ABSTRACT

Title of Document: UTILIZATION OF ENTERPRISE RESOURCE PLANNING TOOLS BY SMALL TO MEDIUM SIZE CONSTRUCTION ORGANIZATIONS: A DECISION-MAKING MODEL

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Enterprise Resource Planning (ERP) utilization in the Construction Industry has been limited to a few large organizations. Significant segments of the industry are either not aware of or have not been able to adopt this new technology successfully. The largest groups of construction organizations that either have failed in their efforts to adopt this technology, or are not familiar with it are the Small to Mid Size Construction Organizations (SMSCO). Failure in or refusing to adopt ERP by this group, despite all its potential benefits, was the problem that was addressed in this research.

This research sets out not only to formulate the reason(s) why SMSCO fail to utilize ERP systems, but also to propose a decision-making model which could be utilized when they decide to adopt an ERP system.

After a careful review of existing technology models, a new ERP Adoption Model (EAM) is formulated and projected. This model adopted a new paradigm shift proposed by Bagozzi (2007) and incorporated it's a new decision making core. Prohibitive criteria that are at play and prevent SMSCO members from successfully adopting and implementing ERP systems were redefined as prohibitive/self-regulation criteria and introduced into the model. Utilizing the results obtained from a field questionnaire distributed among industry experts, these criteria were analyzed and ranked in order to increase the understanding of their impact on EAM's processes.

A case study to verify EAM in general and impact of prohibitive/self-regulation criteria was conducted. Ultimately EAM, incorporating the study's findings associated with prohibitive/self-regulation criteria was finalized and proposed to be utilized by SMSCO in order to increase the chances of successful implementation of ERP system. The results of this study provides SMSCO members that are currently not utilizing ERP systems, but are contemplating its use, with a decision making tool. ERP Adoption Model (EAM) provides a road map that could be utilized as a decision making tool by SMSCO.

UTILIZATION OF ENTERPRISE RESOURCE PLANNING TOOLS BY SMALL TO MEDIUM SIZE CONSTRUCTION ORGANIZATIONS: A DECISION-MAKING MODEL

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Dedication

To my family for their support and encouragement.

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I would like to thank all of the organizations and personnel who assisted me in conducting my field research, and the people who responded to researcher's questionnaires. Without their participation this research could not been completed.

Finally, and most notably this research would have not been possible without support and encouragement of my family. My only remorse lies in fact that my father did not live long enough to see the completion of it, and it is to him that I dedicate this dissertation.

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CHAPTER 1 INTRODUCTION

Section 1.1 Background

The nature of the construction industry has been evolving since the beginning of the twentieth century. The advent of new technologies has hastened this pace. Construction organizations suffer from the “temporary status” mindset. Projects are mostly unique, one-time jobs. Teams are put together for a specific purpose and disbanded as soon as the tasks are completed. People are trained and motivated to complete difficult tasks within short period of time and under strict budgetary constraints. Difficult problems are routinely resolved to meet the unique requirements of different projects. Jobs are competitively bid across the globe with varying rules and regulations. People come and people go. Tasks change in the middle of implementation. Materials do not show up in time, and at times, are not available all together. Labor issues become time bombs that can easily derail the entire project; however, amid all this chaos, jobs are completed successfully. The reason for this success can be mostly attributed to the knowledge that collectively resides within the minds of the members the project team. This knowledge, even though essential to the success of the organization and created at a great cost, has not been recognized as such and therefore been allowed to dissipate from the organization.

The process of managing this knowledge has been impacted by the evolution of technology in this area. Just as any other topic on the edge of the scientific platform, its definition and nature has evolved. The process of knowledge management has been defined to mean the path by which knowledge is created, acquired, communicated, shared, applied, and effectively utilized and managed, in order to

meet existing and emerging needs, to identify and exploit existing and acquired knowledge assets (Egbu & Bootterhill, 2002). At the same time, the process of knowledge management has been defined to be set of management activities that frame and guide knowledge production in an organization (Koch, 2002). Additionally, this process has been defined as identification, optimization, and active management of intellectual assets to create value, increase productivity, and gain and sustain competitive advantage (Web, 1998).

It is apparent that in order to clearly and simply define the knowledge management process one must first define what knowledge is. Knowledge must be distinguished from information. It is critical to make this distinction so that the focus does not shift on to Information Systems. Knowledge itself has been defined as a dynamic human process of justifying personal belief toward the "truth", i.e. a justified true belief (Nonaka & Takeuchi, 1995). In addition, it has been simply defined as know – why, know – how, and know – who. Knowledge is built from data, which is first processed as information. Information becomes knowledge when it enters the system and is validated as a useful tool to be re-used.

With the advances made in IT technology and its ever expanding possibilities, hopes were raised that the means and methods in the construction industry will be revolutionized by the application of IT technology. It was understood that utilizing this technology would allow the industry to harness the power of collective knowledge. In addition, regulatory and competitive forces, financial demands of owners, and an ever-shortening timeline to finish projects contributed to an increased pace of the utilization of this technology in the construction industry. It took the construction industry longer than other industries to realize the importance of the

utilization of IT applications in improving the possibility of ultimate success in an integrated project environment.

One of the concepts that have been evaluated and, at times, utilized by construction organizations in achieving the goal of improved efficiency thru better management of collaborated knowledge is Enterprise Resource Planning (ERP). ERP systems have been defined to be a "computer program that provides a general working platform for all departments of an enterprise with their management functions being integrated into the program" (Jingsheng & Halpin, 2003). These systems have been utilized to optimize the company's internal and external processes. ERP has been a very rapidly growing business. By early 2000, the ERP revolution generated over $20 billion in revenues annually for suppliers and an additional $20 billion for consulting firms (Willcocks and Sykes, 2002). Originally ERP was created and implemented for and in the industrial manufacturing sector as a planning tool. The original systems or Material Requirement Planning (MRP) were utilized as tools to maximize the efficiency of ordering and managing the inventory of materials required for the production processes by using forecast sales (Laudon, & Laudon, 2002). Later, these systems were modified to also handle management of resource allocation for equipment and labor as well, by forecasting financial and production issues, as demand changed. With the advances made in information technology, MRPs were converted into ERPs, as they were modified to integrate additional front and back office functions such as warehousing, distribution, quality control, purchasing, financials, human resources, sales force, and electronic commerce. Historically in construction, ERP-type concepts have been utilized by large organizations to manage materials at different stages of project implementation. Various Material Management

Systems (MMS) have been utilized to integrate the functions of material requirement planning, takeoff, purchasing, expedition, shipping, receiving, inventory, distribution, and even accounting functions (Bell & Stukhart, 1987).

ERP applications that are currently in use by the construction industry can be categorized into two separate groups: pre-packaged Software, and Web-based Project Management System (WPMS). Currently, the world's largest pre-packaged ERP software providers include SAP, Oracle, PeopleSoft, J.D. Edwards, and Baan. SAP is said to have about 60% of the world market (Holland, Light, Kawalek, 1999). Among all various different types of software packages that are available, the most popular system is SAP R/3 (O'Conner and Dodd 1999; Jacobs and Whybark 2000).

