
RA13	2	1	0	-1	-2	0	
RA14	2	1	0	-1	-2	0	
RA15	2	1	0	-1	-2	0	
RA16	2	1	0	-1	-2	0	
RA17	2	1	0	-1	-2	0	
RA18	2	1	0	-1	-2	0	
RA19	2	1	0	-1	-2	0	

RA20 is to be answered if a portion of the system is subcontracted.

Question Number	Choices			
	A	**B**	**C**	**D**
RA20	-4	2	2	2

O. QUALITY ENGINEERING SECTION

Question Number	Choices						
	A	B	C	D	E	F	G
QE1	2	-2	2				
QE2	2	2	2	0			
QE3	1	1	1	1	1	1	0
QE4	2	0	-2	-4			

	Choices					
Question Number	5	4	3	2	1	N/A
QE5	2	1	0	-1	-2	0
QE6	2	1	0	-1	-2	0
QE7	2	1	0	-1	-2	0
QE8	2	1	0	-1	-2	0
QE9	2	1	0	-1	-2	0
QE10	2	1	0	-1	-2	0
QE11	2	1	0	-1	-2	0
QE12	2	1	0	-1	-2	0
QE13	2	1	0	-1	-2	0
QE14	2	1	0	-1	-2	0
QE15	2	1	0	-1	-2	0
QE16	-2	-1	0	1	2	0
QE17	2	1	0	-1	-2	0
QE18	2	1	0	-1	-2	0
QE19	2	1	0	-1	-2	0

Question Number	Choices									
	A	B	C	D	E	F	G	H	I	J
QE20	1	1	1	1	1	1	1	1	1	0

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APPENDIX H: DATA ANALYSIS OF SCORES

ACRONYMS			
Communication	C	People Area Score	PEOPLE
Teamwork	T	Process Area Score	PROCESS
Leadership	L	Product Area Score	PRODUCT
Organizational Commitment	OC	Risk Area Score	RISK
Project Manager	PM	PME Score	PME
Stakeholder Involvement	SI	Rounded PME Score	PME-R
Staffing and Hiring	S	Project Success Rating by	PSR
Requirements Management	RM		
Project Monitoring and Control	PMC		
Project Planning and Estimation	PPE		
Scope Management	SM		
Configuration Management	CM		
Quality Engineering	QE		
Risk Assessment	RA		
Risk Control	RC		

	C	T	L	OC	PM	SI	S	RM	PMC	PPE	SM	CM	QE	RA	RC	PEOPLE	PROCESS	PRODUCT	RISK	PME	PME-R	PSR
C	*	0.79	0.67	0.51	0.78	0.64	0.39	0.45	0.62	0.75	0.68	0.13	0.54	0.53	0.57	0.87	0.72	0.30	0.61	0.74	0.66	0.53
T		*	0.70	0.78	0.82	0.51	0.74	0.43	0.51	0.79	0.64	0.16	0.54	0.53	0.32	0.96	0.68	0.33	0.47	0.73	0.63	0.52
L			*	0.39	0.71	0.13	0.49	0.45	0.48	0.29	0.58	0.26	0.32	0.54	0.36	0.73	0.55	0.33	0.49	0.62	0.61	0.71
OC				*	0.45	0.31	0.83	0.41	0.16	0.60	0.32	0.01	0.59	0.19	-0.20	0.76	0.44	0.23	0.00	0.46	0.34	0.13
PM					*	0.40	0.58	0.46	0.65	0.72	0.62	0.27	0.37	0.63	0.60	0.85	0.71	0.36	0.68	0.76	0.72	0.69
SI						*	0.22	0.48	0.46	0.72	0.60	0.17	0.30	0.54	0.56	0.60	0.66	0.25	0.60	0.61	0.54	0.28
S							*	0.62	0.27	0.60	0.45	0.33	0.62	0.46	-0.02	0.76	0.59	0.50	0.25	0.64	0.59	0.42
RM								*	0.50	0.54	0.69	0.76	0.55	0.73	0.31	0.61	0.85	0.81	0.58	0.84	0.84	0.52
PMC									*	0.49	0.75	0.37	0.57	0.80	0.66	0.58	0.80	0.51	0.81	0.77	0.76	0.50
PPE										*	0.61	0.31	0.57	0.55	0.45	0.81	0.76	0.46	0.55	0.77	0.70	0.40
SM											*	0.45	0.55	0.84	0.57	0.71	0.92	0.56	0.78	0.86	0.80	0.52
CM												*	0.39	0.57	0.30	0.25	0.60	0.94	0.48	0.67	0.76	0.55
QE													*	0.47	0.21	0.59	0.66	0.69	0.38	0.70	0.66	0.28
RA														*	0.65	0.63	0.88	0.63	0.92	0.87	0.87	0.56
RC															*	0.41	0.57	0.31	0.90	0.61	0.62	0.61
PEOPLE																*	0.80	0.42	0.57	0.83	0.75	0.59
PROCESS																	*	0.72	0.80	0.97	0.93	0.58
PRODUCT																		*	0.53	0.79	0.85	0.54
RISK																			*	0.82	0.82	0.64
PME																				*	0.98	0.68
PME-R																					*	0.73

