TAILORING SMALL IT PROJECTS IN THE PROJECT PLANNING PHASE

by

Michael F. Mulhearn
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Information Technology

Committee:

_____	Dr. Peggy Brouse, Dissertation Director
_____	Dr. Andrew Sage, Committee Member
_____	Dr. David Schum, Committee Member
_____	Dr. Michael Casey, Committee Member
_____	Dr. Daniel Menascé, Senior Associate Dean
_____	Dr. Lloyd J. Griffiths, Dean, Volgenau School of Engineering

Date: 5/5/11

Spring Semester 2011
George Mason University
Fairfax, VA

Tailoring Small IT Projects in the Project Planning Phase

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

By

Michael F. Mulhearn
Master of Science
George Mason University, 2002

Director: Peggy Brouse, Associate Professor
Volgenau School of Engineering

Spring Semester 2011
George Mason University
Fairfax, VA

DEDICATION

This is dedicated to my mother and father, Barbara and John Mulhearn, who always pushed me to learn.

ACKNOWLEDGEMENTS

I would like to thank my professors who took the time and energy to teach me and guide me during this long journey. It was a pleasure to stand on the shoulders of giants.

I want to thank my wife Debbie and children, Mikey and Madison, for giving me the love, support, and time to let me pursue my dream.

I would also like to thank my colleagues who provided encouragement, support, and help throughout this process.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANSI	American National Standards Institute
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
EIA	Electronic Industries Association
IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
ISO	International Standards Organization
IT	Information Technology
ITIL	Information Technology Infrastructure Library
LOE	Level-of-Effort
MIL-STD	Military Standard
PM	Project Management
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMP	Project Management Professional
ROI	Return on Investment
SE	Systems Engineering
SME	Subject Matter Expert

ABSTRACT

TAILORING SMALL IT PROJECTS IN THE PROJECT PLANNING PHASE

Michael F. Mulhearn, Ph.D.

George Mason University, 2011

Dissertation Director: Dr. Peggy Brouse

Project management (PM) and systems engineering (SE) are essential skills in information technology (IT). There is an abundance of information available detailing the comprehensive bodies of knowledge, standards, and best practices. Despite the volume of information, there is surprisingly little information about how to tailor PM and SE tasks for small IT projects. Small projects cost between $5,000 and $1.5M and range from three to twelve months in duration. (Kerzner, 2009) The goal of this research has been to extract heuristics from the PM and SE experts and literature to better understand and quantify required tasks, develop and verify tailoring methods, build the methods into an expert system, and test the expert system with novice users to determine the effectiveness of the tailoring methods and the expert system. Research has been conducted to add new methods to help project managers effectively plan and manage small projects.

CHAPTER 1: INTRODUCTION

All sectors of every modern economy have been steadily migrating towards an increased reliance on IT. IT is now at the heart of everything, including manufacturing, telecommunications, healthcare, banking and finance, entertainment, law enforcement, and many other industries. IT has expanded despite the difficulty of delivering projects with the desired capabilities within cost and schedule. For the last several years, global spending in IT has exceeded three trillion dollars, with a record high of $3.4T. (Reuters, 2009) A far larger figure describes the financial equities that depend on IT for success. At this magnitude, high failure rates and project inefficiencies translate into billions of dollars of lost revenue and opportunity. Clearly, the world cannot continue to afford these problems even though this has been the history of IT. Depending on the specific study and how failure was defined, IT failure rates have ranged from 26% to 68%. (Lynch, 2009) (El Emam, 2009)

Management of projects, including IT projects, has been traditionally divided into two partially overlapping functions: traditional project management (PM) and systems engineering (SE). PM is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements." (PMBOK, 2009) SE is defined as "an interdisciplinary approach and means to enable the realization of successful systems. SE focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with

design synthesis and system validation while considering the complete problem. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs." (SE Handbook, 2007) Project managers typically focus on cost and schedule management while systems engineers focus on all phases of the technical solution. (Mooz, 1997) Additionally, these separate professions often do not sufficiently interact with each other. (Mooz, 1997) Both PM and SE skills and functions are essential to the success of IT projects. IT project systems engineers need project management knowledge and skills, and IT project managers need systems engineering knowledge and skills. The functions of PM and SE are also the only two functions that coordinate all of the other subject matter expertise on a project. It is imperative that they understand each other's skills and responsibilities. The problem becomes critical in the case of small IT projects which often cannot afford the services of both full time project managers and full time systems engineers. Such programs inevitably end up with only one of these two specialties, thereby missing the benefit of the other specialty.

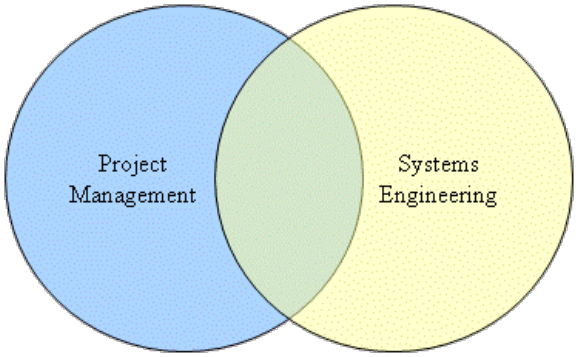


Figure 1. Project Management and Systems Engineering Overlap

Planning differentiates the good project managers from the bad project managers. (Kerzner, 2009) Creating project plans and managing small projects is a significant problem in the IT industry. Too often, people who are assigned to manage projects do not have the knowledge and experience to effectively manage those projects. Many organizations attempt to mitigate this problem by sending their project managers to training. The problem is that superficial knowledge of PM and SE is not sufficient to make appropriate decisions on how to tailor projects and optimize a project plan for small projects. This lack of understanding contributes to a high rate of project failures.

The focus of this research is on small IT projects. There are potentially many definitions of a "small project." For the purposes of this research, a small project is defined as one having a duration from three to twelve months and a dollar value from $5,000 to $1.5M. (Kerzner, 2009) A recent survey showed that about half of IT projects fit into this category. About half the projects had a duration of less than nine months and had fewer than ten developers. (El Emam, 2008) With the high failure rate and a

significant portion of projects in the small category, simplifying the approach to the management and engineering of IT projects may lead to fewer failures, more efficient project execution, and have a major impact on this industry.

Small IT projects have additional challenges because they often have limited infrastructure resources, limited skill sets, project personnel performing multiple roles, and management and technical roles combined. (Johnson, 1998) For the project manager who often has to assume the additional roles of a systems engineer and a technical lead, the lanes of responsibility between PM and SE disappear. The project lead is the single person responsible for delivering the project that meets customer needs within cost and schedule. Since some of the PM and SE functions overlap, converging the most critical PM and SE functions into a single taxonomy will help clarify the functions and tasks that need to be performed on small IT projects.

The goal of this research is to create a methodology based on the standards that can help the project manager tailor the PM and SE methods to an appropriate size and scope for small projects. This involves selecting the most relevant aspects of the PM and SE bodies of knowledge, and incorporating them into a new concise taxonomy. The research reported in this dissertation attests to the benefits of the proposed combined taxonomy that includes the most relevant aspects of PM and SE.

Apprentice's law states that it takes 5000 hours to turn a novice into an expert. (Endres, 2003) This suggests that it would take as many as 10,000 hours to master the domains of PM both and SE. 10,000 hours translates to about five years of full-time effort. Since the project leader is likely performing these duties on a part-time basis, the

time required to master these areas would be much longer. Providing expert knowledge in a manner that can be immediately useful will benefit both professions.

Research

The goal of this research has been to develop a methodology for converting the most relevant aspects of PM and SE tools used in large programs to small IT projects. An expert system was created to enable novice project managers to benefit from this research. The expert system that was created has been able to be understood and implemented by a novice project manager for small IT projects. The concept of operations for the expert system developed and reported here is as follows:

1. The project manager logs into a web-based project planning assist tool.
2. The project manager fills out the template and answers a set of questions about the project. The template includes questions about the purpose of the project, the technology involved, the requirements, the areas of risk, the schedule, the skills sets required, and other management issues.
3. The project manager selects the documents and reviews that are needed and selects a date when they are due or will be performed.
4. The project manager hits the compute button. The expert system generates a project plan along with warning messages that identify potential project risks.
5. The project manager can go back and make changes to improve the plan.

The project manager can use the planning tool as a preliminary guide to be used in the formulation of the final plan for the project. The plan includes suggestions on: management and systems engineering functions to perform, functions to waiver,

functions to deviate from, deliverable items, schedule, reviews, risk areas, skill sets required to perform the work, and documentation. The hope was that this expert system would provide a lot of the knowledge of an experienced project manager to a less experienced project manager.

The hypotheses that were tested in this dissertation were as follows:

- 1A - Novice project managers will produce project plans with an industry accepted number of document deliverables using an expert system.
- 1B - Novice project managers will produce project plans with an industry accepted type of document deliverables using an expert system.
- 2A - Novice project managers will produce project plans with an industry accepted number of project reviews using an expert system.
- 2B - Novice project managers will produce project plans with an industry accepted type of project reviews using an expert system.
- 3 - Novice project managers have higher confidence of success in their projects using an expert system to create their project plans.

The term “industry accepted” means the recommended documents and reviews from the survey that was conducted.

Methodology

This research extracted heuristics from the PM and SE experts and literature to better understand and quantify these tasks, developed and verified tailoring methods, built the methods into an expert system, and tested the expert system with novice users to determine the effectiveness of the tailoring methods and the expert system. Methods

were developed to tailor PM and SE tasks for small IT projects. The project consisted of reviewing the PM and SE literature to provide a list of the possible tasks that could be performed. PM and SE professionals were surveyed to determine those tasks that were necessary for a small project, tasks that could be performed in a limited manner, and tasks that could be waivered. A set of time proven key concepts were extracted from the literature to better understand and quantify these tasks. The tasks and heuristics were coded into an expert system. The expert system interacted with the project manager to answer questions about the project, and generated a project plan that recommended tasks to be performed, reviews to be conducted, documents to be delivered, and other deliverables. Figure 1 shows the major dissertation tasks that were performed.

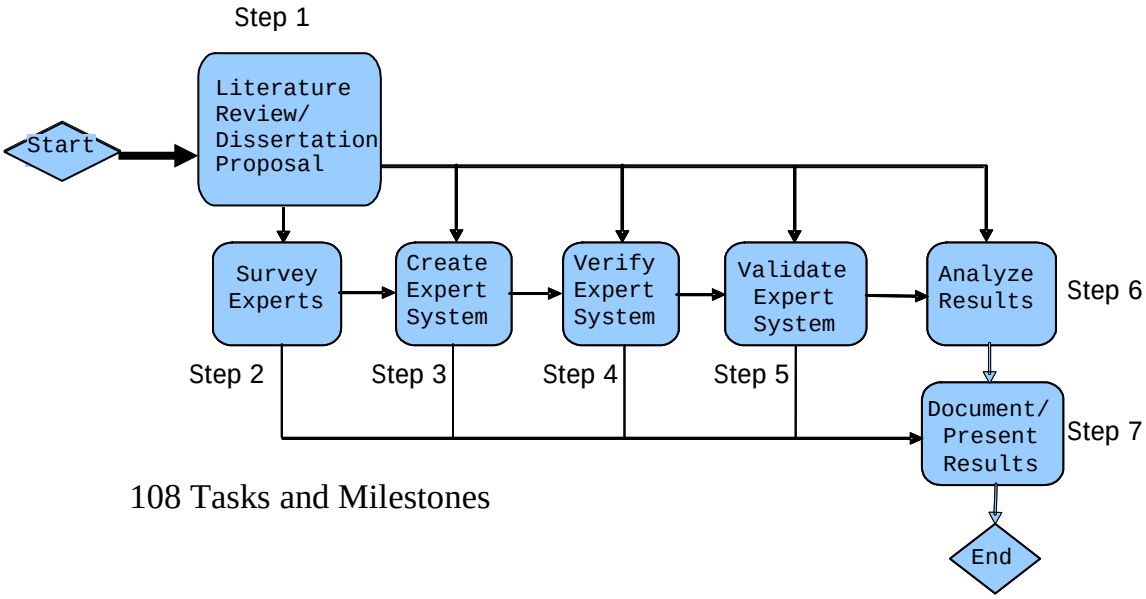


Figure 2. Major Dissertation Tasks

The areas of research used established and accepted procedures to perform the following tasks.

1. Literature review / dissertation proposal - A comprehensive literature review was conducted using books, journal articles, and engineering standards. Professional organizations such as INCOSE (International Council on Systems Engineering) and PMI (Project Management Institute) provided a baseline for best practices in the field. Experts were also contacted directly for consultation.

2. Survey Experts - Experts were surveyed to define the scope of small projects and determine project management and systems engineering methods that were required, were useful, or were not needed. The expert opinion was combined with the literature to generate heuristics that were applied to small IT projects.

3. Create expert system - The heuristics generated from the literature review and the surveys were programmed into an expert system.

4. Verify expert system - One test scenario was generated for testing. The test scenario was generated with the help of subject matter experts (SMEs) in the area of digital asset management systems.

5. Validate expert system - The expert system was tested with novice project managers at the end of a project management class. The expert system was tested using a Posttest-Only Control Group Design. (Cherulnik, 2001) One group used the expert system to help generate the project plan and the control group planned the project without the help of the expert system. The results from the survey were compared to both groups to validate the expert system.

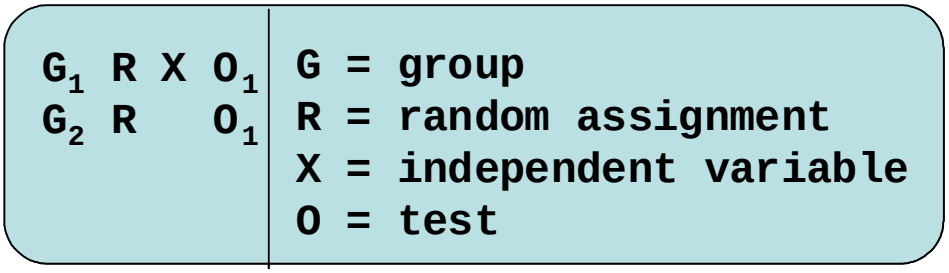


Figure 3. Variables for a Posttest-Only Control Group Design

6. Analyze results - The results from the project plans were compared to the top 15% of the recommended documents and reviews from the survey. A comparison of the percentages of the documents and reviews that were selected for the project plans was calculated.

7. Document the results - The research was documented and written throughout the project.

The results of this study helped determine ways that PM and SE tools and methods could be tailored for small IT projects. Based on the size, complexity, and type of project, it was expected that a smaller number and scale of PM and SE tools should be applied to small IT projects. The intent was that the expert system would have been beneficial to the novice PM by providing guidance similar to that of an expert. The intent was also that the project plans created with the help of an expert system would contain the number and type of documentation and reviews that are closer to an industry accepted standard than those created without help.

CHAPTER 2: LITERATURE REVIEW

Many studies have been done to identify the sources of IT project failures and to measure the IT project failure rates. The main cause of IT project failure is rooted in requirements. In the field of software engineering, Glass' Law states that "requirement deficiencies are the prime source of project failures." (Endres. 2003) In a survey of why IT projects fail, nine out of the ten reasons were requirements based. (Fretty, 2006) Failure rates vary depending on the study and the definitions of success, failure, and challenged projects. The rates from the Chaos Report from Standish in 2009 report that 32% of projects were successful, 44% of the projects were challenged (over budget, delivered late, delivered with reduced functionality), and 24% failed (cancelled prior to delivery or delivered but never used). (Lynch, 2009) Another survey estimated that currently about 26% to 34% of IT projects fail. (El Emam, 2009) The differences in failure rates are primarily due to the differences in the definitions of the categories. However, even using the lower failure rate numbers, shows that IT projects have significant problems with successful delivery. Successful delivery, however, requires the skills of both project managers and systems engineers, yet most small projects cannot afford both. Although it is common to attribute the failure of projects to poor management, the reality is more complex. Most projects of any substantive size are "managed" partly by project managers and partly by systems engineers. These two classes of professions have different responsibilities with different backgrounds and

skills. Once the responsibilities for different areas are assigned, they have to work together to ensure project success. In the case of small projects, financial constraints limit the inclusion of both a project manager and a systems engineer. The project leader, who may not be trained in PM or SE, will have to perform both functions well.

The IT industry has a framework for "best practices" that was developed in the 1980s by the United Kingdom's Office of Government Commerce. The Information Technology Infrastructure Library (ITIL) is a set of guidelines for organizing the end-to-end delivery and service management of IT systems. The best practices are focused on providing solid explanations of what and why tasks are to be performed. ITIL is process and business driven to provide the overall context of service management, technology, operations, and people must be integrated to provide end-to-end service management. Although it has been around for over twenty years, it has not achieved widespread adoption by the IT industry. (ITIL, 2010) The volume and scope of ITIL make it difficult to adopt.

The Project Management Body of Knowledge (PMBOK) has become the defacto standard for managing IT projects. Project Management Institute boasts a membership of over 308,000 professionals in over 170 countries. (PMI, 2009) Project managers with PM certifications are sought by the IT industry to manage projects. The fourth edition of the PMBOK defines nine knowledge areas required for project management summarized in Table 1. One of the changes to the latest edition of the PMBOK was the greater emphasis on requirements engineering under the category of scope management. Although there is additional emphasis in a subcategory, there may not be enough

guidance to help improve failure rates. Since poor requirements engineering is a big factor in IT project failures, it should be a focal point for industry improvement.

Other and more recent ontologies have been proposed. Ontology is defined as "a branch of metaphysics concerned with the nature and relations of being." (Merriam-Webster, 2011) Aramo-Immonen proposed an ontology in the context of mega-projects and learning during project execution. (Aramo-Immonen, 2009) Cheah and Chang also proposed an ontology for multi-site project management ontology system development methodology. (Cheah, 2005) Although these are reasonable alternatives, the PMBOK continues to be the standard for project management.

Table 1. PM Knowledge Areas (PMI, 2008)

Project Management Knowledge Areas	Definitions
Project Integration Management	Processes and activities needed to identify, define, combine, unify and coordinate project management activities
Project Scope Management	Processes required to ensure the project includes all, and only the work required, to successfully complete the project
Project Time Management	Processes required to manage timely completion of the project
Project Cost Management	Processes involved in estimating, budgeting, and controlling costs so the project can be completed within budget
Project Quality Management	Processes and activities that determine the quality policies, objectives, and responsibilities to satisfy project needs
Project Human Resource Management	Processes that organize, manage, and lead the project team
Project Communications Management	Processes required to ensure timely generation, collection, storage, retrieval, and disposition of project information
Project Risk Management	Processes of risk management, planning, identification, analysis, response planning and monitoring and control
Project Procurement Management	Processes necessary to purchase or acquire products, services, or results needed from outside the project team

The SE profession has several standards that have been published and are currently used by practitioners. These standards include: ANSI/EIA-632, IEEE 1220, ISO-15288, MIL-STD-499C, the Software Engineering Institute's Capability Maturity Model Integration (CMMI), and the Systems Engineering Handbook from INCOSE. These standards share some common areas, but also have areas of omission and areas that conflict. Honour and Valerdi coordinated and combined these standards into a single ontology that provides general agreement across eight systems engineering areas (Honour, 2006). The eight areas defined by Honour and Valerdi are shown in Table 2 and are mission/purpose

definition, requirements engineering, system architecting, system implementation, technical analysis, technical management / leadership, scope management, and verification and validation. While Honour and Valerdi's work is excellent, others have derived and published alternative combinations of ontologies, all of which are acknowledged and were carefully studied as part of this research. (Madni, 2007) (Sarder, 2007)

Table 2. SE Knowledge Area (Honour.2006)

SE Knowledge Areas	Definitions
Mission / Purpose Definition	Defines the mission and purpose of the new or changed system
Requirements Engineering	Creation and management of requirements, formal technical statements that define capabilities, characteristics, and quality
System Architecting	Design aspect of systems engineering that defines the system in terms of its component elements and their relationships
System Implementation	Responsible for the technical development of the system, including delivery and installation of the prototype version
Technical Analysis	Responsible for system-level technical analysis, particularly Assessing system performance against requirements
Technical Management / Leadership	Technical management and leadership of the project
Scope Management	Technical definition and management of acquisition and supply issues
Verification and Validation	Comparison of the system with the requirements and the intended use of the system

There are differences among the earlier mentioned SE standards, and SE practitioners have used these standards to successfully deliver projects. The benefit of a single SE ontology is a common understanding of the terminology and the scope of systems

engineering. Conflicting standards and widely varying industry implementations of SE make it difficult for both experienced professionals and for those entering the field to make sense of the information and apply it to their project needs. Confusion and lack of clarity increase failure rates and project costs. Additionally, a single SE ontoplogy would facilitate the cross training of project managers into the SE body of knowledge and best practices.

Small Projects

Despite the large number of small projects, the topic area rarely appears in the literature. In 1997, Johnson and Brodman discussed the challenges of tailoring the Capability Maturity Model (CMM) to small businesses, small organizations, and small projects. At the time, small businesses were having trouble implementing CMM due to the overhead required to implement the processes. Their research showed that documentation overload, layered management, scope of reviews overkill, limited resources, high training costs, and unrelated practices were the primary challenges to adoption (Johnson, 1997). They continued their work and described the characteristics of small organizations to include a flat management structure, limited personnel performing many roles, limited dollars for overhead, and LOE (level-of-effort) approach to workload (Johnson, 1998). Boehm, Valerdi, and Honour discuss the ROI (return on investment) of systems engineering in software intensive projects. One of the outcomes of their research showed that the ROI for small projects that used more than 15% of systems engineering overhead did not benefit from additional systems engineering effort (Boehm, 2007). The implication is that smaller projects may require less overhead for PM and SE

Small projects have not been defined by any of the professional organizations so this adds to the confusion. Definitions that have appeared in the literature include: a small project has 3-5 people and is under 6 months in duration (Paulk, 1998), under 24 person months and 6 month duration (Srivastave, 2006), and under 20 software developers (Johnson, 1998). It would be impossible to achieve agreement on the definition of a small project with hard limits. For the purposes of this research, a small project is a small project is defined as one having a duration from three to twelve months and a dollar value from $5,000 to $1.5M. (Kerzner, 2009) A recent survey showed that about half of IT projects fit into this category. About half the projects had a duration of less than nine months and had fewer than ten developers. (El Emam, 2008) The main points are that small projects are short in duration, have a limited number of personnel resources, limited skill sets, limited overhead, and management and technical roles are combined (Johnson, 1998).

Definitions

For the purposes of this research, it is important to distinguish between ontology and taxonomy. The term taxonomy is defined as "the study of the general principles of scientific classification." (Merriam-Webster's, 2011) This research provided a general classification for IT knowledge areas. Although others have created ontologies for PM and SE bodies of knowledge, the term taxonomy is more appropriate for this research since it does not attempts to specialize or carefully limit the categorization process of the knowledge areas of IT. The lexicon and definitions used by the PM and SE professions are different and can be a source of confusion for an inexperienced team leader. There are also multiple definitions for some of the key concepts. The problem is that the same

terms mean different things to different people and organizations. PMI provides definitions in the PMBOK while INCOSE provides a glossary of SE terms with definitions from several sources. Where multiple definitions exist, only the first definition is listed. The definitions from the PMBOK and INCOSE are compared.

Project - PMI Definition – "A project is a temporary endeavor undertaken to create a unique product, service, or result." (PMI 2004)

Project - INCOSE SE Terms Glossary – 2 Definitions – "A defined time- and cost-controlled activity with clearly established objectives and boundary conditions executed to gain knowledge, create a capability, or provide a service. (NASA MDP92)" (INCOSE 1998)

Project Management - PMI Definition – "Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements." (PMI 2004)

Project Management – INCOSE SE Terms Glossary – "The planning, organizing, directing, and controlling of company resources to meet specific goals and objectives within time, within cost and at the desired performance level. (Bahill/Sandia)" (INCOSE 1998)

Systems Engineering – PMI Definition – Systems engineering is not defined by the PMBOK.