The number of architecture, engineering, and construction firms that are currently using or are planning to use WPMSs is on the rise. Currently, there are three implementation options for WPMS. The first of these options is Application Service Providers (ASPs), which are those systems that can be rented or leased from a web-based service provider. The second option consists of the group that provides a comprehensive family of project management software solutions that can be purchased and installed to work in conjunction with the existing legacy systems. Finally project centric & web-based programs, which are created by the organization's employees and utilize web technology to collaborate and manage specific projects.

Section 1.2 Problem Statement

ERP has become an integral part of business process across the globe. Utilization of ERP worldwide in other industrial sectors has been steady and growing. Its critical influence in creating new business environments and processes has been significant. Different organizations in various sectors have committed to spending and have already spent large sums of capital for the implementation of ERP in their organizations. These same companies have been able to document major improvements, both tangible and intangible, in their operations as a result of ERP implementation.

Acceptance of ERP as a valuable tool by various organizations has been well documented. Large numbers of Fortune 500 corporations have turned to ERP to integrate their operation and make it more efficient and profitable. Globally, the same observation can be made for some of the most successful corporations in the world. The question needs to be asked - why is this? What are some of the perceived benefits that cause corporations to commit to the implementation of ERP in their organizations? As indicated by Oliver, & Romm (2002), “in common with other types of investment activity the adoption of an ERP system is a purposive intervention by an organization for bringing about a new state of affairs that is judged to be superior to the current state”. The following is the list of most significant factors that are often mentioned as a reason for committing to the implementation of ERP:

- Integration
- Information Access
- Standardization & Process Improvement

- Business Considerations
- Dissatisfaction with out dated legacy systems

Once committed to an ERP system, companies have been able to improve customer relations, strengthen supply chain partnerships, enhance organizational flexibility, improve decision-making capabilities and reduce project completion time and cost (Ahmed, and Ahmed, Azhar, Mallikarjuna, 2003). Some organizations that have implemented full ERP packages reported 30% to 300% net return on their investment (Shi, & Halpin 2003).

Even though Enterprise Resource Planning (ERP) has been fully implemented by various organizations internationally, in almost all of the other major industrial sectors, its utilization in the construction industry has been limited to use by a few large organizations. Significant segments of the industry are either not aware of or have not been able to adopt this new technology successfully. The largest groups of construction organizations that have either failed in their efforts to adopt this technology, or are not familiar with it are Small to Mid Size Construction Organizations (SMSCO). These organizations constitute the backbone of the construction industry and have their own particular financial and operational needs. Failure or refusal of SMSCO to adopt ERP, despite all its potential benefits, is a problem that needs to be addressed.

It can be hypothesized that;

> Hypothesis #1: There are number of critical/prohibitive criteria that lead to failure or lack of utilization of ERP by SMSCO. These criteria need to be identified and studied.

Hypothesis #2: It is important to make an attempt to evaluate the level of impact for each of the prohibitive criteria in order to obtain a hierarchy of importance.

Hypothesis #3: Available alternative systems in the market at this time are not addressing the problem with the same level of success.

Hypothesis #4: A comparison of the currently-available alternative ERP systems can be made showing the effect of prohibitive criteria on specific platform in an SMSCO environment.

Hypothesis #5: A decision-making model that can be utilized by SMSCO in selecting and adopting an ERP system is needed and can be formulated.

Studies that have been conducted so far to identify the prohibitive factors are limited in nature and results. They are mostly based on limited case studies or anecdotal evidence provided by stories in the trade press. To date, there is no large scale empirical study that addresses the issues of why the use of ERP is not as widespread as it should be in SMSCO.

In addition no study has been conducted that deals with creation of a decision-making model for adoption of ERP system by SMSCO. The research agenda presented here will identify a decision-making model which will incorporate the prohibitive criteria and their hierarchy of importance, leading to an increased implementation of ERP tools by SMSCO, and thereby resulting in realization of additional benefits for this important group.

Section 1.3 Research Objectives

In order to facilitate an increase of utilization of ERP tools by SMSCO, a proper understanding of prohibitive criteria and their role in the decision-making process is vital. Detail analysis of the above-mentioned criteria including their relative importance and impact on alternative ERP platforms will be studied. In addition it is the objective of this research to; based on existing theory of information technology adoption models, formulate a decision-making model that would incorporate the prohibitive criteria in its process.

Several opinions/facts exist regarding status of utilization of ERP by SMSCO. These opinions are either cited in literature or commonly perceived by industry insiders, and are as follows;

1. A large majority of SMSCO do not utilize current ERP tools to manage their projects.
2. There are number of criteria that cause ERP implementation to fail.
3. There are number of critical criteria that prohibit SMSCO from use of ERP tools.
4. There are adequate alternative systems that can be utilized by SMSCO to adopt ERP.
5. There is no decision-making model that could be utilized by SMSCO to properly evaluate and adopt the right system.

The above mentioned opinion/facts would lead one to raise the following questions regarding the failure or lack of utilization of ERP tools in the management of projects by SMSCO:

1. Why do substantial numbers of SMSCO do not use ERP tools to manage their projects?
2. What are the major prohibitive criteria with ERP implementation by SMSCO?
3. Knowing the prohibitive criteria in play, what critical attributes or measures should be used to evaluate the performance of a particular ERP system?
4. What are the relationships, if any, between these criteria and can they be ranked?
5. Can a decision -making model to adopt an ERP system be formulated to be utilized by SMSCO?

This research is intended to provide answers to all of the aforementioned questions, from which the following objectives are derived:

1. Formulate the reason(s) why SMSCO fail to utilize or are not successful in implementing any existing ERP tools in managing their projects.
2. Identify the prohibitive criteria that should be analyzed in order to increase the understanding of and the chance for selection of the most proper ERP system, leading to a larger acceptance of ERP tools by SMSCO.
3. Examine the impact of these prohibitive criteria operating on an alternative ERP system platform.
4. Establish a hierarchical ranking for the prohibitive criteria, reflecting their level of importance and overall impact.
5. Based on existing theory of information technology adoption, generate a decision-making model and guidelines that could be used by SMSCO in order to properly adopt ERP systems.

6. Incorporate the role and impact of prohibitive criteria into the decision making model.

The results of this research can be beneficial to all SMSCO organizations that currently are not taking advantage of the potential savings that a proper ERP system can generate for them. In addition, for those organizations that have attempted and failed to properly implement an ERP system, this research will act as a guide so that they can correct the miscalculation. Altogether, the results of this research can lead to a more widespread acceptance of ERP systems in SMSCO.

Section 1.4 Research Scope & Methodology

The research tasks were divided into five major phases, which proceeded according to the proposed methodology shown in Figure 1.