APPENDIX I: PROJECT SUCCESS POTENTIAL EVALUATION LIST [FROM (THE STANDISH GROUP, 1995B)]

Project Success Potential	
User Involvement • Do I have the right user(s)? • Did I involve the user(s) early and often? • Do I have a quality user(s) relationship? • Do I make involvement easy? • Did I find out what the user(s) needs? For each question with a YES answer, add 3.8 points to the total project success potential score. Total Points (not to exceed 19)	**Small Project Milestones** • Am I using the 80/20 rule? • Am I using a top-down design? • Am I setting time limits? • Am I using a prototype tool? • Can I measure progress? For each question with a YES answer, add 1.8 points to the total project success potential score. Total Points (not to exceed 9)
Executive Management Support • Do I have the key executive(s)? • Does the key executive have a stake in the outcome? • Is failure acceptable? • Do I have a well defined plan? • Does the project team have a stake? For each question with a YES answer, add 3.2 points to the total project success potential score. Total Points (not to exceed 16)	**Competent Staff** • Do I know the skills required? • Do I have the right people? • Do I have a training program? • Do I have incentives? • Will the staff see it through? For each question with a YES answer, add 1.6 points to the total project success potential score. Total Points (not to exceed 8)
Developing a Clear Statement of Reqts • Do I have a concise vision? • Do I have a functional analysis? • Do I have a risk assessment? • Do I have a business case? • Can I measure the project? For each question with a YES answer, add 3 points to the total project success potential score. Total Points (not to exceed 15)	**Project Ownership:** • Do I have defined roles? • Do I have a defined organization? • Does everyone know their role? • Are incentives attached to success? • Is everyone committed? For each question with a YES answer, add 1.2 points to the total project success potential score. Total Points (not to exceed 6)
Proper Planning • Do I have a problem statement? • Do I have a solution statement? • Do I have the right people? • Do I have a firm specification? • Do I have attainable milestones? For each question with a YES answer, add 2.2 points to the total project success potential score. Total Points (not to exceed 11)	**Clear Vision and Objectives** • Is the vision shared? • Is the vision aligned with company goals? • Are the objectives achievable? • Are the objectives measurable? • Do I have honest sanity checks? For each question with a YES answer, add 0.6 points to the total project success potential score. Total Points (not to exceed 3)
Setting Realistic Expectations • Do I have clear specifications? • Do I have prioritization of needs? • Do I have small milestones? • Can I manage change? • Can I prototype? For each question with a YES answer, add 2 points to the total project success potential score. Total Points (not to exceed 10)	**Hard Working, Focused Staff** • Are there incentives? • Are we concentrating on quantifiable deliverables? • Does each member have part ownership? • Does everyone work together? • Are we building confidence? For each question with a YES answer, add 0.6 points to the total project success potential score. Total Points (not to exceed 3) Calculate all of the points to achieve the final score. The Success Potential for Project…

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