Systems Engineering - INCOSE SE Terms Glossary – 26 Definitions – "An interdisciplinary approach to evolve and verify an integrated and life-cycle balanced set

of system product and process solutions that satisfy customer needs. (MIL-STD-499B-UNAPPROVED)" (INCOSE 1998)

CHAPTER 3: SUMMARY OF NEW WORK

There were three primary original tasks that needed to be done in order to test the hypotheses. They are summarized in this short chapter and will be discussed in greater detail in the following chapters.

1. An IT project taxonomy that identified IT knowledge areas was needed to organize the survey. The new taxonomy was created from combining PM knowledge areas with SE knowledge areas. The intent of the new IT taxonomy was to retain the information from both PM and SE and eliminate the overlap.
2. The most critical documents and reviews were identified for small IT projects. These documents and reviews were determined by surveying IT professionals. The results were based on experimental data.
3. An expert project planning assistant was created to provide a template for the project manager to plan small IT projects. The project planning assistant is a web based tool that contained a format for a project plan, guidance for selecting documents and reviews, and heuristics from the IT, PM, and SE literature to assist project managers in the creation of their project plan. The project planning assistant was successfully tested with novice project managers to verify the results of the research.

Another minor area of new work was providing a detailed comparison of the knowledge areas of the PMBOK and EIA-632. This was the subject of an INCOSE conference paper titled “Project Manager Use of PMBOK and EIA-632 Processes in

Engineering a Small System". That paper outlined the overlapping knowledge areas of PM and a single SE standard. The research reported in that paper was expanded significantly during the present research reported in this dissertation to include many of the SE standards. The final result was the creation of the IT project knowledge areas reported in this dissertation.

CHAPTER 4: SURVEY

IT Project Taxonomy

For the purposes of identifying the most important documents and reviews through a survey, an IT project taxonomy for the knowledge areas was needed to clearly present the information. There are many ways an IT project taxonomy could be constructed. The PMBOK was selected as the baseline for PM, and the ontology created by Honour and Valerdi was selected as the baseline for SE. Since PM and SE share some common areas, the PM and SE knowledge areas can be partially combined. In order to be useful, the combination of knowledge areas must be recognizable and acceptable to both PM and SE professionals. In areas of overlap between PM and SE bodies of knowledge, the PM verbiage was used because the PMBOK is the largest accepted standard used by IT professionals. In trying to merge areas of overlap between the PM and SE bodies of knowledge three situations emerged: 1) Areas with a PM emphasis, 2) Areas with a significant amount of knowledge from both PM and SE, and 3) Areas with an SE emphasis. In cases where the information was almost identical and covered by the PMBOK, the knowledge area verbiage from PM was used.

Project Management Knowledge Areas

The difficulty of merging separate knowledge areas is highlighted here since there may be many-to-one or many-to-many mappings between PM and SE. (Kauffman, 1998) (Brouse, 2009) In these cases, it was decided to supplement the PM areas with SE areas.

There are six PM knowledge areas that should be maintained and augmented with SE knowledge. These include project time management, project cost management, project quality management, project human resource management, project communications management, and project risk management.

Knowledge Areas with Significant Overlap

The overlapping knowledge areas demonstrate that there are many ways to generate knowledge areas. The PMBOK knowledge area of project integration management overlaps significantly with the SE areas of mission/purpose definition and technical management and leadership. Project integration management is the starting point for projects and covers the areas of developing the project charter, developing the management plan, managing the execution of the project, monitoring and controlling the project, making changes to the project, and closing the project. (PMBOK, 2009) Developing the project charter is similar to defining the purpose and mission of a project. Managing, controlling, and changing the project are similar to the technical management and leadership found in the SE knowledge area. Combining these areas could be accomplished by augmenting the existing PM knowledge area with the SE knowledge areas.

The PMBOK defines project scope management in terms of the work required to be done by a project. The SE standards define scope management as managing contracts. This can be confusing since the SE area of scope management is different than the PM area of scope management. For the purposes of the new taxonomy, scope management was defined in PMBOK terms. Scope management involves collecting requirements,

defining the scope, creating the WBS, verifying the scope, and controlling the scope (PMBOK, 2009). The SE categories of requirements engineering and verification and validation somewhat overlap with the PMBOK area of scope management but provide greater details on methods. The SE knowledge areas can be very helpful in augmenting the PMBOK by bringing tools and methods that are not covered in the PMBOK. Given that most IT projects fail due to some problem with requirements (Fretty, 2006), strengthening this area should help with failure rates.

Project procurement management plans, conducts, administers and closes procurement actions (PMBOK, 2009). This is very similar to the SE category of scope management. The purpose of these knowledge areas is to manage work that is done by others for an organization. Given the similarity, these knowledge areas were easily combined.

Systems Engineering Knowledge Areas

Some of the primary functions of systems engineering are to design and build a system. Systems architecting, system implementation, and technical analysis are knowledge areas that define how to design, build, and deliver a system in great detail. Since the PMBOK is a management document, it does not cover the design, building, and delivering processes for systems. Knowledge areas that provide tools, methods, and guidance for the functions would be beneficial to the IT industry. These knowledge areas would benefit IT projects by introducing methods to handle the complexity of IT projects. Table 3 shows the combined knowledge areas.

Table 3. The Combined Knowledge Areas

Project Management Areas	Overlapping Areas	Systems Engineering Areas
Project Time Management	Project Integration Management	System Architecting
Project Cost Management	Mission / Purpose Definition	System Implementation
Project Quality Management	Technical Management / Leadership	Technical Analysis
Project Human Resource Management	Project Scope Management	
Project Communications Management	Requirements Engineering	
Project Risk Management	Verification and Validation	
	Project Procurement Management	
	Scope Management	

The PM and the SE knowledge areas converge into an IT taxonomy of twelve categories. These twelve categories are project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communications management, project risk management, and project procurement management, systems architecting, systems implementation, and technical analysis. Table 4 identifies these twelve IT knowledge areas.

Table 4. IT Knowledge Areas

IT 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
10	System Architecting
11	System Implementation
12	Technical Analysis

Combining PM and SE Knowledge Areas for Resource Limited Projects

For resource-limited projects, it would be clearly beneficial to merge some PM and SE knowledge areas so that a single individual can perform both functions competently. The goal has been to identify how best to merge aspects of the PM and SE bodies of knowledge that would be needed by a single person to perform both of these functions for small projects. The first step was to identify which of the many project related documents and reviews were considered to be of highest values to IT professionals, IT project managers, and IT systems engineers. A survey was conducted to gain insight into the importance of each document and review for an IT project that was under twelve months and $1.5M. PM and SE standards were reviewed to identify the documents and reviews. The standards that were reviewed included the PMBOK,

ANSI/EIA-632, IEEE 1220, ISO-15288, MIL-STD-499C, the Software Engineering Institute's CMMI, and the Systems Engineering Handbook from INCOSE. The documents and reviews were both unique to a particular standard and contained in more than one standard. The standards contained a total of 74 documents and 34 reviews. The survey was sent to 105 individuals. There were 56 responses, 45 non-responses, and four responses by individuals who felt they did not have the background to properly answer the questions. The response rate was high partly because some of the recipients of the questionnaire knew the authors and were willing to complete the survey. Another reason for the high response rate was that many of the participants had a long history in these areas and were eager to share their opinions.

The survey instructed the participants to group the documents and reviews into one of three categories; "fully perform", "perform in a limited manner", and "don't perform." The categories were defined as:

"Fully Perform" – This document or review is necessary for the project and should be performed in great detail. This category was assigned a one.

"Perform in a Limited Manner" - Some of information in the document or review is helpful for the project and should be performed in a limited manner. This category was assigned a two.

"Don't Perform" - This document or review is not needed for a project of this size and scope. This category was assigned a three.

The category "fully perform" was assigned a numerical value of "1", "perform in a limited manner" was assigned a "2", and "don't perform" was assigned a "3". Lower

scores indicate that a document or review is more important to the project. The documents were grouped into twelve knowledge areas and there was one area for reviews. Each of the documents and reviews included a definition that was accessible with a single click of the mouse if needed by the participant. It is emphasized that the intent of this work was not to significantly change either PM or SE, but to provide IT project managers with an IT knowledge areas. The intent of the survey was many-fold:

1. Identify the areas of emphasis for project managers and systems engineers in the context of others in the IT profession.
2. Identify common areas in the PM and SE bodies of knowledge where no cross-training would be needed.
3. Identify areas where each of these two professions could benefit from cross-training.
4. Identify the elements of PM and SE which should be taught to a person who is neither a PM nor an SE, so that such a person could manage IT projects.

The documents and reviews were grouped into twelve knowledge areas and one area for reviews. Each of the documents and reviews included a definition that was accessible with a single click of the mouse by the participant. The twelve knowledge areas included the following documents.

1. Project Integration Management – 13 documents: business case, project charter, project management plan, performance reports, tasking document, strategic plan, concept specification, maintenance concept, concept of operations, disposal concept, total cost of ownership, systems engineering management plan, and software development plan.

2. Project Scope Management – 10 documents: requirements document, work performance measurements, requirements management plan, requirements traceability matrix, project scope statement, project scope baseline, work breakdown structure (WBS), WBS dictionary, scope management plan, and testability plan.

3. Project Time Management – 6 documents: activity list, milestone list, project schedule, project schedule network diagram, activity resource requirements document, and resource breakdown structure.

4. Project Cost Management – 5 documents: activity cost estimates, cost performance baseline, budget forecasts, cost management plan, and earned value management documents.

5. Project Quality Management – 4 documents: quality management plan, quality metrics, quality checklists, and process improvement plan.

6. Project Human Resource Management – 3 documents: human resource plan, staffing management plan, and training plan.

7. Project Communications Management – 1 document: communications management plan.

8. Project Risk Management – 2 documents: risk management plan and risk register.

9. Project Procurement Management: 7 documents – procurement management plan, statement of work, source selection criteria, resource calendar, request for proposal, contract, and contractor identified technical information services plan.

10. System Architecting – 15 documents: enterprise policies, project procedures, configuration management plan, data management plan, electromagnetic

compatibility/interface control plan, human factors engineering plan, interface control plan, supportability plan, maintenance plan, reliability plan, producibility plan, system safety plan, system security plan, survivability management plan, and mass properties control plan.

11. System Implementation – 3 documents: system specification documents, integrated data package, and systems integration plan.

12. Technical Analysis – 5 documents: trade-off analysis document, system verification plan, system validation plan, test plan, and test procedures.

Table 5 shows the ranked order of the documents for all of the survey participants.

Table 5. Document Rankings

Rank	Document Name	Score	Rank	Document Name	Score
1	Project Schedule	1.125	38	SOW	1.839
2	Requirements	1.179	39	Interface Control Plan	1.893
3	Milestone List	1.250	40	Maintenance Plan	1.907
4	Concept of Operations	1.304	41	Procurement Management Plan	1.911
5	Project Management Plan	1.339	42	Total Cost of Ownership	1.929
6	Test Plan	1.375	43	Requirements Management Plan	1.929
7	Project Scope Statement	1.393	44	Quality Checklists	1.929
8	Test Procedures	1.429	45	Work Performance Measurements	1.946
9	System Security Plan	1.455	46	Project Procedures	1.946
10	Business Case	1.464	47	Quality Metrics	1.964
11	WBS	1.464	48	Quality Management Plan	1.982
12	Activity Cost Estimates	1.464	49	Human Resource Plan	2.018
13	System Specifications	1.464	50	Activity Resource Requirements	2.018
14	Contract	1.500	51	Integrated Data Package	2.054
15	Tasking Documents	1.589	52	Resource Breakdown Structure	2.073
16	Concept Specification	1.589	53	WBS Dictionary	2.089
17	Testability Plan	1.600	54	Risk Register	2.089
18	Performance Reports	1.607	55	Trade-off Analysis Document	2.089
19	Risk Management Plan	1.607	56	Project Schedule Network Diagram	2.091
20	Requirements Traceability Matrix	1.618	57	Communications Management Plan	2.107
21	Activity List	1.625	58	Supportability Plan	2.125
22	Budget Forecasts	1.625	59	Scope Management Plan	2.143
23	CM plan	1.636	60	System Safety Plan	2.161
24	Data Management Plan	1.636	61	Strategic Plan	2.179
25	RFP	1.643	62	Training Plan	2.196
26	Systems Integration Plan	1.661	63	Survivability Management Plan	2.196
27	Software Development plan	1.691	64	Resource Calendar	2.214
28	System Verification Plan	1.714	65	Services Plan	2.232
29	Cost Performance Baseline	1.750	66	Enterprise Ploicies	2.250
30	Staffing Management Plan	1.750	67	Reliability Plan	2.268
31	Project Charter	1.804	68	Process Improvement Plan	2.339
32	Source Selection Criteria	1.804	69	Disposal Concept	2.375
33	Cost Management Plan	1.818	70	EVM	2.375
34	System Validaton Plan	1.818	71	EMI interface control plan	2.393
35	SEMP	1.821	72	Human Factors Engineering Plan	2.429
36	Maintenance Concept	1.839	73	Producability Plan	2.429
37	Project Scope Baseline	1.839	74	Mass Properties Control Plan	2.661

Reviews were grouped into a single category. There were 34 reviews including management, phase-end, disbursement, employee performance, inspections and product

reviews, performance, quality audits, approved change request, status, documentation, activity cost estimate, activity duration estimate, risk, procurement performance, procurement audit, system definition, system requirements, subsystem requirements, alternative system, system technical, preliminary design, system detailed design, system critical design, functional configuration audit, physical configuration audit, system verification, test readiness, initial operational test and evaluation, readiness, design configuration audit, production approval, component, system acceptance, and operational readiness. Table 6 shows the ranked order of the reviews for all of the survey participants.

Table 6. Review Rankings

Rank	Review Name	Score	Rank	ReviewName	Score
1	System Acceptance	1.482	18	Inspection and Product Reviews	1.857
2	Operational Readiness	1.482	19	System Technical	1.889
3	Systems CDR	1.527	20	Employee Performance Review	1.911
4	Systems Requirements	1.554	21	Quality Audits	2.036
5	Management Review	1.571	22	Activity Cost Estimate	2.054
6	Status	1.589	23	System Definition	2.089
7	IOT&E Review	1.696	24	Subsystem Requirements	2.143
8	Approved Change Request	1.714	25	Functional Configuration	2.143
9	Documentation	1.750	26	Activity Duration Estimate	2.161
10	System Verification	1.768	27	Design Configuration Audits	2.196
11	Test Readiness	1.768	28	Production Approval	2.196
12	Phase-end Review	1.782	29	Procurement Performance	2.200
13	System PDR	1.786	30	Physical Configuration	2.286
14	Risk Reviews	1.804	31	Disbursement Review	2.309
15	System Detailed Design	1.818	32	Component	2.321
16	Readiness	1.818	33	Procurement Audit	2.375
17	Performance Reviews	1.821	34	Alternative System	2.464

The survey asked for job title for the purpose of helping the subsequent analysis identify the difference in the replies to the surveys between PMs and SEs. There were 21 self-identified project managers and 9 self-identified systems engineers. Table 7 shows the ranked order of documents for project managers.

Table 7. Project Manager Document Rankings

Rank	Document Name	Score	Rank	Document Name	Score
1	Project Schedule	1.190	38	Cost Management Plan	1.857
2	Requirements	1.286	39	Quality Management Plan	1.857
3	Project Management Plan	1.333	40	Maintenance Plan	1.857
4	Project Scope Statement	1.333	41	System Validaton Plan	1.857
5	Activity Cost Estimates	1.381	42	Maintenance Concept	1.905
6	Test Procedures	1.381	43	SEMP	1.905
7	Milestone List	1.429	44	Communications Management Plan	1.905
8	Test Plan	1.429	45	Project Procedures	1.905
9	Concept of Operations	1.476	46	Requirements Management Plan	1.952
10	Budget Forecasts	1.476	47	Source Selection Criteria	1.952
11	Contract	1.476	48	Procurement Management Plan	2.000
12	System Security Plan	1.476	49	Interface Control Plan	2.000
13	Tasking Documents	1.524	50	Supportability Plan	2.000
14	System Specifications	1.524	51	System Safety Plan	2.000
15	Requirements Traceability Matrix	1.571	52	WBS Dictionary	2.048
16	CM plan	1.600	53	Activity Resource Requirements	2.048
17	Concept Specification	1.619	54	Resource Breakdown Structure	2.048
18	Software Development plan	1.619	55	Risk Register	2.048
19	WBS	1.619	56	Integrated Data Package	2.048
20	Cost Performance Baseline	1.619	57	Trade-off Analysis Document	2.048
21	Performance Reports	1.667	58	Human Resource Plan	2.095
22	Risk Management Plan	1.667	59	Enterprise Ploicies	2.095
23	SOW	1.667	60	Scope Management Plan	2.143
24	Data Management Plan	1.667	61	Resource Calendar	2.143
25	System Verification Plan	1.667	62	Reliability Plan	2.143
26	Business Case	1.714	63	Project Schedule Network Diagram	2.190
27	Staffing Management Plan	1.714	64	Process Improvement Plan	2.190
28	Testability Plan	1.750	65	Training Plan	2.190
29	Project Scope Baseline	1.762	66	Survivability Management Plan	2.238
30	Project Charter	1.810	67	Strategic Plan	2.286
31	Total Cost of Ownership	1.810	68	Producability Plan	2.286
32	Quality Metrics	1.810	69	Services Plan	2.333
33	Quality Checklists	1.810	70	Disposal Concept	2.381
34	RFP	1.810	71	Human Factors Engineering Plan	2.381
35	Systems Integration Plan	1.810	72	EVM	2.429
36	Work Performance Measurements	1.857	73	EMI interface control plan	2.429
37	Activity List	1.857	74	Mass Properties Control Plan	2.714

Table 8 shows the ranked order of documents for systems engineers.

Table 8. System Engineer Document Rankings

Rank	Document Name	Score	Rank	Document Name	Score
1	Business Case	1.111	38	Project Charter	2.000
2	Requirements	1.222	39	Software Development plan	2.000
3	Project Scope Statement	1.222	40	Requirements Management Plan	2.000
4	Milestone List	1.222	41	Project Scope Baseline	2.000
5	Project Schedule	1.222	42	Scope Management Plan	2.000
6	Project Management Plan	1.333	43	Project Schedule Network Diagram	2.000
7	Concept of Operations	1.333	44	Quality Metrics	2.000
8	WBS	1.333	45	Quality Checklists	2.000
9	Activity List	1.333	46	Staffing Management Plan	2.000
10	System Security Plan	1.333	47	Contract	2.000
11	Requirements Traceability Matrix	1.444	48	Maintenance Plan	2.000
12	Concept Specification	1.556	49	Trade-off Analysis Document	2.000
13	SEMP	1.556	50	Cost Management Plan	2.111
14	Testability Plan	1.556	51	Procurement Management Plan	2.111
15	System Specifications	1.556	52	Supportability Plan	2.111
16	Systems Integration Plan	1.556	53	Survivability Management Plan	2.111
17	Test Plan	1.556	54	Work Performance Measurements	2.222
18	Activity Resource Requirements	1.667	55	WBS Dictionary	2.222
19	Activity Cost Estimates	1.667	56	EVM	2.222
20	Risk Management Plan	1.667	57	Quality Management Plan	2.222
21	Data Management Plan	1.667	58	Human Resource Plan	2.222
22	Interface Control Plan	1.667	59	Training Plan	2.222
23	Test Procedures	1.667	60	EMI interface control plan	2.222
24	Tasking Documents	1.778	61	Integrated Data Package	2.222
25	Maintenance Concept	1.778	62	Strategic Plan	2.333
26	Resource Breakdown Structure	1.778	63	Communications Management Plan	2.333
27	Budget Forecasts	1.778	64	Risk Register	2.333
28	Source Selection Criteria	1.778	65	Services Plan	2.333
29	RFP	1.778	66	Enterprise Ploicies	2.333
30	CM plan	1.778	67	System Safety Plan	2.333
31	Performance Reports	1.889	68	Disposal Concept	2.444
32	Total Cost of Ownership	1.889	69	Resource Calendar	2.444
33	Cost Performance Baseline	1.889	70	Human Factors Engineering Plan	2.444
34	SOW	1.889	71	Process Improvement Plan	2.556
35	Project Procedures	1.889	72	Reliability Plan	2.556
36	System Verification Plan	1.889	73	Producability Plan	2.667
37	System Validaton Plan	1.889	74	Mass Properties Control Plan	2.889

In relation to each other, project managers and systems engineers predictably emphasized different documents and denoted their emphasis by the relative score that was given to each document and review. A comparison was made using the score for each document

and review. Areas that were different by greater than .25 were deemed to be significant. Table 9 shows areas of project manager emphasis and areas of systems engineering emphasis for documents.

Table 9. Areas of PM and SE Emphasis for Documents

Difference	Areas of PM Emphasis
0.524	Contract
0.429	Communications Management Plan
0.413	Reliability Plan
0.381	Software Development plan
0.381	Producability Plan
0.365	Work Performance Measurements
0.365	Quality Management Plan
0.365	Process Improvement Plan
0.333	System Safety Plan
0.302	Resource Calendar
0.302	Budget Forecasts
0.286	Risk Register
0.286	Activity Cost Estimates
0.286	Staffing Management Plan
0.286	Test Procedures
0.270	Cost Performance Baseline
0.254	Tasking Documents
0.254	Cost Management Plan

Difference	Areas of SE Emphasis
0.603	Business Case
0.524	Activity List
0.381	Activity Resource Requirements
0.349	SEMP
0.333	Interface Control Plan
0.286	WBS
0.270	Resource Breakdown Structure
0.254	Systems Integration Plan

The results show that project managers are more focused on plans and cost documents, and that systems engineers seem to focus more on the business case, activities, resources, and integrating with other systems. This supports the assertion by Mooz that project managers focus on cost and schedule activities while systems engineers are focus on the end-to-end solution. (Mooz, 1997) The same procedure was applied to project reviews. All of the 34 reviews were grouped into a single category. Table 10

shows the review ranking for project managers and Table 11 shows the review ranking for systems engineers.

Table 10. Project Manager Review Rankings

Rank	Review Name	Score	Rank	Review Name	Score
1	Operational Readiness	1.381	18	Readiness	1.810
2	Status	1.429	19	Phase-end Review	1.857
3	Systems CDR	1.429	20	Employee Performance Review	1.952
4	System Acceptance	1.429	21	System Definition	1.952
5	Management Review	1.524	22	Quality Audits	2.000
6	Systems Requirements	1.571	23	Activity Cost Estimate	2.000
7	Documentation	1.667	24	Design Configuration Audits	2.048
8	System PDR	1.667	25	Production Approval	2.048
9	Performance Reviews	1.762	26	Activity Duration Estimate	2.095
10	Approved Change Request	1.762	27	Functional Configuration	2.095
11	Risk Reviews	1.762	28	Procurement Performance	2.238
12	System Detailed Design	1.762	29	Physical Configuration	2.238
13	IOT&E Review	1.762	30	Component	2.238
14	Inspection and Product Reviews	1.810	31	Disbursement Review	2.286
15	System Technical	1.810	32	Procurement Audit	2.333
16	System Verification	1.810	33	Subsystem Requirements	2.476
17	Test Readiness	1.810	34	Alternative System	2.524

Table 11. Systems Engineer Review Rankings

Rank	Review Name	Score	Rank	Review Name	Score
1	Systems Requirements	1.667	18	Procurement Performance	2.000
2	System Verification	1.667	19	System Definition	2.000
3	System Acceptance	1.667	20	Subsystem Requirements	2.000
4	Operational Readiness	1.667	21	System PDR	2.000
5	Readiness	1.750	22	Employee Performance Review	2.111
6	Management Review	1.778	23	Alternative System	2.111
7	Status	1.778	24	System Technical	2.111
8	Systems CDR	1.778	25	Quality Audits	2.222
9	IOT&E Review	1.778	26	Activity Cost Estimate	2.222
10	Approved Change Request	1.889	27	Activity Duration Estimate	2.222
11	Risk Reviews	1.889	28	Disbursement Review	2.333
12	System Detailed Design	1.889	29	Procurement Audit	2.333
13	Test Readiness	1.889	30	Design Configuration Audits	2.333
14	Phase-end Review	2.000	31	Production Approval	2.333
15	Inspection and Product Reviews	2.000	32	Functional Configuration	2.444
16	Performance Reviews	2.000	33	Physical Configuration	2.444
17	Documentation	2.000	34	Component	2.444

Table 12 shows the areas where project managers and systems engineers differed the most with regard to which reviews were considered as being most important.