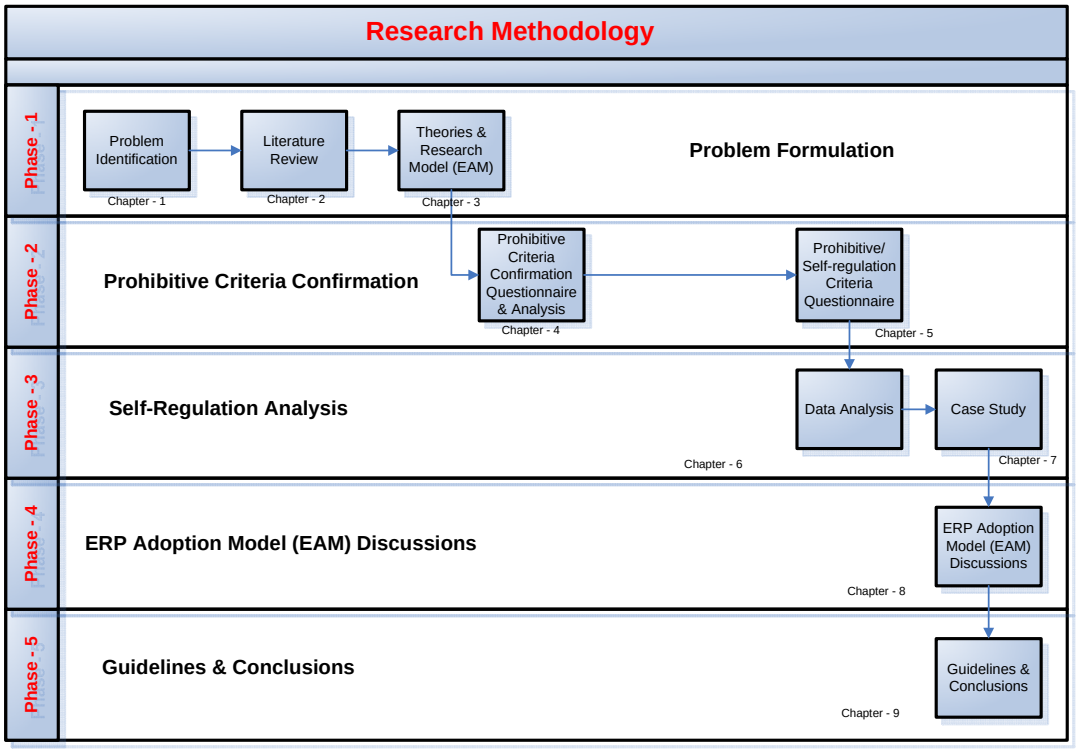

Figure 1 Research Methodology

A detailed description of each phase of the research is as follows:

Phase 1 - Problem Formulation

After identification of the problem to be resolved by this research was completed, comprehensive literature review was conducted in the area of ERP applications in all

industrial sectors with special attention given to the construction industry. In particular, ERP applications utilized by SMSCO were scrutinized, and in order to obtain an in depth knowledge of this subject, on-site interviews relating to their ERP experiences were conducted with various owners of SMSCO.

Current understandings of technology adoption process, associated risks and benefits of ERP application were studied. Number of existing and prominent technology adoption models were reviewed and based on their applicability to technology adoption in construction three of them were further scrutinized.

Based on this review a proposed paradigm shift in technology acceptance model was adopted and incorporated into development of a new research model. Based on literature reviews and interviews, it was decided that the first step in advancing this topic would be to identify the prohibitive criteria leading to lack of utilization by SMSCO.

Phase 2 - Prohibitive Criteria Confirmation

A questionnaire was designed, pilot-tested, and used as the primary instrument to survey the SMSCO sector and collect the necessary data. Based on the analysis of the results obtained from this questionnaire, number of critical prohibitive criteria that would affect adoption and implementation of ERP by SMSCO was identified. Alternative ERP systems that are currently available for utilization were categorized and investigated. It was decided that in order to confirm and complete the required analysis to gauge the impact of the prohibitive criteria and their potential role in self-regulation part of proposed decision-making model, a second questionnaire be designed and submitted to industry experts for completion. These experts were chosen because they had previous relevant experience with the implementation of

ERP systems. The second questionnaire was distributed via SurveyMonkey, a web-based service.

Phase 3 – Self-Regulation Analysis

The data obtained as a result of the second field questionnaire were analyzed to formulate a hierarchical ranking system for the prohibitive criteria and establish a thorough understanding of their role as self-regulating elements in the decision-making model. The relationships of the prohibitive criteria were analyzed. The results obtained for alternative ERP systems were compared so that the final recommendations could address the applicability and adoptability of a system. Various statistical methods were utilized to complete this analysis. In order to validate the research model a case study that dealt with a medium size general contracting firm's adoption of an ERP system was conducted.

Phase 4 – ERP Adoption Model (EAM) Discussions

As a result of data analysis and the case study conducted, the previously mentioned ERP Adoption Model (EAM) was completed. Prohibitive criteria and their ranking were adopted by getting incorporated into the self-regulation element of research model. Each individual element was further analyzed and its sub parts were identified. Issues of importance to the final version of EAM were presented and discussed in detail.

Phase – 5 Guidelines & Conclusions

Practical guidelines to be used by other SMSCO members were generated. Finally major findings of the research were reviewed and applicable limitations were highlighted. In addition, recommendations for future research in this area were made.

Section 1.5 Organization of Dissertation

The contents of the remaining chapters of this dissertation are organized as follows:

- Chapter 2 reviews the literature produced by previous research related to ERP implementation in the construction industry and other relevant topics. Particular attention is given to issues affecting SMSCO. Potential benefits of ERP utilization by SMSCO are highlighted. Research dealing with the risk and failure of ERP implementation by SMSCO is scrutinized. Prohibitive criteria, leading to the creation of obstacles to the ERP implementation in the SMSCO environment that have been identified by previous research, are discussed. Existing ERP systems are categorized and reviewed for SMSCO applicability. In addition existing theory about decision making process are reviewed.
- In Chapter 3, three of the most prominent technology adoption models and a proposed paradigm shift in technology adoption are presented to form the theoretical background of the research model, and then the research model and its components along with their inter relationships is presented.
- In Chapter 4 Prohibitive Criteria questionnaire is discussed fully. In order to validate the prohibitive criteria identified by literature review, a questionnaire was designed and distributed to SMSCO's executives for completion. A descriptive analysis for answers obtained for each question is provided. Based on the findings of the questionnaire and previously conducted literature review, critical determinants are identified and set as prohibitive criteria.
- Chapter 5 deals with the Self-regulation questionnaire. The prohibitive criteria that were identified previously are further broken down into subcategories and

a new questionnaire dealing with relative strength and impact of these measures is deigned and distributed to industry experts.