Table 12. Areas of Emphasis for PM and SE

Difference	Areas of PM Emphasis
0.349	Functional Configuration
0.349	Status
0.349	Systems CDR
0.333	Documentation
0.333	System PDR
0.302	System Technical
0.286	Design Configuration Audits
0.286	Production Approval
0.286	Operational Readiness
0.254	Management Review

Difference	Areas of SE Emphasis
0.476	Subsystem Requirements
0.413	Alternative System

IT Managers

An important class of stakeholders of both project management and systems engineering is the class of IT managers. This group of people contains both IT managers and IT executive managers. IT managers and IT executive managers are responsible for the success of IT projects from a higher level in the organization. In practice, most of the people in this group were once project managers and/or systems engineers participating on IT project teams. The survey showed that each of the respondents in this category did perform as a project manager and system engineer for some extended period of time during their career. Managers have a significant influence the types of documents and reviews that are required for projects in their organization. Many organizations have implemented processes that specify the documents and reviews required for their organization.

Table 13 shows the average years of work experience, average years of experience working in IT, average years of experience as a project manager, and average years of experience as a systems engineer. The survey respondents had lots of relevant experience to offer to this research. The data also showed that professionals working in this field often serve in many roles in IT projects.

Table 13. Years of Experience

Cateogry	Years Work Experience	Years IT Experience	Years PM Experience	Years SE Experience
Project Managers	24.95	14.52	11.81	11.24
System Engineers	30	16.44	9.89	17.22
IT Managers	28.89	21.33	17	11.33

The survey contained two categories of managers; IT managers and IT executive managers. There were six responses from the IT executive manager category and three responses from the IT manager category for a total of nine responses. Table 14 shows the ranked documents and Table 15 shows the ranked reviews for IT managers. Tables 14 and 15 show that the areas of emphasis depend upon where one sits in the organization. The data shows that IT managers have different priorities compared to both project managers and systems engineers.

Table 14. IT Manager Document Rankings

Rank	Document Name	Score	Rank	Document Name	Score
1	Concept of Operations	1.111	38	Interface Control Plan	1.778
2	Requirements	1.111	39	Integrated Data Package	1.778
3	Milestone List	1.111	40	Requirements Traceability Matrix	1.875
4	Project Schedule	1.111	41	Project Charter	1.889
5	Contract	1.111	42	Tasking Documents	1.889
6	Activity List	1.222	43	Requirements Management Plan	1.889
7	System Specifications	1.222	44	Quality Checklists	1.889
8	Test Plan	1.222	45	Procurement Management Plan	1.889
9	System Security Plan	1.250	46	Project Procedures	1.889
10	Business Case	1.333	47	Strategic Plan	2.000
11	Project Scope Statement	1.333	48	Work Performance Measurements	2.000
12	WBS	1.333	49	WBS Dictionary	2.000
13	RFP	1.333	50	Quality Management Plan	2.000
14	Test Procedures	1.333	51	Scope Management Plan	2.111
15	System Validaton Plan	1.375	52	Quality Metrics	2.111
16	Project Management Plan	1.444	53	Communications Management Plan	2.111
17	Activity Cost Estimates	1.444	54	Supportability Plan	2.111
18	CM plan	1.444	55	System Safety Plan	2.111
19	Systems Integration Plan	1.444	56	Disposal Concept	2.222
20	System Verification Plan	1.444	57	Total Cost of Ownership	2.222
21	Risk Management Plan	1.556	58	Project Schedule Network Diagram	2.222
22	Maintenance Concept	1.667	59	Resource Breakdown Structure	2.222
23	SEMP	1.667	60	Risk Register	2.222
24	Software Development plan	1.667	61	Resource Calendar	2.222
25	Project Scope Baseline	1.667	62	Enterprise Ploicies	2.222
26	Testability Plan	1.667	63	Reliability Plan	2.222
27	Budget Forecasts	1.667	64	Trade-off Analysis Document	2.222
28	Human Resource Plan	1.667	65	Activity Resource Requirements	2.333
29	SOW	1.667	66	Training Plan	2.333
30	Source Selection Criteria	1.667	67	Services Plan	2.333
31	Maintenance Plan	1.750	68	Survivability Management Plan	2.333
32	Performance Reports	1.778	69	Process Improvement Plan	2.444
33	Concept Specification	1.778	70	Producability Plan	2.444
34	Cost Performance Baseline	1.778	71	Human Factors Engineering Plan	2.556
35	Cost Management Plan	1.778	72	Mass Properties Control Plan	2.556
36	Staffing Management Plan	1.778	73	EVM	2.667
37	Data Management Plan	1.778	74	EMI interface control plan	2.667

Table 15. IT Manager Review Rankings

Rank	Review Name	Score	Rank	ReviewName	Score
1	Operational Readiness	1.111	18	Inspection and Product Reviews	1.778
2	Status	1.333	19	Risk Reviews	1.778
3	Systems Requirements	1.333	20	Employee Performance Review	1.889
4	System Acceptance	1.333	21	Subsystem Requirements	1.889
5	Management Review	1.444	22	Quality Audits	2.000
6	Documentation	1.444	23	Functional Configuration	2.111
7	Systems CDR	1.444	24	Disbursement Review	2.125
8	System Verification	1.444	25	Activity Cost Estimate	2.222
9	Phase-end Review	1.556	26	Procurement Performance	2.222
10	System PDR	1.556	27	Procurement Audit	2.222
11	IOT&E Review	1.556	28	System Definition	2.222
12	Readiness	1.556	29	Physical Configuration	2.222
13	System Technical	1.625	30	Design Configuration Audits	2.333
14	System Detailed Design	1.625	31	Production Approval	2.333
15	Performance Reviews	1.667	32	Component	2.333
16	Approved Change Request	1.667	33	Activity Duration Estimate	2.444
17	Test Readiness	1.667	34	Alternative System	2.667

CHAPTER 5: SURVEY RESULTS

This survey had 56 respondents with 959 years of IT experience and 688 years of project management experience. The group was very experienced and averaged over 17 years of IT experience, over 12 years of PM experience, and more than 11 years of SE experience. The number of respondents was sufficient to provide insight into the project planning documents and reviews used for small IT projects. The results provided a basis for placing documents and reviews into one of three categories for the project planning assistant tool. The value of the planning assistant is that it provides a comprehensive list of documents and reviews and orders them in a manner to provide guidance on whether to perform the task. A definition of the document and review was also provided with the reference for the definition.

The data from the distinct groups provided insight into how each group would order the importance of documents and reviews. The documents and reviews were rank ordered with an average over all of the people surveyed. Three different subgroups were extracted from the overall group which were PMs, SEs, and IT managers.

The data had some interesting characteristics. The answers to most of the questions were spread over all the options as opposed to being clustered together in a single category. There were several possible reasons for this. They include:

- Different respondents (e.g. SE's, PMs, and IT Managers) have different priorities.

- Different respondents have different levels of experience.
- Most respondents wanted to answer “it depends”, and since that was not an option, they picked an answer among the ones allowed without thinking too much about it.
- Some of the respondents were not familiar with some of the documents they were asked to opine on (e.g. PMs were not too familiar with SE’s documents, and vice versa), and so they selected an answer without thinking.

Would a much larger number of respondents have resulted in a better experiment? Not necessarily. Gallop and other opinion tests knowingly and intentionally sample the target population and do not try to collect opinions from tens of thousands of individuals. They are able to assign a small margin of error to the answers they get even from such limited samplings.

The results of the experiment provided the desired goal. The documents and reviews were rank ordered and presented in a project plan in one of three categories: recommended, helpful, and optional. The project planning assistant was designed to maintain all of the documents and reviews then provide the ability to review all of the selected ones at the end of the section. The rank ordering provides the novice PMs with a sense of the more important documents and reviews in the context of small IT projects.

CHAPTER 6: TESTING THE EXPERT SYSTEM

The expert system was tested using novice project managers from a graduate level project management class at George Mason University. The course code was SYST 530 from the spring 2011 semester. There were 31 students in the class: 22 were classroom students and nine were distance learning students who logged into the class over the Internet. The students received a classroom presentation for the purpose of being recruited to be participants in this study. Participation was voluntary. Students who participated received two points of extra credit to be added to their grade. See Appendix D for the presentation. In order to receive the two points of extra credit, the students had to complete a project plan and a short survey. See Appendix E to view the survey. The project plan assistant was tested using a post-test-only, control-group design. The students were randomly selected for the group using the project planning assistant and the group that did not use the project planning assistant. 15 students were given access to the expert system and 16 students were in the control group. Students were provided with an overview of project plans and the project planning assistant. Students were given two weeks to complete the task.

The test problem that was chosen was the design, development, and delivery of a digital asset management system in the advertising domain. The problem statement was provided for download on the class blackboard and is as follows.

Dear Colleagues

You have been appointed as the project manager for implementing a new digital asset management system. The future of the company depends on you successfully delivering this vital new infrastructure for the company. Management would like to see a plan of how you will accomplish this in two weeks. This is the kind of project that keeps management up at night. They are aware of at least two other advertizing companies that have failed to successfully implement a new infrastructure. One of the companies went out of business and the other was sold for pennies on the dollar.

Background and Problem Statement

You are the head of an IT department of a mid-size but growing advertising company. The company has a legacy filing system that costs them money, time, and it impacts its ability to bid on work for new clients. The company has decided to implement a new digital asset management system to help manage the many different types of data that are required for this business area. Data types include audio in multiple formats, video in multiple formats, images, documents, graphics, and spreadsheets to support advertising campaigns. All of the data needs to be related so it can be quickly recalled to be used for new advertising products.

There is a variety of commercially available digital asset management systems. The systems differ widely in cost and capabilities and none of them will support the enterprise right out of the box. Management does not want to develop custom software, but it realizes it needs to support some customization within the

product to support the work flow. Since the software license alone may cost over one hundred thousand for the enterprise, management wants to review the choice of asset management system prior to committing to purchasing the system. Management also wants to understand the work involved and the cost of customizing the work flow and integrating the existing and expensive software tool set into the system. Management realizes that the company work flow affects every person in the company so the new system must be properly socialized across the company in order to ensure a smooth transition. The CEO suggests that you talk with at least some people from all of the departments to collect their requirements and describe how the new system will improve their work. Company management would like the initial delivery of the system in six months and further refinements to continue for the next six month period. At the end of 12 months, management wants to see a full transition to the system. The company has set aside a maximum of $1.5M to complete all phases of this project. Management understands that it may not have all of the skill sets on staff required to effectively implement the new system, so you may hire up to 5 new people for the project.

Deliverables and Schedule

Deliverables include a completed Project Management Plan and a survey that are due on Thursday March 17. Thanks for the help! It is greatly appreciated! Questions can be sent to mmulhear@gmu.edu

The students were also provided a set of instructions to help get them started.

Simple Procedure for Performing the Project Plan Exercise

1. Read the problem statement. Extract the requirements and suggestions as specific items for your project plan
2. Perform a quick web search on digital asset management systems. This will provide background and understanding of digital asset management systems in the advertising vertical.
3. Read the section in your project management textbook on project plans. It has a suggested template and provides the information that project plans are identifying at the beginning of projects.
4. Write the project plan.

a. For those who are using the project planning assistant. Fill out all the sections. Copy the final output into a word document. There are a couple of sections that you will need to convert to tables. Highlight the sections in word, click on convert to table, select the appropriate number of columns, then hit OK

b. For those who do not have the benefit of the project plan assistant, write the information you feel would be useful for a project plan in a format that you prefer.

5. Complete the document and send it to Rosana as a word document.
6. Fill out the survey form. Please be honest, both positive and negative feedback is welcome.
7. Fill out the survey. This was done in acrobat. At the end of the survey, click on the email submit button. Depending on your email configuration, this may or

may not work. It should create an email automatically and mail it back to me. If it does not work, forward the hardcopy to Rosana.

Thanks again for your participation and help. It is greatly appreciated.

CHAPTER 7: EXPERT SYSTEM RESULTS

The expert system testing had a total of 23 participants out of the 31 individuals in the class, which was a 74% response rate. 11 out of the 15 individuals who were assigned to the expert system participated in study. 12 out of the 16 individuals from the control group participated. The baseline for evaluating the project plans was to compare the specified documents and reviews that were contained the project plan against the recommended documents and reviews from the survey. The main hypothesis was that project plans that specify more of the recommended documents and reviews provide a greater level of detail in the project plan; also that project plans with a greater level of detail and specificity should help the project manager eliminate more uncertainty and identify areas of risk at the beginning of the project, thus producing a better project plan.

The documents and reviews that were recommended for small IT projects were the top 15% of the group. There were 74 documents and 34 reviews that were found in the PM and SE literature. 15% of each category is equivalent to 11.1 documents 5.1 reviews. The numbers were rounded up to twelve and six, respectively. Table 16 shows the top 15% of documents and reviews. 13 documents represented the top 15% of documents since the business case, WBS, activity cost estimates, and system specifications all had the same average score of 1.464.

Table 16. Top 15% of Documents and Reviews

Rank	Document Name	Score	Rank	Review Name	Score
1	Project Schedule	1.125	1	System Acceptance	1.482
2	Requirements	1.179	2	Operational Readiness	1.482
3	Milestone List	1.250	3	Systems CDR	1.527
4	Concept of Operations	1.304	4	Systems Requirements	1.554
5	Project Management Plan	1.339	5	Management Review	1.571
6	Test Plan	1.375	6	Status	1.589
7	Project Scope Statement	1.393			
8	Test Procedures	1.429			
9	System Security Plan	1.455			
10	Business Case	1.464			
11	WBS	1.464			
12	Activity Cost Estimates	1.464			
13	System Specifications	1.464			

The first set hypotheses that were tested were:

- 1A - Novice project managers will produce project plans with an industry accepted number of document deliverables using an expert system.
- 1B - Novice project managers will produce project plans with an industry accepted type of document deliverables using an expert system.

The recommended documents that were specified by the project plans were extracted from each group of project plans. Table 17 shows the percentage of occurrences of each of the 13 recommended documents for each group. In all 13 cases, the group that used the expert system had a higher rate of specificity of documents than the group that did not use the expert system. Project plans from both groups covered project schedule and the

milestone list in detail. There was virtually no difference in the amount of information provided by each of the groups. The greater number of specified documents provides a greater level of detail of the important information for a project. It is critical that this information be understood at the beginning of a project as well as setting the expectations of the project team and management.

Table 17. Rates of Occurrences of Documents

Number	Survey Results	Percent with Expert System	Percent without Expert System
1	Project Schedule	100%	92%
2	Requirements Document	100%	25%
3	Milestone List	100%	83%
4	Concept of Operations	64%	8%
5	Project Management Plan	73%	25%
6	Project Scope Statement	45%	8%
7	Test Plan	73%	25%
8	Test Procedures	64%	17%
9	System Security Plan	65%	17%
10	Business Case	18%	0%
11	Work Breakdown Structure	65%	50%
12	Activity Cost Estimates	82%	0%
13	System Specifications	55%	17%

The next step is to validate the data using the data from the original survey. The original survey provided the same scope as the test data, but with a non-specific IT project. The percentage of the documents that the project manager would fully perform was calculated and is compared to the test group and the control group in Table 18. Each of the top 13 documents was compared to the both the group that used the expert system and the

control group. The percentage that was closest to the expert percentage was highlighted in bright green. Table 18 shows that 11 of the 13 documents from the group that used the expert system were closer to the percentage from the group that was surveyed from part 1 of the project.

Table 18. Document Rate Comparison by Percentages

Number	Survey Results	Percentage of Experts who placed the document in category 1	Percent with Expert System	Percent without Expert System
1	Project Schedule	87.5%	100%	92%
2	Requirements Document	83.9%	100%	25%
3	Milestone List	76.8%	100%	83%
4	Concept of Operations	71.4%	64%	8%
5	Project Management Plan	67.9%	73%	25%
6	Project Scope Statement	64.3%	45%	8%
7	Test Plan	64.3%	73%	25%
8	Test Procedures	58.9%	64%	17%
9	System Security Plan	61.8%	65%	17%
10	Business Case	60.7%	18%	0%
11	Work Breakdown Structure	64.3%	65%	50%
12	Activity Cost Estimates	62.5%	82%	0%
13	System Specifications	53.6%	55%	17%

The experimental data shows that the expert system helped novice project managers create project plans with both an industry number and type of documents. Hypotheses 1A and 1B were, therefore, substantiated with experimental data.

The next set of hypotheses involved project reviews. Project reviews are an important project management tool that allows the project team, management, and other stakeholders to gain insight into the project and provide control for the project. The project plan should specify the reviews that will be conducted at the beginning of the project. The recommended reviews were determined by a survey and are listed in Table 16. The hypotheses to be tested for reviews are:

- 2A - Novice project managers will produce project plans with an industry accepted number of project reviews using an expert system.
- 2B - Novice project managers will produce project plans with an industry accepted type of project reviews using an expert system.

The recommended reviews were extracted from the project plans. Table 19 shows the percentage of the recommended documents and reviews that were specified in the project plans.

Table 19. Rates of Occurrences of Reviews

Number	Survey Results	Percent with Expert System	Percent without Expert System
1	Systems Acceptance Review	90%	0%
2	Operational Readiness Review	45%	8%
3	Systems CDR	64%	17%
4	Systems Requirements Review	91%	17%
5	Management Review	91%	8%
6	Status Review	91%	8%

The percentage of the reviews that the project manager would fully perform was calculated and is compared to the test group and the control group in Table 20.

Table 20. Review Rate Comparison by Percentages

Number	Survey Results	Percentage of Experts who placed the document in category 1	Percent with Expert System	Percent without Expert System
1	Systems Acceptance Review	58.9%	90%	0%
2	Operational Readiness Review	64.3%	45%	8%
3	Systems CDR	60.0%	64%	17%
4	Systems Requirements Review	55.4%	91%	17%
5	Management Review	51.8%	91%	8%
6	Status Review	50.0%	91%	8%

Each of the top 6 reviews was compared to the both the group that used the expert system and the control group. The percentage that was closest to the expert percentage was highlighted in bright green. Table 20 shows that all six of the reviews from the group that used the expert system were closer to the percentage from the group that was surveyed from part 1 of the project. The experimental data shows that the expert system helped novice project managers create project plans with both an industry number and type of reviews. For all six recommended reviews, the group that used the expert system had a much higher percentage of recommended reviews in their project plans compared to the group that did not use the expert system. Hypotheses 2A and 2B were substantiated with experimental data.

The final hypothesis involved the novice project manager's confidence in their project plan. It is important for a project manager to be the leader for the project. If a leader lacks confidence in their understanding and ability to perform on the project, it will be seen by other members of the project team and management as well.

- 3 - Novice project managers have higher confidence of success in their projects using an expert system to create their project plans.

Both groups consisted of novice project managers. Of the 22 people that completed the survey, only two people had any experience as a project manager. Three out of the 22 did not answer the question. One person submitted a survey and the file was corrupted and could not be opened. Additionally, only five of the 20 had ever written a project plan. The level of confidence in the project was asked in the survey that accompanied the project plan test. A five point Likert scale was used. Table 21 shows the scale and corresponding numbers. The survey question was "How confident do you feel that the project plan you created will be a major reason that the project will succeed?"

Table 21. Likert Scale Measuring Confidence

Question 2	Likert Scale
Number	Description
1	Very uncertain
2	Uncertain
3	Neither uncertain nor confident
4	Confident
5	Very confident

The group that used the expert system to create their plans scored a 3 and the group that did not use the expert system scored a 2.83. A 3 on the scale corresponds to neither uncertain nor confident in their project plan and a 2 corresponds to confident in their project plan. This meant there was a .17 difference in the confidence scores. Given the small number of participants, there is not a big difference in confidence levels between the groups to make an assertion about the hypothesis. Although there is a difference, there is not enough data to support the hypothesis.

There were several other observations that were made based on the experimental data.

1. Issues related to schedules were attended to with comparable completeness by both subgroups. The novice project managers from both groups created detailed schedules.
2. Issues related to milestone lists were attended to with comparable completeness by both subgroups. Both groups provided detailed milestones in their plans.
3. Issues related to the specification of requirements behind a project were addressed much more completely and accurately by the subgroup that used the expert system. This is significant because, historically, a major cause of project failures in IT projects has been a substandard articulation of exactly what the project requirements are. Of the 11 people who filled out survey forms that used the expert system, seven out of ten dedicated 5%-10% of the total project budget for requirements engineering. Two people dedicated more than 10% of the total project budget to requirements engineering. One person dedicated less than 5%

of the total budget. Only one of the 11 failed to address the level of project resources that would be dedicated to requirements engineering. None of the project plans from the group that did not use the expert system addressed the level of requirements engineering for the project.

4. Issues related to the identification of the skill sets needed, e.g. SMEs, were performed comparably well by both subgroups. This is attributed to the fact that the identification of obvious critical skills is reasonably self evident.
5. The group that did not use the expert system to create their project plan found it harder to create the project plan. The survey question was "How difficult was it to create a project plan for this project? Table 22 shows the Likert Scale measuring the difficulty of creating a project plan. These results substantiate the hypothesis that the use of an expert system assists in the creation of a project plan; it does so by reminding users of the options at their disposal.

Table 22. Likert Scale Measuring the Difficulty of Creating a Project Plan

Question 3	Likert Scale
Number	Description
1	Very difficult
2	Difficult
3	Neither difficult nor easy
4	Easy
5	Very easy

The group that used the expert system scored a 3.6 whereas the group that used the 2.25. This is a difference of 1.35 which is significant even with a small amount of data. The group that used the expert system also found it helpful in creating the project plan. Table 23 shows the Likert scale of how helpful the expert system was for creating a project plan. The question asked for determining the utility of the expert system was ” If you used the project planning assistant, did you find the project planning assistant helpful for creating your project plan?”

Table 23. Likert Scale Measuring Utility of the Expert System

Question 1	Likert Scale
Number	Description
1	Very useless
2	Useless
3	Marginal
4	Helpful
5	Very helpful

Of the ten respondents who used the expert system, all found it either helpful or very helpful with a score was 4.5.

The survey also asked other basic questions about project plans. The first general question attempted to determine how novice project managers felt about project plans. The question was "Do you believe that project plans are useful?' Table 24 shows the Likert Scale for determining the utility of project plans.

Table 24. Likert Scale Showing Usefulness of Project Plans.

Question 4 Number	Likert Scale Description
1	Very useless
2	Useless
3	It depends
4	Helpful
5	Very helpful

Both groups found it useful and the overall score was 4.32.

It is also important to understand best practices that actually occur in industry. There were three questions that attempted to determine the attitude towards project plans in general. A question asked "Do you see the burden associated with creating, reviewing, abiding by, and if necessary modifying a project plan, to be warranted by the net benefit of having had a project plan?" 16 of the 22 respondents answered that creating project plans was appropriate for all projects, two answered only for large projects, and the

remaining four were undecided. Another question asked “Do you believe that project plans' biggest benefit is to the project leaders, or to the staff that work on the project? “ 19 of 22 answered for both project leaders and project staff, three answered for project leaders only. There was also a question on how the work place views project plans. The question was “Does your company encourage or discourage the use of project plans for small IT projects?” 11 out of 22 answered “not applicable”. The other responses ranged from neither “encourages nor discourages” to “highly encourages”. A more specific question was asked: “If you were assigned a small IT project, what is the likelihood that you would create a project plan?” Table 25 shows the Likert Scale used to determine if the novice project manager would create a project plan for a small IT project.

Table 25. Likert Scale for Creating a Project Plan for a Small IT Project

Question 5	Likert Scale
Number	Description
1	Very unlikely
2	Unlikely
3	Neither unlikely nor likely
4	Likely
5	Very likely

The overall score for this question was 4.45. Of the respondents, 21 answered either likely or very likely. Only one out of the 22 answered neither unlikely nor likely.

CHAPTER 7: DISCUSSION

There are three main topics that will be discussed. These are: 1) The industry response to the IT failure rates, 2) The challenges of IT projects, and 3) The potential effects of an IT taxonomy.

(1) In response to the high project failure rates, the IT industry has standardized on the PMBOK and project management certifications for project managers to manage IT projects. However, the PMBOK is a general standard, used for many other PM activities beyond IT. In an industry that exceeds three trillion per year, it seems reasonable to propose a taxonomy that is specific to that industry. IT projects require both PM and SE skills to be successful. Since there are overlapping functions between PM and SE, creating a taxonomy that combines PM and SE functions will facilitate more efficient and more focused use of tools, methods, and financial resources. It will also provide a framework for industry specific training. With the high failure rates of IT projects, a holistic view of managing projects may yield better results than considering PM and SE as separate professions. In 1998, PMI, the organization that produces the PMBOK had about 6800 certified project management professionals (PMPs). (Kauffman, 1998) In the last decade, the number of PMP credential holders has swelled to over 356,000 (PMI, 2009). With the vast increase in PM professionals available, one would expect to see the IT failure rates decrease, yet, the failure rates have stayed consistently high. This suggests that there are areas beyond the PMBOK that are necessary for IT project

success. It also suggests that the current approach to managing IT projects needs improvement.

(2) In order to improve the success rate of IT projects, one must understand what makes IT projects more challenging than other types of projects. All of the problems associated with projects in general also apply to IT projects. These include, but are not limited to, changes in requirements, changes in project personnel, lack of understanding of requirements, underperforming project personnel, lack of senior management support, poor customer communications, etc. Beyond theses, IT projects can be more complex for several reasons. Some of the reasons include:

- IT projects rarely operate by themselves; they are likely to be delivered within or connected to an existing infrastructure.
- The system of systems approach to IT systems means project success can depend on integration with legacy systems and their problems.
- There is a preponderance to change software requirements more than other requirements because it seems easy to rewrite code.
- Software is not a conventional product that one can touch in the same manner as a physical product. Therefore; it is very difficult to identify problems.
- The rate of change is high; software and hardware are constantly changing. Many systems can be simultaneously changing throughout the project (This includes computer languages, operating system versions, as well as applications software versions.)
- IT systems have many states; verifying and validating the system may not be possible or practical until the system is delivered and implemented.

(3) A taxonomy for IT knowledge areas will benefit the industry by incorporating both PM and SE skill sets. By adding SE knowledge to the taxonomy, IT projects will benefit from the knowledge, methods, and tools that could be applied to IT projects. Systems engineering functions directly address many of the issues that cause IT failures and cost and schedule overruns. Most IT systems are designed to operate with other IT systems. This means that one must have a detailed understanding of the existing environment and the planned changes for the environment over the project lifecycle. It is important to know the architecture and design of the infrastructure and understand how the system functions so that the new system can be successfully delivered within the environment. The SE areas of system architecting, system implementation, and technical analysis, are all used to establish the existing baseline. The rate of change of IT systems complicates projects. With the dynamic nature of hardware and software, preparing for and implementing these planned changes require technical analysis of each change. The SE knowledge area of verification and validation provides more substantial guidance on testing and analysis. Verification and validation also distinguish between building the right system and building the system right. These issues can translate into a dynamic and unstable requirements set. Requirements engineering is a well established SE function. Given that problems with requirements are the main sources of IT project failures, SE seems to be a major part of the missing piece to successful IT projects.

Understanding the true causes of failure and how to remedy the failure is extremely difficult for organizations. It requires an honest appraisal of project personnel and company processes. Projects typically fail because of lack of understanding of

requirements and not having the required skill sets and talent to perform the project. However, a common response to project failure in the IT industry has been to train on project management and attain the PMP certification. Yet, this has done nothing to change the failure rates. It is likely that the PMBOK will continue to be the standard for project management for the IT industry. Adding SE knowledge areas to the PMBOK will address more of the root causes of failure and provide methods for understanding requirements and skills sets required for project execution. SE knowledge areas provide a deeper understanding of requirements by decomposing the problem then building up the solution. The trade spaces and the sets of possible solutions can be more clearly analyzed. The hierarchical approach is also very useful in identifying the skill sets needed to perform the tasks.

One might be tempted to argue that a simple typed long list of every conceivable element that might be relevant to a project could be just as effective as an expert system. This is false. The specific issues that have to be addressed in project plans created for different projects differ a lot from one project plan to the next. A one size does not fit all. An all-inclusive very long list that covers every conceivable element for every conceivable project would be impractically long and would alienate the intended users who would probably shun it. Instead, an expert system provides a much more relevant and much shorter such list that is customized to each different project; being relevant and short are attributes that make the use is such a list a desired task.

In summary, the use of an expert system in the creation of a project plan enhances the completeness and effectiveness of a project plan was experimentally confirmed.

CHAPTER 8: CONCLUSION

This dissertation addressed the significant problem of project failures in IT projects. The IT industry exceeds three trillion dollars per year and cannot continue to afford to accept that a significant number of projects will not deliver their agreed to capabilities within cost and schedule. The dissertation focused on small IT projects which represent a large portion of the total number of IT projects. An IT project taxonomy was created that merged PM and SE areas to address the shortfalls of a PM only approach to managing IT projects. The comprehensive PM and SE bodies of knowledge were studied and the documents and reviews were extracted. The documents were assigned to a knowledge area within the taxonomy with a separate category for reviews. A survey was performed to understand the most important documents and reviews for small IT projects. Experimental data was collected from IT professionals and the documents and reviews were rank ordered. A project planning expert system was created that incorporated the survey results and added heuristics from the PM and SE professions into the project planning template. The project planning expert system was tested using a posttest only control group design with novice project managers. The experiment verified that the group that used the expert system produced project plans with greater and more appropriate detail for identifying projects and reviews that would be performed in the project. The data also showed that there was no difference in the level of confidence the project managers had in their project plans. Novice project

managers also found that it was easier to create project plans using an expert system than without the help with an expert system.

In an industry that requires the use of many disciplines to be successful, it is important to include all of the knowledge areas for information and study for working professionals. The current response using the PMI model has not provided any improvement in the failure rates of IT projects. In an industry of this magnitude, creating IT specific knowledge areas that are adopted and used by professionals should be a priority for the industry. With failure rates of IT projects remaining constant, a new approach should be considered.

APPENDIX A: SURVEY

Appendix A is a copy of the survey that was sent to the participants. The survey was done in Adobe Acrobat Pro Extended. The buttons were active and performed the functions that were stated. A definition for each of the documents and reviews was available if needed. The survey was done in accordance with human subject testing rules and was approved by the George Mason University Human Subjects Review Board.

Small IT Project Survey Consent Form

Tailoring Small Projects in the Project Planning Phase

INFORMED CONSENT FORM

RESEARCH PROCEDURES
This research is being conducted to determine the documents and project reviews needed for small IT projects. If you agree to participate, you will be asked to fill out a survey that should take 15 to 30 minutes by selecting one of three possible choices.

RISKS
There are no foreseeable risks for participating in this research.

BENEFITS
There are no benefits to you as a participant other than to further research in the project management and systems engineering of small IT projects.

CONFIDENTIALITY
The data in this study will be confidential. The identifying data will be removed from the opinion data being collected. Only first names and last initials will be requested. The reports and papers generated from this survey will not use any participant's names. While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your transmission.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. Feel free to delete this form if you do not wish to participate.

CONTACT
This research is being conducted by Mike Mulhearn and Dr. Peggy Brouse at George Mason University. Mr. Mulhearn may be reached at (703)406-8999. Dr. Brouse may be reached at (703) 993-1502. For questions or to report a research-related problem. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study. If you do not want to participate, feel free to delete this form. The George Mason University Human Subjects Review Board has waived the requirement for a signature on this consent form. However, if you wish to sign a consent form, please contact Mike Mulhearn at mfmulhearn@verizon.net

○ I agree to participate in the survey

Small IT Project Survey Form

The purpose of this survey is to determine the project management (PM) and systems engineering (SE) functions that should be performed on small IT projects. In this case, a small project is defined as having a cost less than $1.5M and a duration of three to twelve months. (Kerzner, 2009) You will be asked a series of questions in several categories from PM and SE. You will be asked to place PM and SE documents and reviews into one of three categories as they pertain to small projects. The categories are: Fully Perform, Perform in a Limited Manner, and Don't Perform. The goal is to determine the PM and SE documents and reviews that are necessary for small IT projects.

You will also be asked to provide biographical background on your experience in both PM and SE.

Kerzner, Harold, "Project Management, A Systems Approach to Planning, Scheduling, and Monitoring, 9th Edition," John Wiley and Sons, 2009, p. 336.

First Name

Last Initial

Job Title

Years of Work Experience

Years of IT Experience 0

In practice, people often perform multiple roles in their work. For the purposes of this survey, we are attempting to understand the overlap of PM and SE. For the three questions below, please respond with the number of years of experience in integer values. If you have performed as a project manager, please enter the amount of time you performed as a project manager. If you performed as a systems engineer, please enter the amount of time you performed as a systems engineer. If your performed as both a project manager and systems engineer, please enter the amount of overlapping time that you performed in both the roles. Please indicate if you are a member of any PM or SE professional organization. Also, please indicate your domain area (i.e. DoD, Government, telecom, banking, etc.). When you have completed the form, please click the email submit button to submit the form.

Years of PM Experience 0

Years of SE Experience 0

Years of Overlapping PM/SE Experience 0

☐ PMI

☐ INCOSE

☐ IEEE

Domain Area

Please continue to the next page

Reset Form

Warning: Pressing the Reset Form button will remove all of the data from the form.

2

Please select one of the answers to all of the following questions. Based on your experience, we are interested in how you would conduct a small IT project. For each document and review listed below, please select one of the following; Fully Perform, Perform in a limited Manner, or Don't Perform. The definitions for each term are:

Fully Perform - This is necessary for the project and should be performed in great detail
Perform in a Limited Manner - Some of this is helpful for the project and should be performed in a limited manner
Don't Perform - This is not needed for a project of this size and scope

There are thirteen sections to this survey based on PM and SE knowledge areas, and how they overlap. Please answer the questions assuming you will be managing a small IT project that is twelve months in duration and $1,500,000 in scope. Pease answer all the questions. Thank you in advance for your help.

Section 1 - Project Integration Management. This also includes the SE areas of Mission / Purpose Definition and Technical Management / Leadership

Question 1.1 - Should you create a business case?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.2 - Should you create a project charter?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.3 - Should you create a project management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.4 - Should you create performance reports?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.5 - Should you create a tasking document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.6 - Should you create a strategic plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.7 - Should you create a concept specification document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.8 - Should you create a maintenance concept document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.9 - Should you create a concept of operations document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.10 - Should you create a disposal concept document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.11 - Should you create a total cost of ownership plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.12 - Should you create a Systems Engineering Management Plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 1.13 - Should you create a software development plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 2 - Project Scope Management
This also includes the SE categories of Requirements Engineering and Verification and Validation

Question 2.1 - Should you create a requirements document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.2 - Should you create work performance measurements?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.3 - Should you create a requirements management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.4 - Should you create a requirements traceability matrix?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.5 - Should you create a project scope statement?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.6 - Should you create a project scope baseline?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.7 - Should you create a work breakdown structure (WBS)?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.8 - Should you create a WBS dictionary?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.9 - Should you create a scope management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 2.10 - Should you create a testability plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 3 - Project Time Management

Question 3.1 - Should you create an activity list?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 3.2 - Should you create a milestone list?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 3.3 - Should you create a project schedule?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 3.4 - Should you create a project schedule network diagram?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 3.5 - Should you create an activity resource requirements documen?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 3.6 - Should you create a resource breakdown structure?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 4 - Project Cost Management

Question 4.1 - Should you create activity cost estimates?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 4.2 - Should you create a cost performance baseline?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 4.3 - Should you create budget forecasts?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 4.4 - Should you create a cost management plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 4.5 - Should you create earned value management documents?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 5 - Project Quality Management

Question 5.1 - Should you create a quality management plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 5.2 - Should you create quality metrics?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 5.3 - Should you create quality checklists?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 5.4 - Should you create a process improvement plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 6 - Project Human Resource Management

Question 6.1- Should you create a human resource plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 6.2 - Should you create a staffing management plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 6.3 - Should you create a training plan for project personnel?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 7 - Project Communications Management

Question 7.1 - Should you create a communications management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 8 - Project Risk Management

Question 8.1 - Should you create a risk management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 8.2 - Should you create a risk register?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 9 - Project Procurement Management (Scope Management in SE)

Question 9.1 - Should you create a procurement management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.2 - Should you create a procurement statement of work?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.3 - Should you create source selection criteria?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.4 - Should you create a resource calendar?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.5 - Should you create a request for proposal?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.6 - Do you need to create a contract?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 9.7 - Should you create a contractor identified technical information services plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 10 - System Architecting

Question 10.1 - Should you create enterprise policies?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 10.2 - Should you create project procedures?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 10.3 - Should you create a configuration management plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 10.4 - Should you create a data management plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.5 - Should you create a electromagnetic compatibility/interference control plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.6 - Should you create a human factors engineering plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.7 - Should you create an interface control plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.8 - Should you create a supportability plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.9 - Should you create a maintenance plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.10 - Should you create a reliability plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.11 - Should you create a producibility plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.12 - Should you create a system safety plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.13- Should you create a system security plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.14- Should you create a survivability management plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 10.15- Should you create a mass properties control plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 11 - System Implementation

Question 11.1 - Should you create system specifications documents?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 11.2 - Should you create an integrated data package?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 11.3 - Should you create a systems integration plan?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Section 12 - Technical Analysis

Question 12.1 - Should you create a trade-off analysis document?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 12.2 - Should you create a system verification plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 12.3 - Should you create a system validation plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 12.4 - Should you create a test plan?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 12.5 - Should you create test procedures?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Section 13 - Reviews

Question 13.1 - Should you conduct a management review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.2 - Should you conduct a phase-end review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.3 - Should you conduct a disbursement review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.4 - Should you conduct employee performance reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.5 - Should you conduct inspections and product reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.6 - Should you conduct performance reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.7 - Should you conduct quality audits?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.8 - Should you conduct approved change request reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.9 - Should you conduct status reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.10 - Should you conduct documentation reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.11 - Should you conduct an activity cost estimate review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.12 - Should you conduct an activity duration estimate review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.13 - Should you conduct risk reviews?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.14 - Should you conduct procurement performance reviews?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.15 - Should you conduct a procurement audit?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.16- Should you conduct a system definition review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.17- Should you conduct a systems requirements review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.18- Should you conduct a subsystem requirements review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.19 - Should you conduct an alternative system review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.20 - Should you conduct system technical reviews?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.21- Should you conduct a system preliminary design review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.22 - Should you conduct a system detailed design review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.23 - Should you conduct a systems critical design review?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.24 - Should you conduct a functional configuration audit?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.25 - Should you conduct a physical configuration audit?

Fully Perform Perform in a Limited Manner Don't Perform Show Definition

Question 13.26 - Should you conduct a system verification review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.27 - Should you conduct a test readiness review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.28 - Should you conduct a IOT&E (Initial operational test and evaluation) readiness review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.29 - Should you conduct readiness reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.30 - Should you conduct design configuration audits?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.31 - Should you conduct a production approval review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.32 - Should you conduct component reviews?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.33- Should you conduct a system acceptance review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Question 13.34- Should you conduct an operational readiness review?

◯ Fully Perform ◯ Perform in a Limited Manner ◯ Don't Perform Show Definition

Thank you for your participation in this survey. I greatly appreciate the time and effort you put forth to help me with my dissertation and answer these questions. I believe that your insights to these issues are very valuable and will contribute to the growth of the project management and systems engineering knowledge as it applies to IT projects.

Click the print form button if you would like to maintain a copy for your records.

Print Form

Please click the email submit button when you are ready to submit you survey

Submit by Email

10

APPENDIX B: DATA

Appendix B is the data collected from the survey. The data was exported from Adobe Acrobat Pro Extended into Microsoft Excel. The data shows the percentages of documents and reviews in each of the 3 categories.

Document	Mean	Category 1	Percentage in 1	Category 2	Percentage in 2	Category 3	Percentage in 3	Number of respnses
Business Case	1.4643	34	0.607	18	0.321	4	0.071	56
Project Charter	1.8036	21	0.375	25	0.446	10	0.179	56
Project Management Plan	1.3393	38	0.679	17	0.304	1	0.018	56
Performance Reports	1.6071	27	0.482	24	0.429	5	0.089	56
Tasking Documents	1.5893	30	0.536	19	0.339	7	0.125	56
Strategic Plan	2.1786	14	0.250	18	0.321	24	0.429	56
Concept Specification	1.5893	29	0.518	21	0.375	6	0.107	56
Maintenance Concept	1.8393	15	0.268	35	0.625	6	0.107	56
Concept of Operations	1.3036	40	0.714	15	0.268	1	0.018	56
Disposal Concept	2.3750	3	0.054	29	0.518	24	0.429	56
Total Cost of Ownership	1.9286	17	0.304	26	0.464	13	0.232	56
SEMP	1.8214	21	0.375	24	0.429	11	0.196	56
Software Development plan	1.6909	25	0.455	22	0.400	8	0.145	55
Requirements	1.1786	47	0.839	8	0.143	1	0.018	56
Work Performance Measurements	1.9464	17	0.304	25	0.446	14	0.250	56
Requirements Management Plan	1.9286	12	0.214	36	0.643	8	0.143	56
Requirements Traceability Matrix	1.6182	27	0.491	22	0.400	6	0.109	55
Project Scope Statement	1.3929	36	0.643	18	0.321	2	0.036	56
Project Scope Baseline	1.8393	18	0.321	29	0.518	9	0.161	56
WBS	1.4643	36	0.643	14	0.250	6	0.107	56
WBS Dictionary	2.0893	13	0.232	25	0.446	18	0.321	56
Scope Management Plan	2.1429	14	0.250	20	0.357	22	0.393	56
Testability Plan	1.6000	26	0.473	25	0.455	4	0.073	55
Activity List	1.6250	26	0.464	25	0.446	5	0.089	56
Milestone List	1.2500	43	0.768	12	0.214	1	0.018	56
Project Schedule	1.1250	49	0.875	7	0.125	0	0.000	56
Project Schedule Network Diagram	2.0909	14	0.255	22	0.400	19	0.345	55
Activity Resource Requirements	2.0182	14	0.255	26	0.473	15	0.273	55
Resource Breakdown Structure	2.0727	12	0.218	27	0.491	16	0.291	55
Activity Cost Estimates	1.4643	35	0.625	16	0.286	5	0.089	56
Cost Performance Baseline	1.7500	25	0.446	20	0.357	11	0.196	56
Budget Forecasts	1.6250	29	0.518	19	0.339	8	0.143	56
Cost Management Plan	1.8182	22	0.400	21	0.382	12	0.218	55
EVM	2.3750	6	0.107	23	0.411	27	0.482	56
Quality Management Plan	1.9821	18	0.321	21	0.375	17	0.304	56
Quality Metrics	1.9643	17	0.304	24	0.429	15	0.268	56
Quality Checklists	1.9286	16	0.286	28	0.500	12	0.214	56

Document	Mean	Category 1	Percentage in 1	Category 2	Percentage in 2	Category 3	Percentage in 3	Number of respnses
Process Improvement Plan	2.3393	7	0.125	23	0.411	26	0.464	56
Human Resource Plan	2.0179	15	0.268	25	0.446	16	0.286	56
Staffing Management Plan	1.7500	22	0.393	26	0.464	8	0.143	56
Training Plan	2.1964	11	0.196	23	0.411	22	0.393	56
Communications Management Plan	2.1071	15	0.268	20	0.357	21	0.375	56
Risk Management Plan	1.6071	30	0.536	18	0.321	8	0.143	56
Risk Register	2.0893	15	0.268	21	0.375	20	0.357	56
Procurement Management Plan	1.9107	17	0.304	27	0.482	12	0.214	56
SOW	1.8393	26	0.464	13	0.232	17	0.304	56
Source Selection Criteria	1.8036	24	0.429	19	0.339	13	0.232	56
Resource Calendar	2.2143	11	0.196	22	0.393	23	0.411	56
RFP	1.6429	30	0.536	16	0.286	10	0.179	56
Contract	1.5000	37	0.661	10	0.179	9	0.161	56
Services Plan	2.2321	8	0.143	27	0.482	21	0.375	56
Enterprise Ploicies	2.2500	10	0.179	22	0.393	24	0.429	56
Project Procedures	1.9464	16	0.286	27	0.482	13	0.232	56
CM plan	1.6364	26	0.473	23	0.418	6	0.109	55
Data Management Plan	1.6364	25	0.455	25	0.455	5	0.091	55
EMI interface control plan	2.3929	8	0.143	18	0.321	30	0.536	56
Human Factors Engineering Plan	2.4286	5	0.089	22	0.393	29	0.518	56
Interface Control Plan	1.8929	21	0.375	20	0.357	15	0.268	56
Supportability Plan	2.1250	11	0.196	27	0.482	18	0.321	56
Maintenance Plan	1.9074	17	0.315	25	0.463	12	0.222	54
Reliability Plan	2.2679	10	0.179	21	0.375	25	0.446	56
Producability Plan	2.4286	5	0.089	22	0.393	29	0.518	56
System Safety Plan	2.1607	14	0.250	19	0.339	23	0.411	56
System Security Plan	1.4545	34	0.618	17	0.309	4	0.073	55
Survivability Management Plan	2.1964	12	0.214	21	0.375	23	0.411	56
Mass Properties Control Plan	2.6607	2	0.036	15	0.268	39	0.696	56
System Specifications	1.4643	30	0.536	26	0.464	0	0.000	56
Integrated Data Package	2.0536	12	0.214	29	0.518	15	0.268	56
Systems Integration Plan	1.6607	24	0.429	27	0.482	5	0.089	56
Trade-off Analysis Document	2.0893	12	0.214	27	0.482	17	0.304	56
System Verification Plan	1.7143	23	0.411	26	0.464	7	0.125	56

Document	Mean	Category 1	Percentage in 1	Category 2	Percentage in 2	Category 3	Percentage in 3	Number of respnses
System Validaton Plan	1.8182	22	0.400	21	0.382	12	0.218	55
Test Plan	1.3750	36	0.643	19	0.339	1	0.018	56
Test Procedures	1.4286	33	0.589	22	0.393	1	0.018	56
Management Review	1.5714	29	0.518	22	0.393	5	0.089	56
Phase-end Review	1.7818	21	0.382	25	0.455	9	0.164	55
Disbursement Review	2.3091	8	0.145	22	0.400	25	0.455	55
Employee Performance Review	1.9107	25	0.446	11	0.196	20	0.357	56
Inspection and Product Reviews	1.8571	20	0.357	24	0.429	12	0.214	56
Performance Reviews	1.8214	24	0.429	18	0.321	14	0.250	56
Quality Audits	2.0357	13	0.232	28	0.500	15	0.268	56
Approved Change Request	1.7143	25	0.446	22	0.393	9	0.161	56
Status	1.5893	28	0.500	23	0.411	5	0.089	56
Documentation	1.7500	22	0.393	26	0.464	8	0.143	56
Activity Cost Estimate	2.0536	12	0.214	29	0.518	15	0.268	56
Activity Duration Estimate	2.1607	12	0.214	23	0.411	21	0.375	56
Risk Reviews	1.8036	20	0.357	27	0.482	9	0.161	56
Procurement Performance	2.2000	10	0.182	24	0.436	21	0.382	55
Procurement Audit	2.3750	9	0.161	17	0.304	30	0.536	56
System Definition	2.0893	15	0.268	21	0.375	20	0.357	56
Systems Requirements	1.5536	31	0.554	19	0.339	6	0.107	56
Subsystem Requirements	2.1429	15	0.268	18	0.321	23	0.411	56
Alternative System	2.4643	6	0.107	18	0.321	32	0.571	56
System Technical	1.8889	15	0.278	30	0.556	9	0.167	54
System PDR	1.7857	25	0.446	18	0.321	13	0.232	56
System Detailed Design	1.8182	22	0.400	21	0.382	12	0.218	55
Systems CDR	1.5273	33	0.600	15	0.273	7	0.127	55
Functional Configuration	2.1429	11	0.196	26	0.464	19	0.339	56
Physical Configuration	2.2857	11	0.196	18	0.321	27	0.482	56
System Verification	1.7679	25	0.446	19	0.339	12	0.214	56
Test Readiness	1.7679	24	0.429	21	0.375	11	0.196	56
IOT&E Review	1.6964	28	0.500	17	0.304	11	0.196	56
Readiness	1.8182	21	0.382	23	0.418	11	0.200	55
Design Configuration Audits	2.1964	11	0.196	23	0.411	22	0.393	56
Production Approval	2.1964	12	0.214	21	0.375	23	0.411	56
Component	2.3214	6	0.107	26	0.464	24	0.429	56
System Acceptance	1.4821	33	0.589	19	0.339	4	0.071	56
Operational Readiness	1.4821	36	0.643	13	0.232	7	0.125	56

APPENDIX C: SCREEN SHOTS FROM EXPERT SYSTEM

Appendix C is a copy of the screen shots from the expert system. The expert system was coded in File Maker Pro. The test of the expert system was done in accordance with human subject testing rules and was approved by the George Mason University Human Subjects Review Board.