- Chapter 6 includes the study that analyzes the findings of the second questionnaire. This study establishes the ranking of various critical prohibitive criteria and their relative impact on the successful implementation of an ERP system across alternative ERP system platforms. In addition, inter-criteria comparisons will be conducted.
- Chapter 7 includes the conduct of a case study dealing with a decision making process of ERP adoption by a medium size general contractor utilizing the research model. The findings of the case study are utilized to validate the research model and its processes.
- Chapter 8 presents a final version of the research model EAM. Theoretical version of EAM is amended to reflect the impact of the prohibitive/self-regulation criteria. Issues of importance to the final version of EAM are presented and discussed in detail.
- Finally, Chapter 9 presents practical guidelines to be utilized by members of SMSCO in adopting ERP systems. In addition summary and conclusions of this research, its limitations and recommendations for future work are presented.

CHAPTER 2 LITERATURE REVIEW

Section 2.1 Current Status of ERP Utilization

What is ERP and what does it represent? The first step in achieving the objectives of this study requires a clear definition of ERP. These systems are very complicated and, without a clear definition, they could mean different things to different entities. In the past, ERP has been defined by Ohlsson & Ollfors (2001), to be “A type of computer system that assists international companies in managing their information flows”. More definitively it has been described as a system able to “reduce the financial reporting, purchasing, and support expenses of management information system (MIS), and lead to more timely analysis and reporting of sales, customer, and cost data” (Wagle, 1998). The most concise definition of ERP has been offered by Tsung, (2004), “ERP is a system that aims to integrate the main business functions across all the departments within an organization.” In addition ERP has been viewed by (Irani & Love, 2001) to be “a structural iterative business process, which offers organizational learning during the life cycle of technology”. The definition of ERP should be modified for construction to be “information technology based computer platform that allows for integration of various business processes of an organization in order to increase efficiency, and thus profits, using a single database”.

ERP originally was created for and implemented in industrial manufacturing sector as a planning tool. The original systems or Material Requirement Planning (MRP) were utilized as tools to maximize the efficiency of ordering and managing the inventory of materials required for the production processes by using forecast sales (Laudon, &

Laudon, 2002). Later, these systems were modified to also handle management of resource allocation for equipment and labor as well, by forecasting financial and production issues, as demand changes. With the advances made in information technology, MRPs were converted into ERPs as they were modified to integrate additional front and back office functions such as warehousing, distribution, quality control, purchasing, financials, human resources, sales force, and electronic commerce. Historically in construction, ERP-type systems have been utilized by large organizations to manage materials at different stages of project implementation. Various Material Management Systems (MMS) have been utilized to integrate the functions of material requirement planning, takeoff, purchasing, expedition, shipping, receiving, inventory, distribution, and even accounting functions (Bell and Stukhart, 1987).

The acceptance of ERP as a valuable tool by various organizations has been well documented. Large numbers of Fortune 500 corporations have turned to ERP to integrate their operation and make it more efficient and profitable. On a wider scale, the same observation can be made for some of the most successful corporations in the world. By early 2000, the ERP revolution generated over $20 billion in revenues annually for suppliers and an additional $20 billion for consulting firms (Willcocks and Sykes, 2000). ERP has become an integral part of business process across the globe.

New software applications are entering the market place at a steady rate. There are numerous venders that advertise their product as the ultimate solution for the industry. Current vendors in the market are a mixture of some original companies and many more that have been created as result of industry mergers. Innovative visions,

adaptability, simplicity, cost, support services, and non-generic solutions are among some of the factors that have helped these organizations survive the tumultuous market place.

Presently the world's largest ERP providers include SAP, Oracle, PeopleSoft, J.D. Edwards, and Baan. SAP is said to have about 60% of the world market (Holland et al., 1999). Among the various different types of software packages available, the most popular system is SAP R/3 (O'Conner and Dodd 1999; Jacobs and Whybark 2000).

In the construction industry, because of the fragmented nature of the business, ERP implementation and utilization has not reached the same level as the other industrial sectors; however, the construction industry has finally awakened to importance of ERP, even though it is lagging behind other major industries that have been utilizing ERP to improve their efficiencies and bottom lines. Construction organizations have initiated various efforts to develop and/or, at times, invent techniques/technologies that could be utilized in the implementation of their overall enterprise resource planning strategy. Large construction organizations are utilizing software technologies to improve their bottom lines much more quickly than in the recent past.

Investments in IT represent a large financial commitment by the organization therefore the issue of evaluation of ERP has been a topic of interest among academics. As indicated by Frisk and Planten (2004), despite many different attempts in the literature to find solutions for and explanations of how IT evaluation should be conducted, researchers are still far away from generally accepted common concepts. The research conducted by Frisk and Planten (2004), indicated that most papers dealing with ERP evaluation focus on a management perspective. They identify the

following to be main categories under which different approaches to ERP evaluation have been conducted; economic, technical, and interpretative.

Section 2.1.1 ERP Use in the Construction Ind., Key Implementation Issues

As indicated previously, one of the key issues impacting ERP implementation is the human factor. Abdinnour-Helm and Lengnick-Hall (2003), indicate that pre-implementation involvement is a key issue for having a positive attitude towards the ERP. The impact of cultural aspects on the success of the implementation is also analyzed in several papers. Jones, Cline, and Ryan, (2004), suggest a multi-site case study showing that a similar culture facilitates knowledge sharing during ERP implementation. Yen and Sheu (2004), claim national culture to be a critical factor in multi-national settings. Amoako-Gyamph and Salam (2004), agree that shared beliefs may make implementation easier through better acceptance of the system. Lander, Purvis, McCray, and Leigh (2004), consider the trust building mechanism between team members and other participants of the project as a major factor in the implementation process. Botta-Genoulaz et al., (2005), indicate that the impact of company cultural issues is considered as a key dimension of the implementation process as also discussed by Yusuf, Gunasekaran, Abthorpe (2004). As complicated as ERP systems are, it is apparent that during the implementation process a number of conflicts and difficulties occur. Luo and Strong (2004), even suggest a method for controlling the tensions during and after the completion of the project.

The process of implementation and the steps that need to be taken in that process are addressed by number of studies (Ohleson, et al., 2001; Powel, Barry 2005: Botta-Genoulz et al. 2005). Research conducted by Somers and Nelson (2003), resulted in a

new methodology to identify a critical step in implementation. They use a probabilistic description to identify which activities associated with various steps of the ERP implementation are important. Botta-Genoulaz et al. (2005), identify the key aspects of the implementation process as training, communications, and/or role of the steering committee, but they have yet to be analyzed in detail. Additional research suggests decision support tools for the participants of multi-agent system are also essential (Lea and Gupta, 2005). These tools deal with collecting information and interacting with users in order to facilitate ERP implementation. Research conducted by Mabert, Soni, and Venkataramanan, deals with the identification of the most suitable implementation processes for different organizations. They base their findings on the results obtained in case studies completed in U.S. The research suggests that the implementation method is dependant upon the size of the company. Parr and Shanks (2000), suggest taxonomy of ERP implementation categories. Wu and Wang (2003), focus on the industrial sector, particularly the size of the industry, to compare the differences in implementation, whereas Huin (2003), specifically address the implementation of ERP systems in South Asian SMEs.

Since one of the main objectives of this study deals with finding the reasons for a lack of utilization of ERP by SMSCO, it naturally followed that the reasons for committing to ERP must be investigated in more detail.