Project Plan Assistant

Informed Consent Form

Tailoring Small IT Projects in the Project Planning Phase

INFORMED CONSENT FORM

RESEARCH PROCEDURES
This research is being conducted to determine if this project planning template can provide a better mechanism for creating project plans for small IT projects. If you agree to participate, you will be asked to fill out a project planning template that should take about 30 minutes to complete four sections. Upon completion, a PDF will be generated with your tailored project plan.

RISKS
There are no foreseeable risks for participating in this research.

BENEFITS
There are no benefits to you as a participant other than to further research in the project management and systems engineering of small IT projects.

CONFIDENTIALITY
The data in this study will be confidential. The identifying data will be removed from the opinion data being collected. Only first names and last initials will be requested. The reports and papers generated from this research will not use any participant's names. While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your transmission.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. Feel free to delete this form if you do not wish to participate.

CONTACT
This research is being conducted by Mike Mulhearn and Dr. Peggy Brouse at George Mason University. Mr. Mulhearn may be reached at (703)406-8999. Dr. Brouse may be reached at (703) 993-1502. For questions or to report a research-related problem. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study. If you do not want to participate, feel free to exit the program. The George Mason University Human Subjects Review Board has waived the requirement for a signature on this consent form. However, if you wish to sign a consent form, please contact Mike Mulhearn at mfmulhearn@verizon.net

I agree to participate in this study [I Agree]

Project Plan Assistant

Purpose of the Template

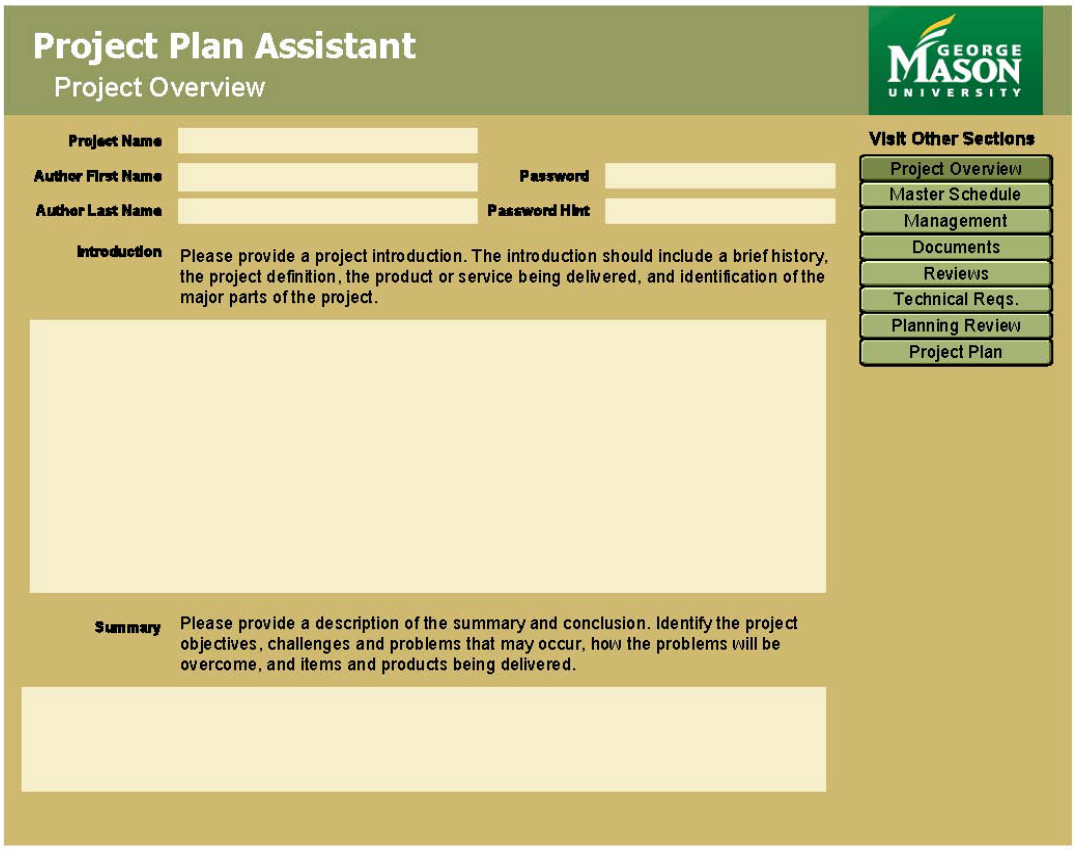
Welcome to the Project Plan Assistant. The purpose of the software is to help project managers plan their small IT projects. Project plans are fundamental to project success. They provide a series of guidelines for the life of the project. They define:

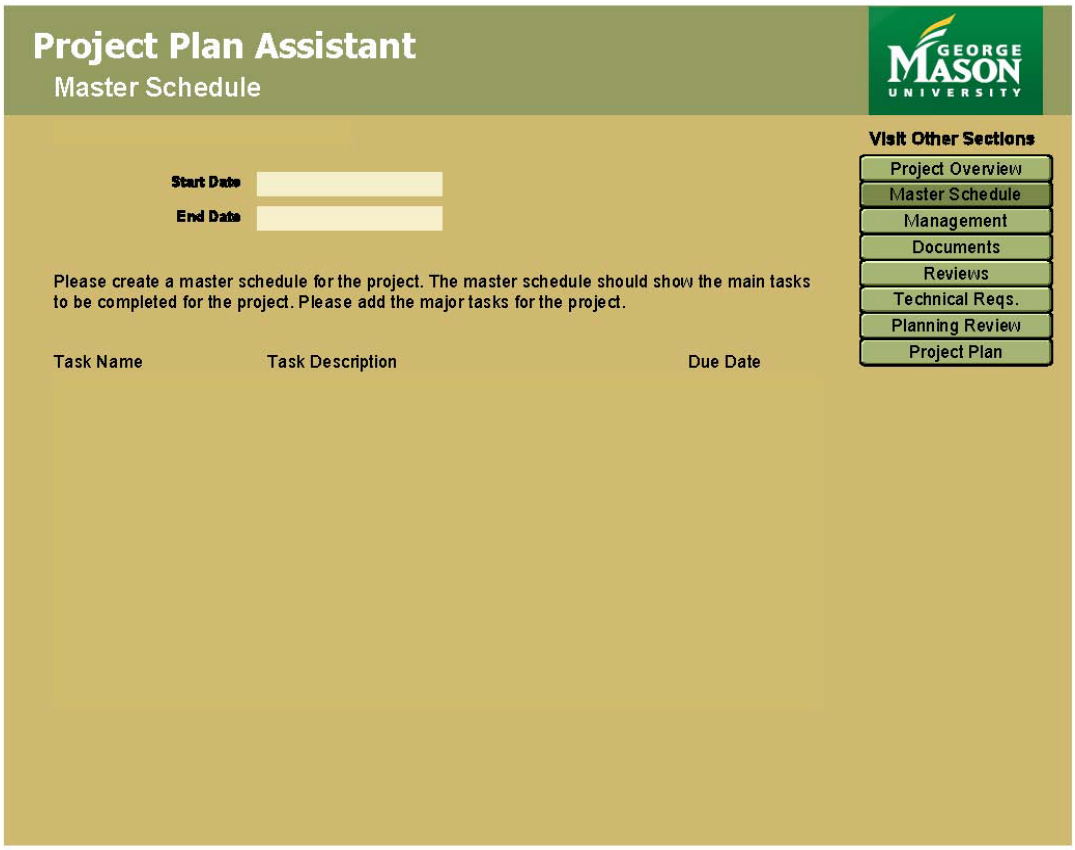
- what will be accomplished
- how the project will be accomplished
- where the project will be accomplished
- why the project will be accomplished
- when the project will be accomplished
- who will work on the project
- and how much the project will cost.

Project plans eliminate uncertainty and prevent things from falling through the cracks. The format that will be used for this plan includes an introduction, summary and conclusions, management, and technical sections. Please add the requested information and answer the questions to generate an project plan that is tailored to your project.

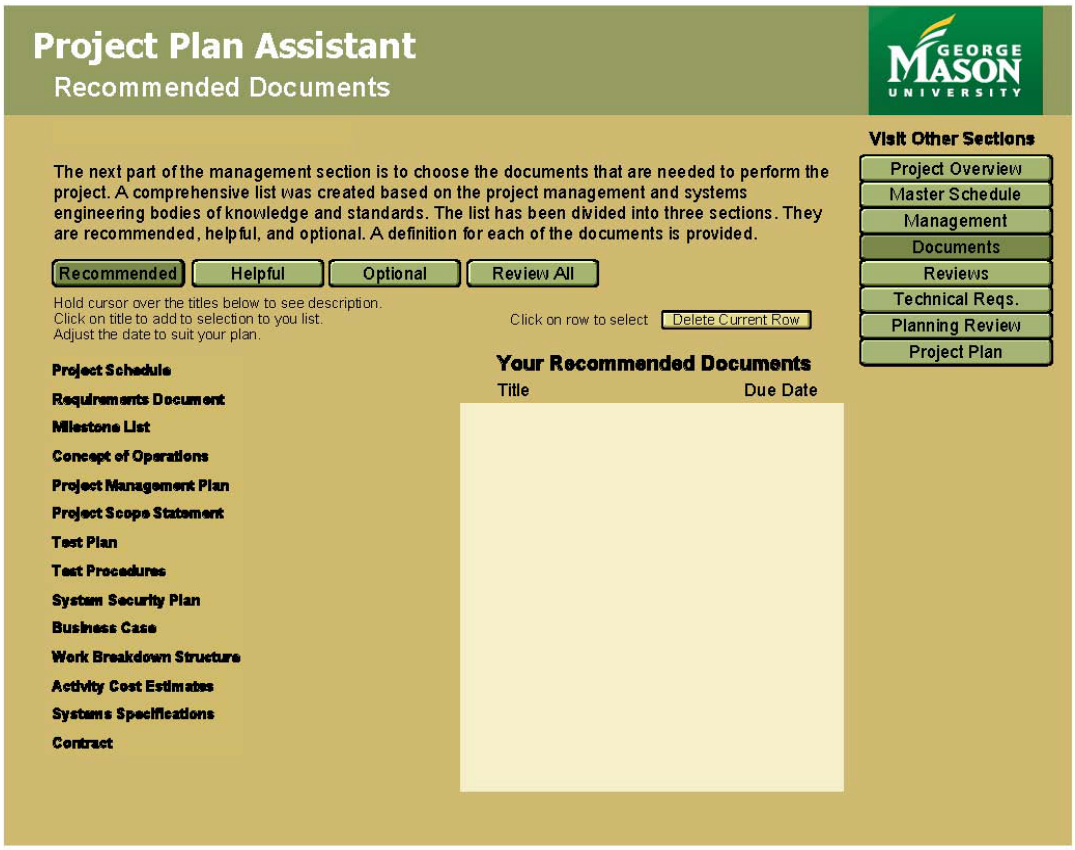
Initiate New Project

Locate Existing Project


Project Plan Assistant
Project Overview
GEORGE MASON UNIVERSITY
Project Name
Author First Name
Author Last Name
Password
Password Hint
Introduction
Please provide a project introduction. The introduction should include a brief history, the project definition, the product or service being delivered, and identification of the major parts of the project.
Summary
Please provide a description of the summary and conclusion. Identify the project objectives, challenges and problems that may occur, how the problems will be overcome, and items and products being delivered.
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan


Project Plan Assistant
Master Schedule
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
Start Date
End Date
Please create a master schedule for the project. The master schedule should show the main tasks to be completed for the project. Please add the major tasks for the project.
Task Name
Task Description
Due Date


Project Plan Assistant
Management
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The first part of the management section is to identify the skills sets that are required to perform the project tasks. Then, select the skill sets that are available for this project. Please select the skill sets that are required and the skill sets that are available. Some personnel may fit into more than one category.
Skill
Availability
Quantity
Notes


Project Plan Assistant
Recommended Documents
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the documents that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the documents is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
Project Schedule
Requirements Document
Milestone List
Concept of Operations
Project Management Plan
Project Scope Statement
Test Plan
Test Procedures
System Security Plan
Business Case
Work Breakdown Structure
Activity Cost Estimates
Systems Specifications
Contract
Your Recommended Documents
Title
Due Date

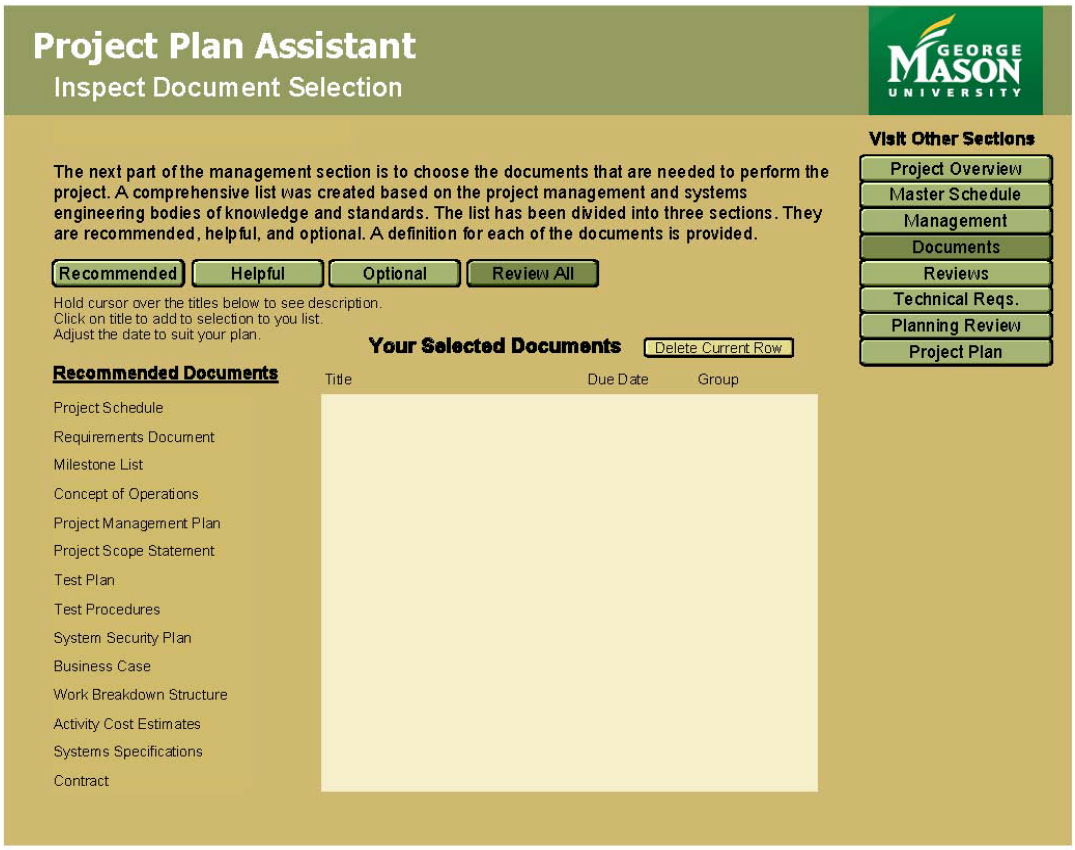

Project Plan Assistant
Helpful Documents
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the documents that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the documents is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
Your Helpful Documents
Title
Due Date
Tasking Documents
Concept Specification
Reqs. Traceability
Testability Plan
Performance Reports
Activity List
Risk Management Plan
Budget Forcasts
CM Plan
Data Mgmt. Plan
RFP
Systems Integration Plan
Software Dvlp. Plan
System Verification Plan
Cost Performance Baseline
System Validation Plan
Maintenance Concept
SEMP
Project Scope Baseline
SOW
Interface Control Plan
Maintenance Plan
Requirements Mgmt.
Quality Checklists
Procurement Mgmt.
Total Cost of Ownership
Work Performance
Project Procedures
Quality Metrics
Quality Mgmt. Plan

Project Plan Assistant

Helpful Documents

- Staffing Mgmt. Plan
- Source Selection Criteria
- Cost Mgmt. Plan
- Project Charter
- Human Resources Plan
- Activity Resources Req.
- Integrated Data Pkg.


Project Plan Assistant
Optional Documents
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the documents that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the documents is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
Your Optional Documents
Title
Due Date
WBS Dictionary
Resource Breakdown
Risk Register
Trade-off Analysis
Project Schd. Network Diag.
Communication Mgmt.
Scope Mgmt. Plan
Supportability Plan
System Safety Plan
Strategic Plan
Training Plan
Survivability Mgmt. Plan
Resource Calendar
Services Plan
Enterprise Policies
Reliability Plan
Process Improvement
Disposal Concept
EVM
EMI Interface Control
Human Factors Engineer.
Producability Plan
Mass Properties Control


Project Plan Assistant
Inspect Document Selection
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the documents that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the documents is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Your Selected Documents
Delete Current Row
Recommended Documents
Title
Due Date
Group
Project Schedule
Requirements Document
Milestone List
Concept of Operations
Project Management Plan
Project Scope Statement
Test Plan
Test Procedures
System Security Plan
Business Case
Work Breakdown Structure
Activity Cost Estimates
Systems Specifications
Contract

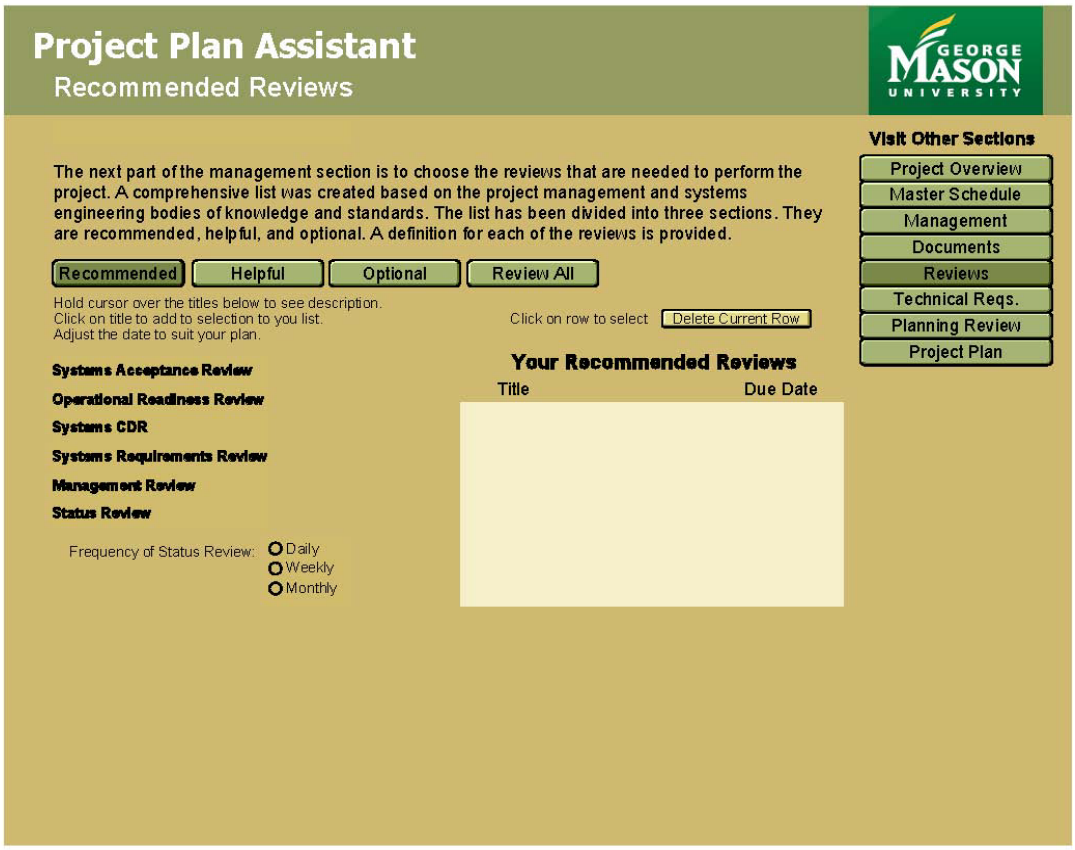

Project Plan Assistant
Inspect Document Selection
GEORGE MASON UNIVERSITY
Contract
Helpful Documents
Tasking Documents
Concept Specification
Reqs. Traceability
Testability Plan
Performance Reports
Activity List
Risk Management Plan
Budget Forcasts
CM Plan
Data Mgmt. Plan
RFP
Systems Integrationn Plan
Software Dvlp. Plan
System Verification Plan
Cost Performance Baseline
Staffing Mgmt. Plan
Source Selection Criteria
Cost Mgmt. Plan
Project Charter
System Validation Plan
Maintenance Concept


Project Plan Assistant
Inspect Document Selection
GEORGE MASON UNIVERSITY
SEMP
Project Scope Baseline
SOW
Interface Control Plan
Maintenance Plan
Reqiurements Mgmt.
Quality Checklists
Procurement Mgmt.
Total Cost of Ownership
Work Performance
Project Procedures
Quality Metrics
Quality Mgmt. Plan
Human Resources Plan
Activity Resources Req.
Integrated Data Pkg.
Optional Documents
WBS Dictionary
Resource Breakdown
Risk Register
Trade-off Analysis
Project Schd. Network Diag.
Communication Mgmt.

Project Plan Assistant

Inspect Document Selection

Scope Mgmt. Plan
Supportability Plan
System Safety Plan
Strategic Plan
Training Plan
Survivability Mgmt. Plan
Resource Calendar
Services Plan
Enterprise Policies
Reliability Plan
Process Improvement
Disposal Concept
EVM
EMI Interface Control
Human Factors Engineer.
Producability Plan
Mass Properties Control


Project Plan Assistant
Recommended Reviews
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the reviews that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the reviews is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
Your Recommended Reviews
Title
Due Date
Systems Acceptance Review
Operational Readiness Review
Systems CDR
Systems Requirements Review
Management Review
Status Review
Frequency of Status Review:
Daily
Weekly
Monthly


Project Plan Assistant
Helpful Reviews
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the reviews that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the reviews is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
IOT&E Review
Approved Change Request Review
Documentation Review
System Verification Review
Test Readiness Review
Phase-End Review
Systems PDR
Readiness Review
Risk Review
System Detailed Design Review
Performance Review
Inspection and Product Review
System Technical Review
Employee Performance Review
Quality Audits
Your Helpful Reviews
Title
Due Date


Project Plan Assistant
Optional Reviews
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the reviews that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the reviews is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Click on row to select
Delete Current Row
Your Optional Reviews
Title
Due Date
Activity Cost Estimate Review
System Definition Review
Subsystems Requirements Review
Functional Configuration Review
Activity Duration Estimate Review
Design Configuration Audits
Production Approval Review
Procurement Performance Review
Physical Configuration Audits
Component Review
Disbursement Review
Procurement Audit
Alternative System Review


Project Plan Assistant
Inspect Review Selection
GEORGE MASON UNIVERSITY
Visit Other Sections
Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan
The next part of the management section is to choose the reviews that are needed to perform the project. A comprehensive list was created based on the project management and systems engineering bodies of knowledge and standards. The list has been divided into three sections. They are recommended, helpful, and optional. A definition for each of the reviews is provided.
Recommended
Helpful
Optional
Review All
Hold cursor over the titles below to see description.
Click on title to add to selection to you list.
Adjust the date to suit your plan.
Your Selected Reviews
Delete Current Row
Title
Due Date
Group
Recommended Reviews
Systems Acceptance Review
Operational Readiness Review
Systems CDR
Systems Requirements Review
Management Review
Status Review
Frequency of Status Review:
Daily
Weekly
Monthly
Helpful Reviews
IOT&E Review
Approved Change Request Review
Documentation Review
System Verification Review


Project Plan Assistant
Inspect Review Selection
GEORGE MASON UNIVERSITY
Test Readiness Review
Phase-End Review
Systems PDR
Readiness Review
Risk Review
System Detailed Design Review
Performance Review
Inspection and Product Review
System Technical Review
Employee Performance Review
Quality Audits
Optional Reviews
Activity Cost Estimate Review
System Definition Review
Subsystems Requirements Review
Functional Configuration Review
Activity Duration Estimate Review
Design Configuration Audits
Production Approval Review
Procurement Performance Review
Physical Configuration Audits
Component Review
Disbursement Review

Project Plan Assistant

Inspect Review Selection

Procurement Audit

Alternative System Review

Project Plan Assistant

Technical Requirements

Visit Other Sections

Project Overview
Master Schedule
Management
Documents
Reviews
Technical Reqs.
Planning Review
Project Plan

This section focuses on requirements. Given that requirements are a major source of project failures, the project manager, systems engineer, and organizational management should understand all aspects of the system and how it will be used.

What is the intent of the system?

- ○ Create a new system/capability
- ○ Lower operating costs

The requirements engineering process is a structured set of activities which are followed to derive, validate, and maintain a systems requirements document. Does your organization have:

- ○ a formal reqirements engineering process?
- ○ an informal requirements engineering process?

Has a requirements document been created?

- ○ Yes
- ○ No

The requirements engineering process is a structured set of activities which are followed to derive, validate, and maintain a systems requirements document. Does your organization have:

- ○ a formal reqirements management process?
- ○ an informal requirements management process?

Please Describe how the changes in requirements will be managed:

Project Plan Assistant

Technical Requirements

The purpose of the project is to deliver:

- ○ Products
- ○ Services
- ○ Both products and services

The cost of requirements engineering depends on the type, size, and complexity of the system. Surveys have shown that for smaller systems that are mostly software, the requiremetns engineering process costs about 10% of the total budget. How much of the project budget has been planned for requirements engineering?

- ○ More than 10% of the total project budget
- ○ Between 5% - 10% of the total project budget
- ○ Less than 5% of the total project budget

The four main activities involved in the requirements engineering process include elicitation, analysis and negotiation, documentation, and validation. Please select the functions that have been performed for this project.

- ☐ Elicitation
- ☐ Analysis and negotiation
- ☐ Documentation
- ☐ Validation

Elicitation: The system requirements are discovered through the consultation with stakeholders. From system documents, domain knowledge, and market studies.

Analysis and negotiation: The requirements are analyzed in great detail and a decision is made on which requirements are accepted. The output is a set of agreed to requirements.

Documentation: The agreed to requirements are documented to an appropriate level of detail.

Validation: The requirements are checked for completeness and consistency. Validated requirements are the basis for system development.

APPENDIX D: STUDY PARTICIPATION PRESENTATION

Appendix D is a copy of the presentation that was given to the class in order to recruit participants for the test. The survey was coded in Microsoft PowerPoint.

Tailoring Small IT Projects in the Project Planning Phase Recruitment for the Study

Mike Mulhearn

GMU PhD student

Agenda

- Overview
- Purpose
- Informed consent
- Tasks
- Questions

Overview

- Most everything in today's economy depends at least in part on information technology (IT)
  - Worldwide spending in IT exceeds $3T per year
  - Far greater number describes the equities that depends on IT
- IT projects continue to suffer from high rates of project failures
  - Some studies show that 70% of IT projects do not deliver their agreed to requirements within cost and schedule constraints
  - Most of the IT project failures are rooted in requirements
- PM certifications have not helped
  - Since 1998, the number of PMP certified professionals has jumped from about 6,800 to over 357,000
  - IT failure rates have remained constant

Purpose

- PhD thesis attempts to address this by creating an expert system or template to help project managers plan small IT projects
- Part 1 – surveyed IT professionals to understand the documents and reviews one should use for small IT projects
- Part 2 – create an expert system to test the template

Informed Consent

- Purpose of the study – determine if a project planning expert system will help PMs create better project plans
- Compensation – students will receive 2 points of extra credit for participation in the study and completion of the survey
- Study methodology – Post Test Only, Control Group Design
  - ½ students will use expert system
  - ½ students will not be able to use expert system
  - All students will have access to the template after the test
  - Students will fill out a short survey upon completion
- Project plan should take less than an hour to complete

"Failing to plan is planning to fail"

Project Plans

- Welcome to the Project Plan Assistant. The purpose of the software is to help project managers plan their small IT projects. Project plans are fundamental to project success. They provide a series of guidelines for the life of the project. They define:
  - what will be accomplished
  - how the project will be accomplished
  - where the project will be accomplished
  - why the project will be accomplished
  - when the project will be accomplished
  - who will work on the project
  - how much the project will cost.
- Project plans eliminate uncertainty and prevent things from falling through the cracks. The format that will be used for this plan includes an introduction, summary and conclusions, management, and technical sections. Please add the requested information and answer the questions to generate an project plan that is tailored to your project

Tasks

- Students will be given a description of a project
- Students will create a project plan for conducting the project
  - ½ the students will use the expert system
  - ½ the students will not use the expert system
  - All students will fill out the survey
- Students will be given 2 weeks to complete the project plan – due date is March 17

Questions?

- Thank you for your participation in this study!
- Questions can be emailed to
  - mmulhear@gmu.edu

APPENDIX E: SURVEY ON PROJECT PLANS

Appendix E is a copy of the survey that attempts to elicit information about the expert system. The survey was coded in Adobe Acrobat Pro Extended.

IT Project Plan Survey Form

The purpose of this survey is to understand the extent to which project plans are useful in the context of small IT projects. In this case, a small project is defined as having a cost between $5K and $1.5M and a duration of three to twelve months. (Kerzner, 2008) You will be asked to provide background on your experience in information technology (IT), project management (PM), and systems engineering (SE). You will also be asked a series of questions on project plans. Please answer as candidly as possible, there are no right or wrong answers.

First Name _____ Last Initial _____

Years of IT Experience _____ Years of PM Experience _____ Years of SE Experience _____

How many project plans have you created? _____

Did you use the project planning assistant to help create your project plan? _____

If you used the project planning assistant, did you find the project planning assistant helpful for creating your project plan?

◯ Very useless ◯ Useless ◯ Marginal ◯ Helpful ◯ Very helpful

How confident do you feel that the project plan you created will be a major reason why the project will succeed?

◯ Very uncertain ◯ Uncertain ◯ Neither uncertain nor confident ◯ Confident ◯ Very confident

How difficult was it to create a project plan for this project?

◯ Very difficult ◯ Difficult ◯ Neither difficult nor easy ◯ Easy ◯ Very easy

Do you believe that project plans are useful?

◯ Very useless ◯ Useless ◯ It depends ◯ Useful ◯ Very useful

If you were assigned a small IT project, what is the likelihood that you would create a project plan?

◯ Very unlikely ◯ Unlikely ◯ Neither unlikely nor likely ◯ Likely ◯ Very likely

Does your company encourage or discourage the use of project plans for small IT projects?

◯ Highly discourages ◯ Discourages ◯ Neither discourages nor encourages ◯ Encourages ◯ Highly encourages

◯ Not Applicable

Do you believe that project plans' biggest benefit is to the project leaders, or to the staff that work on the project?

◯ Project leaders ◯ Staff ◯ Both ◯ Neither

Do you see the burden associated with creating, reviewing, abiding by, and if necessary modifying a project plan, to be warranted by the net benefit of having had a project plan?

◯ Yes for all projects ◯ Yes for large projects only ◯ Undecided ◯ No benefit

Submit by Email

APPENDIX F: SURVEY RESPONSES

Appendix F is the excel spreadsheet of the survey responses.

Survey Data

Years IT exp	Years PM exp	years SE exp	Used Exp Sys	# of project plans
0	0	17	yes	0
8	0.5	8	yes	1
0	0	5	yes	3
1	0	4	yes	2
1	0	2	yes	0
0	0	8	yes	0
0	0	0	yes	0
0	0	1	yes	0
0	0	1	yes	0
0	0	0	yes	0
			yes	
			no	
			no	
3	0	0	no	0
5	0	0	no	0
0	0	0	no	2
0	0	1	no	0
0	0	0	no	0
0	0	1	no	0
			no	
0	0	0	no	0
0	0	0	no	1
5	3	2	no	7

Question 1	Question 2	Question 3	Question 4
5	3	3	4
5	3	3	5
4	4	2	5
5	3	4	5
5	4	5	5
4	2	4	4
4	3	2	4
4	3	4	4
4	2	4	4
5	3	5	5
	3	2	5
	4	3	5
	2	3	5
	2	3	4
	4	2	5
	2	3	5
			1
	4	2	4
	3	4	4
	2	2	2
	4	1	5
	4	2	5
4.5	3	3.6	4.5
	2.8333333	2.25	4.1666667
	0.1666667	1.35	4.3181818

Question 5	Question 6	Question 7	Question 8
3	4	3	3
5	4	3	1
5	4	3	1
5	5	3	1
5	6	1	1
4	6	3	1
5	6	3	2
5	3	3	1
5	6	3	1
5	6	1	1
4	4	3	3
4	5	3	1
5	3	3	3
4	4	3	1
5	6	1	1
4	6	3	1
3	6	3	1
4	6	3	2
4	5	3	1
4	6	3	3
5	6	3	1
5	5	3	1
4.7	5		
4.25			
4.4545455			

APPENDIX G: TEST RESULTS

Appendix G is an excel spreadsheet of the documents and reviews for each of the subgroups from the project plan test. The first set of 10 is documents that were created with the help of the expert system. The next set of 11 documents was created without the help of an expert system. The next set of 10 reviews was created with the help of an expert system. The final set of 11 reviews was created without the help of an expert system.

Group used expert system 1	2	3
Document Name	Document Name	Document Name
Requirements Document	Project Schedule	Project Schedule
Project Scope Statement	Project Management Plan	Milestone List
System Specifications	Concept of Operations	Project Management Plan
SOW	Work Breakdown Structure	Project Scope Statement
Project Schedule	Milestone List	Work Breakdown Structure
Milestone List	Project Scope Statement	Activity Cost Estimates
Project Management Plan	Requirements Document	Requirements Document
Test Plan	Activity Cost Estimates	Concept of Operations
Activity Cost Estimates	System Specifications	Test Plan
Risk Management Plan	Test Plan	Test Procedures
Budget Forecasts	Test Procedures	System Security Plan
WBS Dictionary		System Specifications
Strategic Plan		
Requirements Management Plan		
System Security Plan		
Work Breakdown Structure		
Contract		
Tasking Documents		
Data Management Plan		
Systems Integration Plan		
System Validation Plan		
Quality Metrics		
Project Procedures		
Human Resources Plan		
Activity Resources Requirements		
Quality Checklists		
Communications Management Plan		
Training Plan		
Process Improvement Plan		
Disposal Concept		
Services Plan		

4	5	6
Document Name	Document Name	Document Name
Project Schedule	Project Schedule	Project Schedule
Project Scope Statement	Milestone List	Project Management Plan
Milestone List	Requirements Document	Requirements Document
Requirements Document	Project Management Plan	Concept of Operations
System Specifications	Software Development Plan	System Security Plan
Activity Cost Estimates	Test Plan	
Test Plan	System Verification Plan	
Test Procedures	Quality Management Plan	
	Reliability Plan	
	System Security Plan	
	Training Plan	

7	8	9
Document Name	Document Name	Document Name
Project Schedule	Project Schedule	Milestone List
Activity Cost Estimates	Milestone List	Systems Integration Plan
Requirements Document	Project Scope Statement	Project Schedule
Concept of Operations	Work Breakdown Structure	Requirements Document
Project Management Plan	SOW	Test Plan
Work Breakdown Structure	Project Management Plan	Work Breakdown Structure
Contract	Requirements Document	Activity Cost Estimates
Test Plan	Contract	Training Plan
Test Procedures	Activity Cost Estimates	
	Test Plan	
	Concept of Operations	
	Test Procedures	
	Business Case	
	System Specifications	
	Requirements Traceability Matrix	
	CM Plan	
	Systems Integration Plan	
	Cost Management Plan	
	Requirements Management Plan	
	Procurement Management Plan	
	Total Cost of Ownership	
	Resource Breakdown Structure	
	Trade-off Analysis Document	
	System Validation Plan	
	System Security Plan	

10 10 Continued 11

Document Name	Document Name	Document Name
EVM	CM Plan	Requirements Document
Contract	Requirements Management Plan	Project Management Plan
Business Case	Maintenance Concept	Project Scope Statement
Project Schedule	Concept of Operations	Concept of Operations
Milestone List	System Security Plan	Project Schedule
Project Management Plan	System Specifications	System Security Plan
Work Breakdown Structure	Systems Integration Plan	Project Schedule
Activity Cost Estimates	Quality Metrics	System Security Plan
Project Scope Statement	Enterprise Policies	Activity Cost Estimates
Software Development Plan	Performance Reports	Milestone List
Staffing Management Plan	System Specifications	Activity Cost Estimates
System Validation Plan	Systems Integration Plan	Milestone List
WBS Dictionary	Quality Metrics	Test Plan
Source Selection Criteria	Enterprise Policies	Contract
Procurement Management Plan	Performance Reports	Test Plan
Test Plan		System Specification
Test Procedures		Test Procedures
Testability Plan		
RFP		
Activity List		
Activity Resources Requirements		
Requirements Document		
Requirements Traceability Matrix		
Trade-off Analysis Document		
Concept Specification Document		
CM Plan		
Requirements Management Plan		
Maintenance Concept		
Concept of Operations		
System Security Plan		

Document Name	**Document Name**
Requirements	Operational Requirements Document
Integration Strategy	Acquisition Plan
Scope Management	staffing plan
Time/Schedule Management	system architecture
Cost Management	Integrated Logistics Support Plan
Quality Management	deployment plan
Human Resource Management	Test Plan
Communications Management	Source Selection
Risk Management	schedule
	milestone list

Without Expert System

3	4
Document Name	**Document Name**
WBS	Concept of Operations
WBS dictionary	system requirements document
SOW	schedule
schedule	security risk plan
milestone list	System Test plan
	training plan
	system design and infrastructure specification
	user training materials
	software trade study
	milestone list

Without Expert System

5	6	7
Document Name	**Document Name**	**Document Name**
Project Schedule	schedule	WBS
communications plan	milestone list	schedule
project plan		software procedures
Risk Assessment		hardware procedures
WBS		maintenance procedures
Change Management Procedure		system development report
milestone list		training manual
		training plan
		milestone list
		Final Project Report

Without Expert System

8	9	10
Document Name	**Document Name**	**Document Name**
system standards	Corporate handbook	Schedule
milestone list	Software testing procedures	work breakdown structure
	Software installation procedures	milestone list
	schedule	
	WBS	
	milestone list	

Without Expert System

11	12
Document Name	**Document Name**
project charter	Project Management Plan
project plan	Work Breakout Structure
Timeline	Project Schedule
Implementtation Plan	Communication Plan
configuration plan	Quality Control Plan
test plan	Risk Analysis and Mitigation Plan
test cases	Configuration Management Plan
service level agreements	Project Performance Measurement Plan
services documentation	Requirements List
functions list	System Security Plan
milestone list	PROJECT PERFORMANCE MEASUREMENT PLAN
online survey	

Reviews

With Expert System 2 3

Review Name	Review Name	Review Name
Status Review	Management Review	Systems Acceptance Review
Systems Requirements Review	Status Review	Systems Requirements Review
Systems Acceptance Review	Systems Requirements Review	Status Review
Operational Readiness Review	Systems CDR	Management Review
Systems CDR	Systems Acceptance Review	
Management Review	Operational Readiness Review	

Reviews

4	5	6
Review Name	Review Name	Review Name
Status Review	Approved Change Request Review	Systems Requirements Review
Phase-End Review	Status Review	Status Review
Activity Cost Estimate Review	Systems Requirements Review	Systems Acceptance Review
Status Review	Systems CDR	
Management Review	Management Review	
Systems Acceptance Review	Systems Acceptance Review	
Systems CDR		
Inspection and Product Review		
Quality Audits		

Reviews

7	8	9
Review Name	Review Name	Review Name
Management Review	Management Review	Status Review
Systems Requirements Review	Systems Requirements Review	Systems Requirements Review
Systems Acceptance Review	Management Review	Management Review
Status Review	Employee Performance Review	Inspection and Product Review
Systems CDR	System Verification Review	
	Operational Readiness Review	
	Readiness Review	
	Systems Acceptance Review	

Reviews

10	11
Review Name	Review Name
Systems Acceptance Review	Operational Readiness Review
Systems Requirements Review	Status Review
Management Review	Management Review
Status Review	Systems Requirements Review
System Verification Review	Systems CDR
Activity Cost Estimate Review	
Approved Change Request Review	
Systems CDR	
System Detailed Design Review	
Phase-End Review	
Performance Review	
Operational Readiness Review	

Without Expert System

1	2	3
Review Name	Review Name	Review Name
None specified	None specified	None specified

Without Expert System

4	5	6
Review Name	Review Name	Review Name
System requirements review	status	None specified
Internal team peer review of system design	final presentation	
System Design Review	frequent baseline reviews	
Operational Readiness Review	weekly meetings	

Without Expert System

7	8	9
Review Name	Review Name	Review Name
None specified	None specified	None specified

Without Expert System

10	11	12
Review Name	Review Name	Review Name
None specified	None specified	None specified

APPENDIX H: 2009 INCOSE CONFERENCE PAPER

Appendix H is a paper that was published based on the research done in this dissertation. The paper was published at the INCOSE 2009 Region 5 Spring Conference. The reference for the paper is: Brouse, Peggy, et al, "Project Manager Use of PMBOK and EIA-632 Processes in Engineering a Small System", *INCOSE 2009 Region 5 Spring Conference*, VA, March 2009.

Project Manager Use of PMBOK and EIA-632 Processes in Engineering a Small System

Dr. Peggy Brouse
Associate Professor
MS: 4A6
4400 University Drive
Fairfax, Virginia 22030
pbrouse@gmu.edu

Mr. Michael Mulhearn
PhD Candidate
George Mason University
mmulhear@gmu.edu

Abstract. In the IT arena, natural career advancement is to move from being a team member to the team leader of a small project team. The promotion is far more complicated than it may intuitively seem because an IT team leader typically wears multiple hats: often serving as the project manager, and systems engineer, and technical lead. Team leadership demands new skill sets that require study and training. Professional documents and standards are a helpful resource**.** This paper reviews the PMBOK (Project Management Body of Knowledge) and EIA-632 (Electronic Industries Alliance) Processes for Engineering a System and outlines the functions specified in the project management and systems engineering areas. These functions are further discussed and mapped to show the disconnects and links between the standards of these two disciplines. In the case of the small project team leader, understanding the differences between the PM (Project management) and SE (systems engineering) duties and functions is vital. The team leader needs to clearly express these functions and responsibilities to the rest of the team and management. The PMBOK and EIA-632 may be structured differently, but they have a lot of information in common. Recommendations are made for which of these standards better applies to specific knowledge areas. Although many organizations have decided to augment skill sets with project management training, additional training in systems engineering would greatly benefit organizations in performing IT projects.

Introduction

Congratulations, management has recognized your technical skills and you have just been promoted to be the team leader of a small project. Now you have the opportunity to demonstrate your abilities by leading a team of technical people to solve a small IT project. That's the good news. The bad news is that you now need new skill sets to perform in this new role. What do you do next? The typical response is to send a person off to a week of project management training, provide them with a certificate, and send them on their journey as a new team leader. This is obviously inadequate as evidenced by the large percentage of project failures in the IT sector. The main point of this paper is to help the new team leader grow into their position by delineating those functions necessary for successful project management.

Small projects can be very challenging. To maintain cost control, project personnel often perform multiple roles (Johnson & Brodman, 1998). In the IT sector, the

project leader typically performs the roles of project manager, systems engineer, and technical lead. Growing into this new position can be daunting. PM and SE are professions onto themselves, with separate professional organizations, standards, and certifications. At a high level, both professions are dedicated to successfully delivering products and services within budget and schedule. Making sense between PM and SE standards and literature will help with the maturation process of the team leader.

Literature Review

The PM and SE approach to projects, and their similarities and differences have been discussed in the literature. Several papers were written on this subject in the 1990s. Kauffman discussed where the PM and SE professions overlap and areas that are unique to each profession (Kauffman 1998). His standards-based approach showed how the PM and SE categories were similar, which profession dominated the categories, and those categories that had no overlap. This paper was written when PMI (Project Management Institute) had 6800 professionals. PMI has grown to over 265,000 members (PMI 2008) and both PMBOK (Project Management Body of Knowledge) and EIA-632 (Electronic Industries Alliance) have been updated since the paper was written. Mooz and Forsberg discussed the integration between project management and systems engineering. Their research noted some important issues in this area. "Project managers are not usually trained in systems engineering and systems engineers are not usually trained in project management." PMI and INCOSE (International Council on Systems Engineering) use different vocabulary, operate separately, and members typically don't participate in the other organization. Analysis of the vendor tools also showed that INCOSE focuses on the technical solution while PMI focuses on cost and schedule management (Mooz et al. 1997). INCOSE has weighed in on the differences. They delineate the roles as the project manager is responsible for providing resources (people, funding, space, and infrastructure) for the project while the systems engineer is responsible for applying the resources to effectively meet the customer's needs for the project (INCOSE 2003). The PMBOK ignores the role of systems engineer; as it is referenced only once with a variety of other engineering functions.

Despite the large number of small projects, the topic area rarely appears in the literature. In 1997, Johnson and Brodman discussed the challenges of tailoring CMM to small businesses, small organizations, and small projects. At the time, small businesses were having trouble implementing CMM (Capability Maturity Model) due to the overhead required to implement the processes. Their research showed that documentation overload, layered management, scope of reviews overkill, limited resources, high training costs, and unrelated practices were the primary challenges to adoption (Johnson et al. 1997). They continued their work and described the characteristics of small organizations to include a flat management structure, limited personnel performing many roles, limited dollars for overhead, and LOE (level-of-effort) approach to workload (Johnson et al. 1998). Boehm, Valerdi, and Honour discuss the ROI (return on investment) of systems engineering in software intensive projects. One of the outcomes of their research showed that the ROI for small projects that used more than

15% of systems engineering overhead did not benefit from additional systems engineering effort (Boehm et al. 2007). The implication is that smaller projects may require less overhead for PM and SE.