The following is the list of most significant factors that are often mentioned as a reason for committing to an implementation of ERP:

- Integration
- Information Access
- Standardization & Process Improvement

- Business Considerations
- Dissatisfaction with outdated legacy systems

The most significant factor identified by various corporations as a main reason to implement ERP has been integration. Most corporations see ERP as a tool that allows them to integrate functions of their front and back offices into a single platform. A study done by Oliver, et al. (2002), indicated that, "integration was the most important rationale in terms of the frequency of reference in each of the technology and organization dimensions and was the most important single rationale." The importance of integration as a justification for ERP adoption emerged strongly in the study completed by Oliver, et al. (2002). Ross (1999); Alvarez (2000); and Markus, Petrice, and Axline (2000), also identified integration as an important issue in ERP adoption (Oliver, et al. 2002). Creation of single platform or a single software product increases usability by creation of a friendly environment in which employees are able to access central information in a timely fashion. Integration is believed to advance the cause of teamwork in an organization.

Improved access to reliable information is a by-product of proper implementation of an ERP system. The flexibility and ease of use provided by ERP systems allow for unrestricted access to timely information that could be used to enhance completion of various tasks in an organization. A study done by Oliver, et al. (2002), indicates that organizations anticipate that the improved access to information will result in a better central control. This same study indicates that approximately 16% of all justificatory statements for ERP adoption were based on improved information access.

Standardization & process improvement is another one of the critical justifications provided for implementation of ERP. Most organizations that have implemented an

ERP system had been operating under some type of inefficient legacy system. Installation of an ERP system is considered to be an opportunity to correct problems associated with older legacy systems. In addition, ERP systems are utilized as an agent of business process re-engineering. The organization is introduced to and forced to adhere to new procedures. This procedural approach cuts across functional departments and widens the functions that an employee can perform. Adherences to ERP systems also provide uniformity throughout the organization so that all inefficiencies associated with different interpretations are eliminated.

Botta-Genoulaz, et al. (2005), indicate that the alignment of the standard ERP processes with the company's business processes has been considered a critical step of the implementation process, and has been covered by number of different researchers. Van der Aalst and Weijters (2004), indicate that process mining is introduced as a precursory step in ERP implementation while Chiplunker, Deskmukh, and Chattopadhyay, (2003), suggest the capture of a complete business environment in a business process re-engineering (BPR) project, with the help of information technology. Daneva (2004), considers that reusing business processes and data requirements is a major issue of implementation. Daneva (2004), also defines the reuse measurements. Soffer, Golany, and Dori, (2003), suggest a reverse engineering process for obtaining an ERP model, which can be aligned with the needs of the enterprise. Daneva (2004), defines the problem of process alignment in term of composition and reconciliation: a general set of business processes and data requirements is established, then standard ERP functionalities are explored to see how closely it match the organization's process and data needs. Luo and Strong (2004), see the alignment in terms of customization of the standard ERP processes, while an

elicitation-based method is suggested by Kato, Saeki, Ohnishi, Nagata, Kaiya, Komiya, Yamamoto, Horai, and Watahiki, (2003) for comparing user requirements to existing packages.

Business considerations also have played a significant role in adoption of ERP. The global nature of today's economy has forced organizations to adjust their operations to encompass the new realities caused by different cultures and time zones. Implementation of ERP has made it possible for these organizations to be able to operate across the globe, providing their products and services at the most competitive rates possible. This increase in the size of their market has resulted in significant growth in their revenues. Maintaining market share and being able to stay with competition has been perceived to be among other business considerations taken into account by organizations. This finding is unfortunately not supported by existing research as indicated by Botto-Genoulza et al. (2005). According to Beard and Sumner (2004), it is due to the "common systems" approach used for the implementation of most ERP systems. They argue that this goal can be achieved with a careful planning and successful management of ERP projects, refinement and re-engineering of the organization, and the post implementation alignment of the ERP system with the organization's strategic direction. From a study of five manufacturing firms, Yen and Sheu (2001), investigate the relationship between ERP implementation practices and a firm's competitive strategy, and confirm that ERP implementation should be aligned with competitive strategy, proposing specific guidelines.

Hunton, Lippincott, and Reck, (2003), examined the longitudinal impact of ERP adoption on firm performance by matching firms that had adopted ERP with firms

that had not. Their results indicate that return on assets, return on investment, and asset turnover were significantly better over a 3 year period for adopters. Their study deals with a productivity paradox associated with ERP systems and suggest that ERP adoption helps firms gain a competitive advantage over non-adopters. ERP makes possible deep changes in relationships, culture, and behaviors that can be crucial sources of advantage in the knowledge economy, but the structure and cultures most able to achieve this level of change are a poor fit with ERP requirements. To reconcile this paradox, Lengnick-Hall, Lengnick-Hall, and Abdinnour-Helm, (2004), propose to consider ERP as an enabling technology to build and augment social and intellectual capital, rather than as an information technology solution for organizational inefficiencies, and to use ERP as a foundation for social and intellectual capital formation.

As mentioned previously, a study by Oliver, et al., (2002), indicated that among organizations that have adopted ERP, there existed dissatisfaction with existing legacy systems. These systems were considered to be old and outdated. They were described by Oliver, et al. (2002), to be "ageing, unworkable, costly, inadequate, inefficient, outmoded, expensive, poorly coordinated, inflexible, disparate, limited, old, idiosyncratic, redundant, cumbersome and technologically inferior". As can be seen by the depth of emotions that had been shown about these legacy systems, organizations were more than glad to have an opportunity to discard them for a more efficient system.

Why it is that SMSCO, being part of the same industry and, at times, in a more dire need of utilizing ERP systems, have so far refused or failed to adopt them?

Section 2.1.2 Benefits of ERP Use by SMSCO

What are some of the perceived benefits that lead corporations to commit to the implementation of ERP in their organizations? As indicated by Olliver and Romm (2002), “in common with other types of investment activity the adoption of an ERP system is a purposive intervention by an organization for bringing about a new state of affairs that is judged to be superior to the current state”. Botta-Genoulaz, Millet, and Garbot (2005), indicate that two distinct research streams are observed from the literature. The first one focuses on the fundamental corporate capabilities driving ERP as a strategic concept, and the second, on the details associated with implementing an information system and their relative successes and costs. Problems of sociological and cultural factors influencing the implementation success as well as the implementation steps have been addressed earlier in literature.

As indicated by Chen, (2001), “planning for ERP adoption generally occurs when an organization realizes that current business processes and procedures are incompetent for their current and or future strategic needs”. As the result of various external and internal forces, the SMSCO operating environment is changing and their procedures are becoming “incompetent”. They are not able to maximize their efficiency and therefore, profit. Any tools that would enable these organizations to reverse this trend must be considered. In order to promote the use of ERP by SMSCO, a more comprehensive look of the potential benefits that could be achieved must be completed. To that end, an extensive review of existing literature was conducted with the emphasis placed on identification and types of potential benefits. Within this context, benefits are defined to be acts that promote increase of efficiency in operation and additional profits generated from operation.