Definitions

The lexicon and definitions used by the PM and SE professions are different and can be a source of confusion for an inexperienced team leader. There are also multiple definitions for some of the key concepts. Which one is right? The answer is that none of them are wrong. The problem is that the same terms mean different things to different people and organizations. PMI provides definitions in the PMBOK while INCOSE provides a glossary of SE terms with definitions from several sources. For the purposes of this paper, below is a list of terms and definitions. Where multiple definitions exist, only the first definition listed will be used.

Project - PMI Definition – "A project is a temporary endeavor undertaken to create a unique product, service, or result." (PMI 2004)

Project - INCOSE SE Terms Glossary – 2 Definitions – "A defined time- and cost-controlled activity with clearly established objectives and boundary conditions executed to gain knowledge, create a capability, or provide a service. (NASA MDP92)" (INCOSE 1998)

Project Management - PMI Definition – "Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements." (PMI 2004)

Project Management – INCOSE SE Terms Glossary – "The planning, organizing, directing, and controlling of company resources to meet specific goals and objectives within time, within cost and at the desired performance level. (Bahill/Sandia)" (INCOSE 1998)

Systems Engineering – PMI Definition – Systems engineering is not defined by the PMBOK.

Systems Engineering - INCOSE SE Terms Glossary – 26 Definitions – "An interdisciplinary approach to evolve and verify an integrated and life-cycle balanced set of system product and process solutions that satisfy customer needs. (MIL-STD-499B-UNAPPROVED)" (INCOSE 1998)

Small projects have not been defined by any of the professional organizations so this adds to the confusion. Definitions that have appeared in the literature include: a small project has 3-5 people and is under 6 months in duration (Paulk, 1998), under 24 person months and 6 month duration (Srivastave et al. 2006), and under 20 software developers (Johnson et al. 1998). It would be impossible to achieve agreement on the definition of a small project with hard limits. The main points are that small projects are short in duration, have a limited number of personnel resources, limited skill sets, limited overhead, and management and technical roles are combined (Johnson et al. 1998).

Standards

The purpose and structure of the standards are different. "The purpose of the PMBOK is to identify that subset of the Project Management Body of Knowledge that is generally recognized as good practice (PMI 2004)." EIA-632 approaches the problem by emphasizing the work required to build a system. "This Standard is intended to enable an enterprise to strengthen its competitiveness in global markets by engineering and producing quality systems, and by delivering its products on time at an affordable price or cost. The focus, therefore, is on conceptualizing, creating, and realizing a system and the products that make up a system (ANSI/EIA 1999)." EIA-632 may be structurally tailored more appropriately in an IT development environment. Therefore, this will be used as the baseline standard for comparison.

In the case of the small project team, it is critical to have a common understanding of the PM and SE functions that need to be performed. The PMBOK and EIA-632 may be structured differently, but they have a lot of information in common. There are also one-to-many, and many-to-many mappings. Although there is overlap, the functionality is different, and there are functions from both standards that are not addressed in the other. Depending on the subject area, each standard has its strengths. Using EIA-632 as the baseline, the PMBOK will be compared to show the common areas. Note that an "X" means there is at least a partial overlap. The standards-based comparison introduced by Kauffman in 1998 will be extended by comparing the standards at a finer level of detail.

Acquisition and Supply

EIA-632 Process Areas	Project Procurement Management	Plan Purchases and Acquisitions	Plan Contracting	Request Seller Responses	Select Sellers	Contract Administration	Contract Closure
Supply Process Requirements							
Product Supply		X	X	X	X	X	X
Acquisition Process Requirements							
Product Acquisition		X	X	X	X	X	X
Supplier Performance		X	X	X	X	X	X

Figure 1.
Acquisition and Supply Overlap

Contracts are a critical part of the business and are addressed by both standards. Figure 1 shows the overlap. Both standards address the need to enter into a written agreement and manage the supplier. The goals of both standards are to create a contract, manage the contract, and deliver the required product or service. The supply process requirements and acquisition process requirements overlap with project procurement management. The PMBOK has a more detailed description of the steps necessary to perform acquisitions and contracts.

Technical Management

EIA-632 Process Areas	Project Integration Management	Develop Project Charter	Develop Preliminary Project Scope Statement	Develop Project Management Plan	Direct and Manage Project Execution	Monitor and Control Project Work	Integrated Change Control	Close Project	Project Scope Management	Scope Planning	Scope Definition	Create WBS	Scope Verification	Scope Control	Project Team Management	Activity Definition	Activity Sequencing	Activity Resource Estimating	Activity Duration Estimating	Schedule Development	Schedule Control
Planning Process Requirements																					
Process Implementation Strategy		X		X						X	X										
Technical Effort Definition			X	X						X	X	X				X					
Schedule and Organization												X					X	X	X	X	X
Technical Plans																					
Work Directives					X											X	X	X	X	X	X
Assessment Process Requirements																					
Progress Against Plans and Schedules					X	X	X							X							X
Progress Against Requirements					X	X	X														
Technical Reviews					X	X	X							X							X
Control Process Requirements																					
Outcomes Management					X	X	X						X								
Information Dissemination						X	X														

Figure 2.
Technical Management Processes

The EIA-632 technical management processes consist of planning, assessment, and control processes. This is the most difficult section of the standard as it relates to the PMBOK. The standards are fundamentally structured differently and there are many-to-many mappings. However, the planning processes are similar in intent. The common goals are to ensure there is a need for a project, create technical plans, generate a work breakdown structure, estimate costs, and develop a schedule for the project. Figures 2 and 3 show the comparisons. Note that two figures were used due to the size of the figure. The one-to-many and many-to-one relationships are confusing. EIA-632 outlines the plans, reviews, and work to be done for planning, assessing, and controlling the project. While, the PMBOK provides a step-by-step approach detailing the inputs, tools

and techniques, and the outputs, the new team leader can follow either technical management approach and be successful.

EIA-632 Process Areas	Project Cost Management	Cost Estimating	Cost Budgeting	Cost Control	Project Quality Management	Quality Planning	Perform Quality Assurance	Perform Quality Control	Project Communication Management	Communications Planning	Information Distribution	Performance Reporting	Manage Stakeholders	Project Risk Management	Risk Management Planning	Risk Identification	Qualitative Risk Analysis	Quantitative Risk Analysis	Risk Response Planning	Risk Monitoring and Control
Planning Process Requirements																				
Process Implementation Strategy																				
Technical Effort Definition															X					
Schedule and Organization						X														
Technical Plans															X	X	X	X	X	X
Work Directives		X	X			X				X										
Assessment Process Requirements																				
Progress Against Plans and Schedules				X																
Progress Against Requirements																				X
Technical Reviews				X			X	X												X
Control Process Requirements																				
Outcomes Management													X			X	X	X	X	X
Information Dissemination											X	X	X							X

Figure 3.
Technical Management Processes

System Design

The system design process areas focus on the requirements definition processes and the solution definition processes. These processes convert requirements into products or services that meet customer needs. EIA-632 provides a detailed description of the requirements engineering processes and the methods that can be employed to reach a set of verified and validated requirements. The solution definition processes provide a list of systems engineering functions that can be performed to analyze and model the proposed design. The PMBOK covers similar material at a very high level in the scope planning and scope definition section. Project quality management also influences the system design by setting standards for the processes and deliverables. See Figure 4. The requirements engineering processes and the solution definition processes are primary systems engineering functions. The details of how to translate requirements into a solution are not covered in the PMBOK. Methods to ensure critical project success: methods to elicit, analyze, document, and validate requirements, and methods to analyze, model, and simulate solutions, are not part of the PMBOK. The high level description of what to do is not very helpful to create a solution. The new team leader should look to EIA-632 for help in requirements engineering and solution definition.

Product Realization

The product realization process areas are responsible for converting the requirements and design into a product or service, delivery, installation, and maintenance services. Figure 5 shows the common areas.

EIA-632 Process Areas	Project Scope Management	Scope Planning	Scope Definition	Create WBS	Scope Verification	Scope Control	Project Quality Management	Quality Planning	Perform Quality Assurance	Perform Quality Control
Requirements Definition Process Requirements										
Acquirer Requirements		X	X					X	X	X
Other Stakeholder Requirements		X	X					X	X	X
System Technical Requirements		X	X					X	X	X
Solution Definition Process Requirements										
Logical Solution Representation			X					X	X	X
Physical Solution Representation			X					X	X	X
Specified Requirements			X					X	X	X

Figure 4.
System Design Process Areas

Both standards address the processes that are involved in translating operational requirements into a product or service. The project quality management section of the PMBOK provides a description of how to drive quality into products and services. The main difference is that EIA-632 addresses the processes up to delivery as well as the final inspection. The PMBOK only covers inspection of the final delivery. The systems engineering functions of modeling and simulation to create evidence that requirements are met provide better guidance for the new team leader. The processes described in EIA-632 can find problems in the project in earlier stages of the development. This allows the team leader more time and resources to make changes to the system design.

EIA-632 Process Areas	Project Integration Management	Develop Project Charter	Develop Preliminary Project Scope Statement	Develop Project Management Plan	Direct and Manage Project Execution	Monitor and Control Project Work	Integrated Change Control	Close Project	Project Scope Management	Scope Planning	Scope Definition	Create WBS	Scope Verification	Scope Control	Project Quality Management	Quality Planning	Perform Quality Assurance	Perform Quality Control
Implementation Process Requirements																		
Implementation													X	X		X	X	X
Transition to Use Process Requirements																		
Transition to Use								X					X	X		X	X	X

Figure 5.
Product Realization Process Areas

Technical Evaluation

EIA-632 Process Areas	Project Scope Management	Scope Planning	Scope Definition	Create WBS	Scope Verification	Scope Control	Project Quality Management	Quality Planning	Perform Quality Assurance	Perform Quality Control	Project Risk Management	Risk Management Planning	Risk Identification	Qualitative Risk Analysis	Quantitative Risk Analysis	Risk Response Planning	Risk Monitoring and Control
System Analysis Process Requirements																	
Effectiveness Analysis					X				X	X							
Tradeoff Analysis									X	X							
Risk Analysis													X	X	X	X	X
Requirements Validation Process Requirements																	
Requirement Statement Validation			X						X	X							
Acquirer Requirements Validation			X						X	X							
Other Stakeholder Requirements Validation			X						X	X							
System Technical Requirements Validation			X						X	X							
Logical Solution Representation Validation			X						X	X							
System Verification Process Requirements																	
Design Solution Verification					X				X	X							
End Product Verification					X				X	X							
Enabling Product Readiness					X				X	X							
End Products Validation Process Requirements																	
End Products Validation									X	X							

Figure 6.

Technical Evaluation Process Areas

The technical evaluation process areas provide in-depth analytical methods to support data-driven decision making. Systems analysis, requirements validation, system verification, and end products validation compose the technical evaluation process area. See Figure 6. These processes address the questions of building the system right and building the right system. EIA-632 stresses the details and presents a comprehensive list of the functions that need to be considered by the team leader to ensure that everything is considered to ensure that the project will be a success. The methods described can be very technical in nature and are not found in management documents. However, a combination of the technical evaluation from EIA-632 and the quality processes from the PMBOK provide a solid foundation for converting requirements into a product or service that is acceptable to the customer.

Human Resource Management

Project human resource management is a knowledge area the PMBOK covers that EIA-632 does not address. Human resource management involves planning, acquiring the project team, developing the project team, and managing the project team. Personnel issues are a traditional project management function and can be the most difficult responsibility or leadership function for a person who is making their first venture into management. The new team leader should seek additional sources of information and training to develop better human resource skills.

Summary of Functional Areas

It can be difficult for the new project manager to make sense out of all of the information that is available. Reading through linear feet of documentation and being able to make decisions on how to proceed is a difficult proposition. A summary of the functional areas with recommendations about where to begin is presented.

Functional Areas	EIA-632	PMBOK
Acquisition and Supply	X	X
Technical Management	X	X
System Design	X	
Product Realization	X	
Technical Evaluation	X	X
Human Resource Management		X

Figure 7.
Summary of Functional Areas

Discussion

The importance of this topic is underscored by the staggering amount invested in IT. Gartner reports that worldwide IT spending will surpass $3.4Trillion in 2008. ([Petty 2008) IT projects are also very risky. The Standish Group reports that in 2004, 71% of

IT projects did not deliver within the estimated cost and schedule. They also report average cost overruns of 54% over the project estimate and average schedule delays were 84% of the plan (Hartmann 2006). This is a significant failure rate which translates into billions of dollars of lost revenue and lost opportunity. In many areas of the IT sector, the response to the high failure rate has been to standardize on the PMBOK and project management certifications. While this is helpful, it does not provide the team leader with sufficient skills to be successful. In a survey of why IT projects fail, nine out of the ten reasons were requirements based. (Fretty 2006) This suggests that the PMBOK does not adequately handle the area of requirements engineering. The recommendations in EIA-632 provide a useful framework for working through the requirements engineering solution definition processes.

Systems engineering functions and methods are a necessary part of every IT project. IT systems rarely operate by themselves. They are typically part of a system of systems solution where they perform local and global functions. The interaction of a new capability with an existing complex system requires detailed systems analysis, solution verification and validation, and regression testing to ensure compatibility of the new capability. The methods to perform these highly technical functions are not outlined in the PMBOK so it is not reasonable to expect the new team leader will know to use these concepts with only the PMBOK as the knowledge base.

For the new project manager, success can be elusive. Moving into a new position requires the person to immediately acquire PM and SE skills. Although there is overlap between PM and SE functions, the emphasis of each approach is different so the team leader needs to understand both PM and SE tools and methods. The areas that are common between each standard do not completely overlap. When each of the process and knowledge areas is decomposed, there are unique methods and functions in each category. Even with training in both PM and SE, the new project manager will be challenged to decide those areas that are most pertinent to the project at hand. Initially, it is critical to spend time to understand the purpose of the project, to ensure that the requirements address the project, and to carefully select the process or knowledge areas from the standards that apply is critical. Apprentice's law states that it takes 5000 hours to turn a novice into an expert. (Endres et al. 2003) This suggests that it would take as many as 10,000 hours to master the domains of PM and SE. 10,000 hours translates to about five years of full-time effort. Since the person is performing these duties on a part-time basis, the time required to master these areas will likely be much longer.

Conclusion

Moving from a strictly technical position to one that is a combination of a management and technical position can be daunting. This challenge includes the lack of a clear lexicon, competing standards and certifications, as well as unreasonable expectations of management who too often expect new team leaders to be immediately successful in an industry with less than a 30% success rate. In the IT arena, one needs to acquire both PM and SE skills and the have the time to understand how to use these skills

to successfully deliver small projects on time and within budget. It is challenging for anyone to quickly learn two new fields of study. This paper has shown that a number of PM and SE functions overlap to some degree while others remain unique. We have summarized a large body of knowledge and provided a guide for the new team leader to navigate the abundant and confusing information. We have also provided a roadmap for successful understanding and use of these complimentary standards.

References

ANSI/EIA, "ANSI/EIA-632-1988 Processes for Engineering a System," 1999.

Boehm, Barry, Valerdi, Ricardo, Honour, Eric, "The ROI of Systems Engineering: Some Quantitative Results for Software-Intensive Systems," *InterScience*, 2007.

Endres, Albert, Rombach, Dieter, "The Handbook of Software and Systems Engineering," Pearson Education Limited, 2003, p.229.

Fretty, Peter, "Why Do IT Projects Really Fail?" PM Network, March 2006, p. 44-48.

Hartmann, Deborah, "Interview with Jim Johnson of the Standish Group," www.infoq.com, August 25, 2006.

INCOSE, "INCOSE SE Terms Glossary," October 1998.

INCOSE, "Relation to Project Management," *INCOSE G2SEBOK*, www.incose.org, Sept. 1, 2003.

Johnson, Donna, Brodman, Judith, "Applying CMM to Small Businesses, Small Organizations, and Small Projects," *Software Process Newsletter*, No. 8 Winter 1997, p.1-5.

Johnson, Donna, Brodman, Judith, "Applying CMM to Small Organizations and Small Projects," *SEPG '98*, Chicago, IL, March 9-12, 1998, p. 8.

Kauffman, Donald, "Project Management and Systems Engineering: Where the Professions Intersect - Generate Synergy Not Conflict," *Proceedings of the Eighth Annual INCOSE International Symposium*, 1998.

Mooz, Harold, Forsberg, Kevin, "Visualizing Systems Engineering and Project Management as an Integrated Process," *INCOSE*, 1997.

Paulk, Mark, "Using the Software CMM in Small Organizations," *Software Engineering Institute*, Carnegie Mellon University, 1998, p.4.

Petty, Christy, "Gartner Says Worldwide IT Spending On Pace to Surpass $3.4Trillion in 2008," www.gartner.com, August 18, 2008.

PMI, "A Guide to the Project Management Body of Knowledge," 2004.
www.pmi.org, Oct. 5, 2008.

Srivastave, Nidhi, Murthy, Sathya, "Small Steps, Giant Leap," *CMU/SEI-2006-SR-001*, 2006, p.236-238.

About the Authors

Dr. Peggy Brouse Associate Professor, Systems Engineering and Operations Research department at George Mason University. Dr. Brouse is involved in several research areas including requirements engineering, cost modeling, and process improvement. Research clients include DoT, VDoT, DoE, VDRPT, and Motorola. Before GMU, she worked at the MITRE Corporation where she managed and

participated as a systems engineer on several projects concerned with requirements analysis, conversion, testing and quality evaluation for NIST, USDA, USGS, DoL, and DoD (Navy, Army).. The area of her current research encompasses process improvement, knowledge engineering, decision support and requirements elicitation.

Mr. Michael Mulhearn PhD candidate at George Mason University in Fairfax, VA. Mr. Mulhearn earned a BSEE in 1987 from WPI in Worcester, MA. He also earned an MSEE in 1995 and an MSSE in 2002 from George Mason University.

APPENDIX I: 2011 INCOSE CONFERENCE PAPER

Appendix I is a paper that will be published based on the research done in this dissertation. The paper has been accepted and will be published and presented at the 21st Annual INCOSE International Symposium, Denver, CO June 20-23.

Identifying the Most Critical Documents and Reviews for Small Information Technology Projects

Michael Mulhearn
George Mason University
4400 University Drive4400
Fairfax, Virginia 22030
mmulhear@gmu.edu

Dr. Peggy Brouse
George Mason University
University Drive
Fairfax, Virginia 22030
pbrouse@gmu.edu

ABSTRACT

Managing Information Technology projects has historically been a very difficult endeavor. For the project manager, there are many project management (PM), systems engineering (SE), and information technology (IT) standards, bodies of knowledge, process models, and management models to use to help manage a project. The wealth of information makes it difficult for project managers and systems engineers of small IT projects to filter through the information and determine the specific documents and reviews that are the most useful to effectively and efficiently manage the project. The goal of this research is to identify the documents and reviews that are most helpful for managing small IT projects.

Background

IT has expanded into every aspect of our lives. All sectors of the modern economy have been steadily migrating towards an increased reliance on IT. Global spending in IT has exceeded three trillion dollars for several years. (Reuters, 2009) A far larger figure describes the financial equities that depend on IT for success. Project managers and systems engineers have participated in the development and delivery of IT systems from the outset. Each of these professions has brought their methods, tools, and standards to manage projects. These standards define and describe the documents and reviews that a project manager and systems engineer could use to manage a project. In the case of small IT projects, the project leader has to be more selective in their choice of documents and reviews in order to stay within budget constraints. The bodies of knowledge, standards, and process models while comprehensive, do not provide guidance on how to tailor the project. The purpose of this research is to help the project manager and systems engineer make decisions on those documents and reviews they should plan for in the project planning phase of a small IT project. For the purposes of this research, a small project is a small project is defined as one having a duration from three to twelve months and a dollar value from $5,000 to $1.5M. (Kerzner, 2009) A recent survey showed that about half of IT projects fit into this category. About half the projects had a duration of less than nine months and had fewer than ten developers. (El Emam, 2008)

Management of IT projects has been traditionally divided into two partially overlapping functions: PM and SE. See Figure 1. PM is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements." (PMBOK, 2009) SE is defined as "an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs." (SE Handbook, 2007) Project managers typically focus on cost and schedule management while systems engineers focus on all phases of the technical solution. (Mooz, 1996) Determining the documents and reviews to provide the proper insight while controlling project costs has proven to be very difficult for the IT industry.

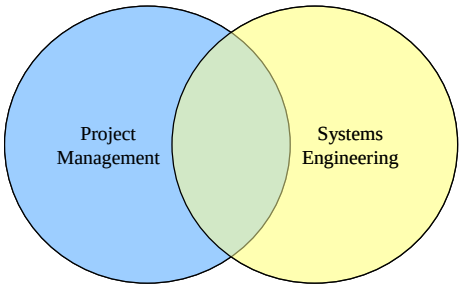


Figure 1. Project Management and Systems Engineering Overlap

Small IT projects are challenging because they may have limited infrastructure resources, limited skill sets, project personnel performing multiple roles, and management and technical roles combined. (Johnson, 1998) For the project manager with additional roles of systems engineer and technical lead, the lanes of responsibility between PM and SE disappear. The project lead is the single person responsible for delivering the project that meets customer needs within cost and schedule.

Literature Review

The Project Management Body of Knowledge (PMBOK) has become the defacto standard for managing IT projects. Project Management Institute boasts a membership of 308,102 people in over 170 countries. (PMI, 2009) Project managers with PM certifications are sought by the IT industry to manage projects. The fourth edition of the PMBOK defines nine knowledge areas required for project management. See figure 2. Aramo-Immonen proposed an ontology in the context of mega-projects and learning during project execution. (Aramo-Immonen, 2009) Cheah and Chang also proposed an ontology for multi-site project management ontology system development methodology.

(Cheah, 2005) Although these are reasonable alternatives, the PMBOK continues to be the standard for project management.

Project Management Knowledge Areas	Definitions
Project Integration Management	Processes and activities needed to identify, define, combine, unify and coordinate project management activities
Project Scope Management	Processes required to ensure the project includes all, and only the work required, to successfully complete the project
Project Time Management	Processes required to manage timely completion of the project
Project Cost Management	Processes involved in estimating, budgeting, and controlling costs so the project can be completed within budget
Project Quality Management	Processes and activities that determine the quality policies, objectives, and responsibilities to satisfy project needs
Project Human Resource Management	Processes that organize, manage, and lead the project team
Project Communications Management	Processes required to ensure timely generation, collection, storage, retrieval, and disposition of project information
Project Risk Management	Processes of risk management, planning, identification, analysis, response planning and monitoring and control
Project Procurement Management	Processes necessary to purchase or acquire products, services, or results needed from outside the project team

Figure 2. PM Knowledge Areas (PMI, 2008)

The SE profession has several standards that have been published and are currently used by practitioners. These standards include: ANSI/EIA-632, IEE1220, ISO-15288, MIL-STD-499C, the Software Engineering Institute's Capability Maturity Model Integration (CMMI), and the Systems Engineering Handbook from INCOSE (International Conference on Systems Engineering). These standards have similar areas, but also have areas of omission and areas that conflict. Honour and Valerdi coordinated and combined these standards into a single ontology that provides general agreement across eight systems engineering areas (Honour et al., 2006). The eight areas defined by Honour and Valerdi are shown in Figure 3 and are mission/purpose definition, requirements engineering, system architecting, system implementation, technical analysis, technical management / leadership, scope management, and verification and validation. While Honour and Valerdi's work is excellent, others have derived and published alternative combinations of ontologies, all of which are acknowledged and were carefully studied as part of the research behind the present paper. (Madni, 2007) (Sarder, 2007)

The IT industry has a framework for "best practices." The Information Technology Infrastructure Library (ITIL) was developed in the 1980s by the United Kingdom's Office of Government Commerce. It is a set of guidelines for organizing the

end-to-end delivery and service management of IT systems. Although it has been around for a long time, it has not achieved widespread adoption by the IT industry.