Typically, process-based benefits that arise from IT investments can be divided into three categories, as indicated by Andersen, (2001), typical efficiency benefits, typical effectiveness benefits, and typical performance benefits. Some of the benefits that could be realized in an SMSCO environment as a result of ERP implementation could be as follows:

1. Improved responsibilities in relation to customers
2. Stronger supply chain partnerships
3. Enhanced organizational flexibility
4. Improved decision-making capabilities
5. A Reduction in project completion time and cost
6. Opportunity for the enterprise to re-engineer and upgrade its business process

The above-mentioned benefits could further be divided into two main categories of tangible and intangible benefits. Historically, as indicated by Murphy and Simon (2002), the different treatment of tangibles and intangibles can be traced to the distinction between goods and services. As far back as Adam Smith, goods were material and could be stored, whereas services were immaterial and transitory. This transitory nature meant that services could not be counted as assets, but goods could. It logically follows that items that had been counted as investment must be tangible. Remenyi, Money, Sherwood-Smith, and Irani (2000), stated that a tangible benefit is one that directly affects the firm's profitability; however, in today's economy many investments are intangible, and these investments yield higher profits that translate to greater output and savings. The International Accounting Standard defines an

intangible as an identifiable non-monetary asset without physical substance held for use in the production or supply of goods or services, for rental to others for administrative purposes (Bradbury, 2001). It is very difficult to determine intangible benefits derived from ERP implementation. Remenyi and Sherwood-Smith (2000), indicated that there are seven key ways in which information systems may deliver direct benefits to organizations. They also indicate that information systems deliver intangible benefits that are not easily assessed. Nandish & Irani (1999) discussed the difficulty of evaluating IT projects in the dynamic environment, especially when intangibles are involved in the evaluation. Tallon, Kraemer, Gurbaxani (2000) cited a number of studies indicating that economic and financial measures fail to assess accurately the payoff of IT projects and suggested that one means of determining value is through the perception of executives. They focused on the strategic fit and contributions of IT projects but indicated that researchers need some how to capture or better represent the intangible benefits of IT. Giaglis, Paul, and Okeefe (1999), discussed the problematic variables associated with qualitative (intangible) benefits in their assessment of information systems evaluations. Litecky (1981) stated that, despite the perceived importance of intangibles, there has been little, if any, guidance on the quantification of derived benefits. He proposed some assumptions as a precondition to quantifying benefits. Both tangible costs and benefits are relatively easy to estimate, whereas intangible benefits are quite difficult to estimate. Hares & Royle (1994) indicated that there are four main intangible benefits in IT investment. The first benefit is internal improvement or infrastructure investment; tangibly important to the business. The second benefit concerns the perception of the business by its customers. The customer-based intangible benefits, consist of those services

that the customer sees now and wants in the future, and includes customer service and user satisfaction. The final two categories are future-based and include market trends, and the ability to adopt and adjust to change.

It is clear that ERP system investments have been categorized as strategic in nature. Literature review identifies the common goal to be an increase in company sales, reduction in production cost, reduction of lead times, and improvements in customer relationships. All of these areas badly in need of improvement by members of SMSCO. In a survey by Meta Group (Steadman, 1999), organizations turned up an average value of $1.5 million when quantifiable cost savings and revenue gains were calculated against system implementation and maintenance cost. Other research indicates that return on assets, return on investment, and asset turnover are significantly better over a 3-year period for those who adopted EPR systems as compared to non adopters (Hunton, Lippincott and Reck, 2003), even if the benefits differ by company size (Mabert, Soni and Venkataramanan), or, according to two organizational characteristics - interdependences and differentiating among a global organization (Gattiker, Goodhue, 2005). In addition, as indicated by Murphy (2002) improved customer service and other related intangible benefits, such as updated and streamlined technical infrastructure, are important intangible benefits that organizations are often seeking when making these investments.

Two main difficulties that exist when it comes to the topic of ERP implementation and its benefits are identification and quantification (Anderson, 2001). The process of identifying benefits that are applicable is rather complicated and since there are no guidelines or standard procedures that all organizations can follow, this leads into inconsistencies (Anderson, 2001). As indicated by Anderson, (2001) the second area

that most difficulties have occurred is the quantification of the benefit items, especially intangible items. Ohlsson, et al. 2001, states that due to the ERP system's multidimensional nature, intangible benefits will affect many aspects of the investing company. He further states that although it is hard to assign any financial values to these intangible benefits, at least without stretching assumptions beyond an acceptable level, it is still important to quantify them. The most common metrics used for these benefits are binary, numeric, or qualitative in nature, and by using these, it is possible to identify and evaluate how they will impact on the company.

Section 2.1.3 Risks & Causes of ERP Failure

Among large organizations that have implemented and are currently using various ERP systems, there are numerous success stories ; however, as Chen (2001) reports, "while companies such as Cisco Systems, Eastman Kodak, and Tektronix have reaped the expected benefits of ERP systems, many businesses are discovering that their ERP implementation is a nightmare". One of the biggest examples of this type of failure was case of FoxMeyer Drug, a $5 billion pharmaceutical company that had to file for bankruptcy as a result of problems generated by a failed ERP system. In addition, Dell Computer spent large sum of money on ERP system that had to be scraped. Some other recent failures of note are cases at Boeing, Dow Chemical, Mobil Europe, Applied Materials, Hershey, and Kellogg's. It is reported that 40% of all ERP installations only achieve partial implementations and 20 % of attempted ERP adoptions are scrapped as total failure. Considering these facts, one must investigate the reasons that attempted implementation lead to such results. Review of these cases reveals certain common criteria that are repeated among all cases ending in a failure. These criteria, which have created such a high degree of failure rate

among large organizations, have been analyzed and studied by previous research. In order to properly analyze each of these criteria we must first define “failure”.

There is an extensive amount of literature that deals with issue of failure of an information system. Tsung (2004), indicate that “unlike success, only one failure factor need be present for the information system to be deemed a failure”. Ewusi-Mensah & Przanyski (1995), discuss three types of failure; these are total abandonment, substantial abandonment, and partial abandonment. Lyytinen & Hirschheim (1987), divide failure up into four distinct categories; correspondence failure, process failure, interaction Failure, and expectation failure. Overall failure criteria can be categorized as either technical or non-technical.

Section 2.1.3.1 Failure Criteria for Large Organizations

In most organizations failure occurs when one or more of failure criteria are not properly addressed. In case of ERP systems, since they are mostly people oriented, most criteria fall into the non-technical category. These criteria can be identified as:

- Evaluation
- Cost – Benefit Analysis
- High Cost & Complexity
- Training
- Time Scale
- Current Practices

Study of the above mentioned failure criteria will help us establish a better understanding of the prohibitive criteria that are preventing a large number of SMSCO from utilizing ERP systems.

Evaluation

Why is evaluation important in the whole concept of ERP? Evaluation has been defined by the Oxford Dictionary and Thesaurus, to be a process in which one can assess, appraise, value, estimate, gauge, calculate, figure, reckon, compute, judge, rate, rank, or quantify. It has also been defined by (Ohlsson, et al. 2001) as a weighing process to assess the value of an object or the merit of a situation. Having a clear and concise understanding of ERP is one of the most critical criteria in either successful implementation or rejection of the whole concept. We evaluate things when we are trying to achieve a better understanding of them, therefore proper evaluation of ERP and establishing a better understanding of its critical criteria are essential elements to the eventual successful implementation, and a must for any organization. Companies will have to decide on committing large amount of capital, both in terms of financial and manpower. This decision should not be made lightly and based on subjective terms, rather it must be addressed through a complete evaluation method that identifies and measures various risk and benefit items. It must be noted that current literature deals extensively with various evaluation methodology and framework that are available. As indicated by Irani and Love (2001), there are lots of studies dealing with innovative attempts to surmount the theoretical problems of IT evaluation, such as conventional financial and economic evaluation, techniques (Brynjolfsson, 1993), return on management (Strassman, 1988), and information economics (Parker, Benson, Trainer, 1988). In addition, others have proposed taxonomies of methods such as Cronk and Fitzgerald (1997), and Irani and Love (2001). Remenyi and Sherwood-Smith (1999) argue that a multi-metric approach will ensure a comprehensive understanding of the organization and the IT project being

developed. Cronk & Fitzgerald (1999), also recommends a multi dimensional methodology involving both quantitative and qualitative components.

Lubbe and Remenyi (1999), argue that too much emphasis is placed upon economic criteria and that management should look into all aspects of the investment in a holistic way.

In order to achieve the value-added benefits of the ERP process, organizations must address the following critical factors:

- Strategic Match
- Stakeholders Influence
- System Specific
- Organizational Impact
- Life Cycle Approach
- Financial Criteria

Current literature mostly concentrates on evaluating the system and its immediate impact, rather than focusing on its strategic potential and match with organizations overall goals and strategy. Most attention is given to financial aspects and little attention is given to non-financial factors, such as customer service, operational efficiency, etc. (Kennerley, Needy 2001). The strategic impact of an ERP implementation must be considered in an evaluation process. ERP implementation goals must match and fit within the overall strategic goals of the organization. Doing so will force the organization as a whole to come into focus with its ultimate goal. These goals must be set with both short and long term views in mind.

Ballentine, Leavy, Powell, (1998) argue that IT investments should be aligned closely with an organization's IT strategy and that there is also a need to align IT strategy with business strategy. Kefi (2002), emphasize the importance of identifying the strategic context before implementing a system or starting an IT project in order to achieve the right business focus. Gemmel & Pagano (2003), are of the opinion that it is necessary to make sure that the IT system also supports the business strategy during the post-implementation evaluation.

The influence of stakeholders must be considered. It is critical to properly identify all stakeholders; both internal and external stakeholders must be considered. They each have an objective that must be taken into account and molded into the overall goal and objective of the organization.

Frisk (2004), indicates that an analysis of the objectives and influence of the various stakeholders is a common part of many of the evaluation studies. External and internal stakeholders of the project (Huang, 2003) etc. are mentioned. Frisk (2004), continues with the finding that, although stakeholders appear to be an essential part of the evaluation, there seems to be an overall lack of explanation on how they should be identified and included in the evaluation (Choenni, Bakker, Baets, 2003; Van Grembergen & Van Bruggen 1999; Griffith& Remenyi, 2003). A number of articles that explore methodologies to include stakeholders, such as Hughes and Jones (2001), emphasize the use of grounded theory in IT evaluation to include stakeholder's views, beliefs, and assumptions are very few. Pouloudi & Whitley (1997), present a methodology to identify stakeholders, which originally was constructed by Freeman and Hannan (1984). This approach emphasizes that stakeholders depend on the specific context, that they cannot be viewed in isolation, that stakeholder's position

may change over time and that feasible options may differ from the stakeholder's whishes. A common theme among all these papers is the fact they all focus more on a continuous evaluation as Irani & Love (2001), would say, they incorporate understanding of benefits, value and suitability of IS/IT.

When an organization is deciding on which, if any, of the ERP tools could be used, they must consider the requirements needed from the system. A specification for the system must be generated within which all or some of the following factors must be a reviewed: interactivity, usability, synergism, reliability, flexibility, speed, and accuracy. As indicated by Frisk (2004), there are some authors that find it important to consider system-specific characteristics in the evaluation of general or specific type of systems. Martin, Bolissian, Pimendis (2003), considers the system characteristics as one part of the evaluation content, while others view them as the most important part to evaluate (Skok Kophamel, Richardson, 2001; Lee, 2001).

If and when an ERP system is implemented within an organization, it must be understood that it will impact the whole organization and its transformation (Holland, Light, 1999), in various ways. Since each way will be significant, each must each be carefully analyzed and reviewed. One of the primary items an ERP implementation will impact is the structure of the organization. Studies confirm that the introduction of business practices and new organizational practices are directly correlated to labor productivity (Falk, 2005). Departments that are accustomed to a certain hierarchy will have to change ways and methods. These changes must be identified and dealt with by reshaping the business processes of the organization. The ability to respond to these required changes should be considered significant. In addition, current external factors within the organization's business environment must be considered.

Government agencies, customers, suppliers, and competitors could generate these external factors. Finally, the impact on the system's users and their ability to adopt the new technology must be considered.

Impact of an IT investment on the organization has also been studied by researchers. Doherty & King (2001), are of the opinion that there needs to be an organizational alignment, which means that one needs to consider the organizational structure, its culture and also aspects of power relations, Kannellis, Lycett, and Paul, (1999), emphasize the importance of considering the strategic fit of an information system (IS) to the strategy, structure, process, technology, and environment. They conclude that a poor fit in the system relates to an inability to respond to change. Stefanoue (2001), points out that an organizational change is required if any benefits are to be realized. Al-Mashare and Zairi (2000), also argue that success necessitates managing adequately a complex context that involves organizational changes across various key areas.

Some authors promote the importance of considering the external environment in IS/IT evaluation, especially in articles that focus on collaborative and inter-organizational systems. Those authors find it important to consider aspects of the external environment of the organization, such as integration process between organizations (Huang, 2003), and social relations with customers and suppliers (McCalla, Ezingeard, and Money, 2003). Li and Ye (1999), provide a definition of the environment, and why it is important that it be considered. They explain that the environment is the totality of outside factors consider by top managers in their decision-making process. Two frames of reference are used to describe the environment: environment as different segments (customers, competitors,

governmental agencies etc.) and environment along critical characteristics such as dynamism and organizational flexibility. As IT's performance depends on contextual factors, it is important to have them in mind during evaluation (Mcbride & Fidler, 1994).

The life cycle approach to the process of evaluation is also a method that must be considered in the evaluation of implementation. This approach allows the organization to complete its evaluation in steps that have been identified by Frisk and Planten (2004), to consist of the following: feasibility, development, implementation, post implementation, and routine operations.