There are differences among the earlier mentioned SE standards, and SE practitioners have used these standards to successfully deliver projects. The benefit of a single SE ontology is a common understanding of the terminology and the scope of systems engineering. Conflicting standards and widely varying industry implementations of SE make it difficult for both experienced professionals and for those entering the field to make sense of the information and apply it to their project needs. Confusion and lack of clarity increase failure rates and project costs.

SE Knowledge Areas	Definitions
Mission / Purpose Definition	Defines the mission and purpose of the new or changed system
Requirements Engineering	Creation and management of requirements, formal technical statements that define capabilities, characteristics, and quality
System Architecting	Design aspect of systems engineering that defines the system in terms of its component elements and their relationships
System Implementation	Responsible for the technical development of the system, including delivery and installation of the prototype version
Technical Analysis	Responsible for system-level technical analysis, particularly Assessing system performance against requirements
Technical Management / Leadership	Technical management and leadership of the project
Scope Management	Technical definition and management of acquisition and supply issues
Verification and Validation	Comparison of the system with the requirements and the intended use of the system

Figure 3. SE Knowledge Areas (Honour et al., 2006)

IT Project Ontology

There are many ways an IT project ontology could be constructed. The PMBOK was selected as the baseline for PM and the ontology created by Honour and Valerdi was selected as the baseline for SE. The PMBOK was selected given that it continues to be the standard for project management knowledge and it is the basis of the PMP certification. The choice for the SE baseline was more difficult. There are several viable options. The ontology created by Honour and Valerdi was selected because it focuses on knowledge areas rather than process areas. In order to maintain consistency, a knowledge area model for SE was the better choice. Since PM and SE share common areas, the PM and SE knowledge areas can be partially combined. In order to be useful, the combination of knowledge areas must be recognizable and acceptable to both PM and

SE professionals. The overriding consideration was to maintain the PMBOK knowledge areas given that it is the largest accepted standard currently being used by IT professionals. There were three areas that emerged; those areas with a PM emphasis, those areas that have a significant amount of knowledge from both PM and SE, and those areas with an SE emphasis. In cases where the information was almost identical and covered by the PMBOK, the knowledge area was assigned to the project management knowledge area.

Project Management Knowledge Areas

The difficulty of combining separate ontologies is highlighted here since there may be many-to-one or many-to-many mappings between PM and SE. In these cases, a decision was made on the SE knowledge area that best fit the PM knowledge area. There was six PM knowledge areas were maintained and augmented with SE knowledge. They include project time management, project cost management, project quality management, project human resource management, project communications management, and project risk management.

Knowledge Areas with Significant Overlap

The overlapping knowledge areas demonstrate that there are many ways to generate knowledge areas. The PMBOK knowledge area of project integration management overlaps significantly with the SE areas of mission/purpose definition and technical management and leadership. Project integration management is the starting point for projects, and covers the areas of developing the project charter, developing the management plan, managing the execution of the project, monitoring and controlling the project, making changes to the project, and closing the project. (PMBOK, 2009) Developing the project charter is similar to defining the purpose and mission of a project. Managing, controlling, and changing the project are similar to the technical management and leadership found in the SE knowledge area. Combining these areas could be accomplished by augmenting the existing PM knowledge area with the SE knowledge areas.

The PMBOK defines project scope management in terms of the work required to be done by a project. The SE standards define scope management as managing contracts. This can be confusing since the SE area of scope management is different than the PM area of scope management. For the purposes of a new ontology, scope management will be defined in PMBOK terms. Scope management involves collecting requirements, defining the scope, creating the WBS, verifying the scope, and controlling the scope (PMBOK, 2009). The SE categories of requirements engineering and verification and validation somewhat overlap with the PMBOK area of scope management but provide greater details on methods. The SE knowledge areas can be very helpful in augmenting the PMBOK by bringing tools and methods that are not covered in the PMBOK.

Project procurement management plans, conducts, administers and closes procurement actions (PMBOK, 2009). This is very similar to the SE category of scope management. The purpose of these knowledge areas is to manage work that is done by others for the organization. Given the similarity, these knowledge areas can be combined without a lot of effort.

Systems Engineering Knowledge Areas

Some of the primary functions of systems engineering are to design and build a system. Systems architecting, system implementation, and technical analysis are knowledge areas that define how to design, build, and deliver a system in great detail. Since the PMBOK is a management document, it does not cover the design, building, and delivering processes for systems. Knowledge areas that provide tools, methods, and guidance for the functions would be beneficial to the IT industry. These knowledge areas would benefit IT projects by introducing methods to handle the complexity of IT projects. Figure 4 shows the combined knowledge areas.

Project Management Areas	Overlapping Areas	Systems Engineering Areas
Project Time Management	Project Integration Management	System Architecting
Project Cost Management	Mission / Purpose Definition	System Implementation
Project Quality Management	Technical Management / Leadership	Technical Analysis
Project Human Resource Management	Project Scope Management	
Project Communications Management	Requirements Engineering	
Project Risk Management	Verification and Validation	
	Project Procurement Management	
	Scope Management	

Figure 4. The Combined Knowledge Areas

The nine PM knowledge areas and the eight SE knowledge areas combine in an overlapping way into an IT ontology of twelve categories. The twelve categories are project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communications management, project risk management, and project procurement management, systems architecting, systems implementation, and technical analysis. See Figure 5.

IT 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
10	System Architecting
11	System Implementation
12	Technical Analysis

Figure 5. IT Knowledge Areas

Research

In order to conduct a survey, an IT project ontology was needed to clearly present the information. A survey was conducted to identify which of the many project related documents and reviews were considered to be of highest values to IT professionals, IT project managers, and IT systems engineers for projects that are under twelve months in duration and cost less than $1.5M. PM and SE standards were reviewed to identify the documents and reviews. The standards that were reviewed included the PMBOK, ANSI/EIA-632, IEEE1220, ISO-15288, MIL-STD-499C, the Software Engineering Institute's Capability Maturity Model Integration (CMMI), and the Systems Engineering Handbook from INCOSE. The documents and reviews were both unique to a particular standard and contained in more than one standard. The standards contained a total of 74 documents and 34 reviews. The survey was sent to a 105 people. There were 56 responses, 45 non-responses, and four people who felt they did not have the background to properly answer the questions. The response rate was high and was due to the socialization of the survey with the participants prior to sending the survey. Many of the participants have a long history in these areas and were eager to share their opinions.

The survey instructed the participants to group the documents and reviews into one of three categories; "fully perform", "perform in a limited manner", and "don't perform." The categories are defined as:

"Fully Perform" - This is necessary for the project and should be performed in great

detail.
"Perform in a Limited Manner" - Some of this is helpful for the project and should be performed in a limited manner.
"Don't Perform" - This is not needed for a project of this size and scope.

The category "fully perform" was assigned a 1, "perform in a limited manner" was assigned a 2, and "don't perform" was assigned a 3. The documents were grouped into twelve knowledge areas and there was one area for reviews. Each of the documents and reviews included a definition that was accessible with a single click of the mouse if needed by the participant. It is emphasized that the intent of this work is not to significantly change either PM or SE, but to provide IT project managers with an IT knowledge areas. The twelve knowledge areas included the following documents.

1. Project Integration Management – 13 documents - business case, project charter, project management plan, performance reports, tasking document, strategic plan, concept specification, maintenance concept, concept of operations, disposal concept, total cost of ownership, systems engineering management plan, and software development plan.
2. Project Scope Management – 10 documents – requirements document, work performance measurements, requirements management plan, requirements traceability matrix, project scope statement, project scope baseline, work breakdown structure (WBS), WBS dictionary, scope management plan, and testability plan.
3. Project Time Management – 6 documents – activity list, milestone list, project schedule, project schedule network diagram, activity resource requirements document, and resource breakdown structure.
4. Project Cost Management – 5 documents – activity cost estimates, cost performance baseline, budget forecasts, cost management plan, and earned value management documents.
5. Project Quality Management – 4 documents – quality management plan, quality metrics, quality checklists, and process improvement plan.
6. Project Human Resource Management – 3 documents- human resource plan, staffing management plan, and training plan.
7. Project Communications Management – 1 document – communications management plan.
8. Project Risk Management – 2 documents - risk management plan and risk register.
9. Project Procurement Management – 7 documents – procurement management plan, statement of work, source selection criteria, resource calendar, request for proposal, contract, and contractor identified technical information services plan.
10. System Architecting – 15 documents – enterprise policies, project procedures, configuration management plan, data management plan, electromagnetic compatibility/interface control plan, human factors engineering plan, interface control plan, supportability plan, maintenance plan, reliability plan, producibility plan, system safety plan, system security plan, survivability management plan, and mass properties control plan.

11. System Implementation – 3 documents – system specification documents, integrated data package, and systems integration plan.
12. Technical Analysis – 5 documents – trade-off analysis document, system verification plan, system validation plan, test plan, and test procedures.

Figure 6 shows the ranked order of the documents for all of the survey participants,

Rank	Document Name	Score	Rank	Document Name	Score	Rank	Document Name	Score
1	Project Schedule	1.190	26	Business Case	1.714	51	System Safety Plan	2.000
2	Requirements	1.286	27	Staffing Management Plan	1.714	52	WBS Dictionary	2.048
3	Project Management Plan	1.333	28	Testability Plan	1.750	53	Activity Resource Requirements	2.048
4	Project Scope Statement	1.333	29	Project Scope Baseline	1.762	54	Resource Breakdown Structure	2.048
5	Activity Cost Estimates	1.381	30	Project Charter	1.810	55	Risk Register	2.048
6	Test Procedures	1.381	31	Total Cost of Ownership	1.810	56	Integrated Data Package	2.048
7	Milestone List	1.429	32	Quality Metrics	1.810	57	Trade-off Analysis Document	2.048
8	Test Plan	1.429	33	Quality Checklists	1.810	58	Human Resource Plan	2.095
9	Concept of Operations	1.476	34	RFP	1.810	59	Enterprise Ploicies	2.095
10	Budget Forecasts	1.476	35	Systems Integration Plan	1.810	60	Scope Management Plan	2.143
11	Contract	1.476	36	Work Performance Measurements	1.857	61	Resource Calendar	2.143
12	System Security Plan	1.476	37	Activity List	1.857	62	Reliability Plan	2.143
13	Tasking Documents	1.524	38	Cost Management Plan	1.857	63	Project Schedule Network Diagram	2.190
14	System Specifications	1.524	39	Quality Management Plan	1.857	64	Process Improvement Plan	2.190
15	Requirements Traceability Matrix	1.571	40	Maintenance Plan	1.857	65	Training Plan	2.190
16	CM plan	1.600	41	System Validaton Plan	1.857	66	Survivability Management Plan	2.238
17	Concept Specification	1.619	42	Maintenance Concept	1.905	67	Strategic Plan	2.286
18	Software Development plan	1.619	43	SEMP	1.905	68	Producability Plan	2.286
19	WBS	1.619	44	Communications Management Plan	1.905	69	Services Plan	2.333
20	Cost Performance Baseline	1.619	45	Project Procedures	1.905	70	Disposal Concept	2.381
21	Performance Reports	1.667	46	Requirements Management Plan	1.952	71	Human Factors Engineering Plan	2.381
22	Risk Management Plan	1.667	47	Source Selection Criteria	1.952	72	EVM	2.429
23	SOW	1.667	48	Procurement Management Plan	2.000	73	EMI interface control plan	2.429
24	Data Management Plan	1.667	49	Interface Control Plan	2.000	74	Mass Properties Control Plan	2.714
25	System Verification Plan	1.667	50	Supportability Plan	2.000			

Figure 6. Document Rankings

Reviews were grouped into a single category. There were 34 reviews including management, phase-end, disbursement, employee performance, inspections and product reviews, performance, quality audits, approved change request, status, documentation, activity cost estimate, activity duration estimate, risk, procurement performance, procurement audit, system definition, system requirements, subsystem requirements, alternative system, system technical, preliminary design, system detailed design, system critical design, functional configuration audit, physical configuration audit, system verification, test readiness, initial operational test and evaluation, readiness, design configuration audit, production approval, component, system acceptance, and operational readiness.

Figure 7 shows the ranked order of the reviews for all of the survey participants.

Rank	Review Name	Score	Rank	Review Name	Score
1	System Acceptance	1.491	18	Inspection and Product Reviews	1.873
2	Operational Readiness	1.491	19	System Technical	1.887
3	Systems CDR	1.537	20	Employee Performance Review	1.927
4	Systems Requirements	1.564	21	Quality Audits	2.036
5	Management Review	1.582	22	Activity Cost Estimate	2.073
6	Status	1.600	23	System Definition	2.109
7	IOT&E Review	1.709	24	Subsystem Requirements	2.145
8	Approved Change Request	1.727	25	Functional Configuration	2.145
9	Documentation	1.745	26	Activity Duration Estimate	2.182
10	System Verification	1.764	27	Design Configuration Audits	2.200
11	Test Readiness	1.782	28	Production Approval	2.200
12	Phase-end Review	1.796	29	Procurement Performance	2.222
13	System PDR	1.800	30	Physical Configuration	2.291
14	Readiness	1.815	31	Component	2.327
15	Risk Reviews	1.818	32	Disbursement Review	2.333
16	System Detailed Design	1.833	33	Procurement Audit	2.382
17	Performance Reviews	1.836	34	Alternative System	2.473

Figure 7. Review Rankings

Discussion

Successfully managing IT projects continues to be a necessary but risky proposition. With failure rates ranging from 34% to about 70% depending upon the study, there is room for improvement. There is an abundance of PM and SE information that can to be applied to managing projects. The problem is that there tends to be too much information. It is difficult for the project manager and systems engineer to select the appropriate documents and reviews that would be beneficial to the project in a cost efficient manner. The purpose of this research was to identify the most critical documents and reviews for a project manager and systems engineer to help structure project plan that is appropriate to the project.

The authors plan to continue this research by using the data collected in the survey as a baseline for creating project plans for small IT projects by creating an expert system. The expert system would also contain the other areas that are usually found in project plans. Based on the survey results, the 74 documents and 34 reviews will be segmented into three categories: “recommended”, “helpful,” and ‘optional.” The project manager and systems engineer could use the expert system to select the documents and reviews that would be helpful for managing the project. The due date for each of these deliverables would be populated as the plan is being constructed. For example, a starting point for selection could be closely reviewing the top 15% of documents and reviews which would appear in the ‘recommended” section. The top 12 documents and the top 6 reviews are highlighted in Figure 8. Using these documents and reviews as a baseline for the creating project plans, the project manager and systems engineer can tailor the project plan that is appropriate to their project. The other documents and reviews would appear

in the "helpful and optional section and could be selected if it was appropriate for the project.

Rank	Document Name	Score
1	Project Schedule	1.127
2	Requirements	1.182
3	Milestone List	1.255
4	Concept of Operations	1.309
5	Project Management Plan	1.327
6	Project Scope Statement	1.382
7	Test Plan	1.382
8	Test Procedures	1.436
9	System Security Plan	1.463
10	Business Case	1.473
11	WBS	1.473
12	Activity Cost Estimates	1.473

Rank	Review Name	Score
1	System Acceptance	1.491
2	Operational Readiness	1.491
3	Systems CDR	1.537
4	Systems Requirements	1.564
5	Management Review	1.582
6	Status	1.600

Figure 8. Top 15% of Documents and Reviews

Conclusion

Managing IT projects will continue to be a challenge. Properly structuring projects at the beginning will facilitate better and more efficient project execution. Identifying the most critical documents and reviews to manage the project will help the project manager balance the information required for performing the project verses the cost of producing documents and conducting reviews. Understanding this information at the beginning of the project provides the ability to adjust the plan while the cost impact is minimal. The hope is that this research will provide guidance on the relative importance of documents and reviews so that project managers and systems engineers can more effectively plan small IT projects.

References

Brouse, Peggy, et al, "Project Manager Use of PMBOK and EIA-632 Processes in Engineering a Small System", INCOSE 2009 Region 5 Spring Conference, VA, March 2009

El Emam, Khaled, Koru, A Gunes, "A Replicated Survey of IT Software Project Failures", *IEEE Software*, Volume 25, Issue 5, Sept-Oct 2008, p. 84-90.

Endres, Albert, Rombach, Dieter, *The Handbook of Software and Systems Engineering*, Pearson Education Limited, 2003, p.16

Fretty, Peter, "Why Do IT Projects Really Fail?", *PM Network*, March 2006, p. 44-48.

Honour, E, & Valerdi, R, "Advancing an Ontology for Systems Engineering to Allow Consistent Measurement," *Proceedings of the Conference on Systems Engineering Research*, Los Angeles, CA, 2006

Johnson, Donna, Brodman, Judith, "Applying CMM to Small Organizations and Small Projects," *SEPG '98*, Chicago, IL, March 9-12, 1998, p. 8.
Kauffman, Donald, "Project Management and Systems Engineering: Where the Professions Intersect - Generate Synergy Not Conflict," *Proceedings of the Eighth Annual INCOSE International Symposium*, 1998.
Kerzner, Harold, *Project Management, A Systems Approach to Planning, Scheduling, and Monitoring, 10th Edition*, John Wiley and Sons, 2009, p. 336.
Lynch, Jennifer, "New CHAOS Numbers Show Startling Results," http://www.standishgroup.com/newsroom/chaos_2009.php, April 23, 2009.
Pettey, Christy, "Gartner Says Worldwide IT Spending to Surpass $3 Trillion in 2007," http://www.gartner.com/it/page.jsp?id=529409
PMI, http://www.pmi.org/AboutUs/Pages/About-PMI.aspx
PMI, *A Guide to the Project Management Body of Knowledge (PMBOK Guide) 4th Edition*, 2008.
Reuters, "Gartner sees global IT spending down 6% in 2009," *The Economic Times*, July 7, 2009.

Acknowledgements

The authors would like to thank and acknowledge Dr. Andrew Sage, Dr. David Schum, Dr. Michael Casey and Dr. Michael Caloyannides for their help and support in the research for this paper.

Biography

Mr. Michael Mulhearn is a PhD candidate at George Mason University in Fairfax, VA. Mr. Mulhearn earned a BSEE in 1987 from WPI in Worcester, MA. He also earned an MSEE in 1995 and an MSSE in 2002 from George Mason University.

Dr. Peggy Brouse is an Associate Professor, Systems Engineering and Operations Research department at George Mason University. Dr. Brouse is involved in several research areas including requirements engineering, cost modeling, and process improvement. Research clients include DoT, VDoT, DoE, VDRPT, and Motorola. Before GMU, she worked at the MITRE Corporation where she managed and participated as a systems engineer on several projects concerned with requirements analysis, conversion, testing and quality evaluation for NIST, USDA, USGS, DoL, and DoD (Navy, Army).. The area of her current research encompasses process improvement, knowledge engineering, decision support and requirements elicitation.

REFERENCES

ANSI/EIA-632, *Processes for Engineering a System*, American National Standards Institute and Electronics Industries Association, 1999.

Aramo-Immonen, Heli, "Project Management Ontology, The Organizational Learning Perspective", *Tampere University of Technology, Publication 836*, 2009.

Boehm, Barry, Valerdi, Ricardo, Honour, Eric, "The ROI of Systems Engineering: Some Quantitative Results for Software-Intensive Systems," *InterScience,* 2007.

Brouse, Peggy, et al, "Project Manager Use of PMBOK and EIA-632 Processes in Engineering a Small System", *INCOSE 2009 Region 5 Spring Conference*, VA, March 2009.

Cheah, Chan, Chang, Elizabeth, "Multi-site Project Management Ontology System Development Methodology", *3rd IEEE International Conference on Industrial Information,* 2006.

Cherulnik, Paul, "Methods for Behavioral Research, A Systematic Approach," Sage Publications, 2001, p. 238

CMMI Team, *Capability Maturity Model Integration Version 1.1*, Carnegie Mellon Software Engineering Institute, Pittsburg, PA, 2002.

El Emam, Khaled, Koru, A Gunes, "A Replicated Survey of IT Software Project Failures", *IEEE Software*, Volume 25, Issue 5, Sept-Oct 2008, p. 84-90.

Endres, Albert, Rombach, Dieter, *The Handbook of Software and Systems Engineering*, Pearson Education Limited, 2003.

Fretty, Peter, "Why Do IT Projects Really Fail?", *PM Network*, March 2006, p. 44-48.

Honour, E, & Valerdi, R, "Advancing an Ontology for Systems Engineering to Allow Consistent Measurement," *Proceedings of the Conference on Systems Engineering Research*, Los Angeles, CA, 2006.

IEEE 1220-1998, *IEEE Standard for Application and Management of the Systems Engineering Process*, Institute for Electrical and Electronics Engineers, 1998.

INCOSE, “INCOSE SE Terms Glossary”, October 1998.

INCOSE, “Relation to Project Management,” INCOSE G2SEBOK, www.incose.org, Sept. 1, 2003

ISO/IEC-15288: 2002, *System Life Cycle Processes*, International Standards Organization, 2002.

ITIL, The Official ITIL Website, http://www.itil-officialsite.com/AboutITIL/WhatisITIL.asp, November 1, 2010.

Johnson, Donna, Brodman, Judith, “Applying CMM to Small Businesses, Small Organizations, and Small Projects,” *Software Process Newsletter*, No. 8 Winter 1997, p.1-5

Johnson, Donna, Brodman, Judith, “Applying CMM to Small Organizations and Small Projects,” *SEPG ’98*, Chicago, IL, March 9-12, 1998, p. 8.

Kauffman, Donald, “Project Management and Systems Engineering: Where the Professions Intersect - Generate Synergy Not Conflict,” *Proceedings of the Eighth Annual INCOSE International Symposium*, 1998.

Kerzner, Harold, *Project Management, A Systems Approach to Planning, Scheduling, and Monitoring, 10th Edition*, John Wiley and Sons, 2009, p. 336.

Lynch, Jennifer, “New CHAOS Numbers Show Startling Results,” http://www.standishgroup.com/newsroom/chaos_2009.php, April 23, 2009.

Madni, Azad, Madni, Carla, Lin, Weiven, “IDEON/IPPD: An Ontology for Systems Engineering Process Design and Management”, *Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics*, Vol. 3, pp. 2597-2602. 1998

Merriam-Webster, http://www.merriam-webster.com/dictionary/, April 21, 2011.

Mooz, Harold, Forsberg, Kevin, “Visualizing Systems Engineering and Project Management as an Integrated Process”, INCOSE, 1997.

Paulk, Mark, “Using the Software CMM in Small Organizations,” *Software Engineering Institute*, Carnegie Mellon University, 1998, p.4.

Pettey, Christy, “Gartner Says Worldwide IT Spending to Surpass $3 Trillion in 2007,” http://www.gartner.com/it/page.jsp?id=529409.

PMI, http://www.pmi.org/AboutUs/Pages/About-PMI.aspx.
PMI, *A Guide to the Project Management Body of Knowledge (PMBOK Guide) 4th Edition*, 2008.

Reuters, "Gartner sees global IT spending down 6% in 2009," *The Economic Times*, July 7, 2009.

Sarder, MD, Ferreria, Susan, "Developing Systems Engineering Ontologies", *IEEE International Conference on Systems of Systems Engineering, SoSE '07*, 16-18 April 2007.

Srivastave, Nidhi, Murthy, Sathya, "Small Steps, Giant Leap," *CMU/SEI-2006-SR-001*, 2006, p.236-238.

The Aerospace Corporation, *Mil-Std-499C (Draft)*, Revised 24 March 2005.

Wikipedia, http://en.wikipedia.org/wiki/, April 18, 2011.

CURRICULUM VITAE

Mr. Michael Mulhearn is a PhD candidate at George Mason University in Fairfax, VA. Mr. Mulhearn earned a BSEE in 1987 from WPI in Worcester, MA. He also earned an MSEE in 1995 and an MSSE in 2002 from George Mason University. He has worked for the U.S. Government for over 22 years.