There are only few papers that used a life-cycle process model (Cronholm & Goldkuhl, 2003; Jones & Hughes, 2001) for IT evaluation or benefit realization in their investigation. Most of papers address feasibility evaluation of IT in general (Berghout & Klompe, 1996; De Jong, Ribbers, 1999; Bannister, 2001; Kumar, 2003). Post-implementation evaluation was pointed out as being important by some authors (Skok et al, 2001; Auer, 1998) but not pursued in any papers other than those that used life cycle based approach (Cronholm & Goldkuhl, 2003). According to Remenyi and Sherwood-Smith, (1999), the evaluation activity should be more participative and directly aimed at the learning process so that what is learned at each step in the process can be carried forward into the overall development process. Irani and Love (2001), state that there is a need to re-think the evaluation process and make it more of a life cycle process that seeks to provide decision-makers with an opportunity for reflecting and learning rather than a process that stigmatizes failure.

By far, the most significant criteria that need to be carefully analyzed when it comes to evaluation of ERP is the financial one. Most organizations are very conscious of

this factor and the impact that it might have on their operation. When dealing with financial criteria, we must be concerned with the metrics used to measure them; after all you cannot adequately evaluate something that has not been correctly quantified. Only relying on subjective measurements will not produce reliable results. In addition, organizations need to approach the investment in an ERP as capital asset expenditure, an asset that needs time to mature and pay dividends. Considering only a short-term view in evaluation of ERP will not truly reflect the potential benefits and costs that must be considered. Experience shows that at times, the ERP implementation process will take anywhere between 2 to 5 years to complete (Gunson, Blasis, 2001). Cost benefit analysis has been mentioned as the most often method used by various organizations to evaluate and justify their investment in ERP. This method of analysis bears such an important imprint on the evaluation process that it needs to be looked into with greater detail.

Cost Benefit Analysis

Cost benefit analysis is defined by Prest & Turvey (1965), as "… a set of questions, the answers to which constitute the general principles of cost benefit analysis:

1. Which costs and which benefits are to be included?
2. How are they to be valued?
3. At what rate are they to be discounted?
4. What are the relevant constraints?"

A cost or benefit has been defined by Parker (1982), to be as measurement of the amount of resources required to produce a product. As indicated by Parker (1982),

costs are normally expressed in terms of quantitative dollars required, whereas benefits could take the qualitative form of cost-saving, cost-avoidance.

In an environment where numbers can dictate results, the board of directors and senior management of organizations in industrial sectors have felt comfortable relying upon cost benefit analysis to finalize their decision when it comes to investment in an ERP. Among all available factors affecting evaluation, it seems that this factor has been relied on by most to demonstrate the viability of the decision either way because it relies on quantitative rather than qualitative terms. It is surprising to find that as reported by CIRIA (1996) in the U.K. (Love, Irani, Li, Tse, and Cheng, 2000) and Australia, organizations in the construction industry do not use any form of cost benefit analysis. This could be the result of problems associated with assessing benefits and costs due to the construction industry's structure, fragmented supply chain, and under capitalization (Anderson, Baldwin, Betts, Carter, Hamilton, Stokes, Thorpe, and 2000; Marsh and Flanagan, 2000).

Among the critical elements to consider when studying cost benefit analysis is the cost and benefit of the tangible vs. the intangible. The tangible category has been defined to be the items that are easily quantifiable and directly affect the profit of the organization. The intangible category has been defined as all items that are difficult to quantify and at times do not directly impact the profit of the firm. Identifying tangible and direct costs and benefits are relatively simple. They are easily recognized. Their life cycle is clear to all concerned and the metrics to measure them are accepted globally. It is the intangible cost and benefit that must be scrutinized more carefully. Their impact on the process is not self-evident. There are no clear metrics to quantify them for the purpose of evaluation. At times certain costs and benefits will be seen as

"constructed" and thus the reliability of the evaluation might decrease; however, their inclusion in the evaluation process is critical. In a study done by Murphy and Simon (2002), it was demonstrated that when intangible benefits were introduced into the evaluation process, even in a limited form, they changed the results significantly and allowed the organization to proceed with implementation of the ERP. As the system grows and supports the complete management structure, the role of intangible benefits becomes more and more significant to the point that ERP implementation becomes a long term capital investment.

Another problem that must be considered when utilizing a cost benefit analysis is the fact as reported by Ohlsson & Ollfors (2001), that this method at times overlooks the issues related to risks with the investment, where by since it does not consider costs and benefits that are too difficult to quantify, it might encourage companies to make low risk investments only.

High Cost & Complexity

The high cost of implementing an ERP system must be analyzed as a failure criterion. It is reported by Chen (2001), that the total ERP cost including software, hardware, consulting, and internal personnel can easily run as high as 2% - 3% of a company's revenues. The cost to implement a new ERP can range anywhere from $2 million to $4 million for a small firm, to over $1 billion for a large company. Cotteller, Austin, and Nolan (1998), reported a breakdown of the implementation costs for its ERP system integration as follows: software, 16%; hardware, 32%; system integration, 38%; and headcount, 14%. A cost category that is included in the breakdown above, but is not highlighted is the cost of consultants. It is suggested by Adam and O'Doherty (2000), that the ratio of the software cost to consultant cost is 1 to 7,

indicating the significant impact of cost associated with hiring a consultant. The above mentioned direct ERP implementation cost items will also generate substantial other indirect and intangible costs that reverberate throughout the whole organization. Corporations that are not adequately prepared to deal with issue of cost from a capital point of view will certainly face difficulties that could cause the ultimate failure of the whole implementation process. ERP systems are complex systems that will require outside resources to be fully implemented. As indicated by Adam, O'Doherty (2000), consultants often advise managers to undertake some degree of re-engineering of key processes before acquiring ERP systems and this adds to the complexity and political character of the projects.

Training

Following the successful implementation of an ERP system organizations need to provide for extensive training of their personnel. This training and its associated issues such as cost and complexity create obstacles for the successful adaptation of an ERP system. Since these systems are continuously updated they require additional training that must be provided to the staff. All this training requires allocation of time and money that must be provided through the overhead budgets of various departments within an organization. The monetary resources that would be necessary to complete the required training are not readily available. In the past, senior management has been hesitant to commit to allocate continued funding for items such as training.

Time Scale

Time to fully implement an ERP system and allow for its full effect to come to fruition is rather long for construction industry standards. The construction industry by nature is a very temporary. Results need to be achieved in a short period of time. Investing in an item that would result in creating additional benefits long after the completion of a job creates a big problem for the industry to address.

Frisk (2004), states that according to an article in *Business Week* (Coy & Mullaney, 2003) American companies today have improved their results thanks to investments in IT made 7 to 8 years ago. Ahmed, Ahmad, Azhar, and Malikarjuna, (2003), indicate that according to case studies that were conducted, the minimum implementation time taken was 1.5 years and the maximum was 5 years. As indicated by West and Daigle (2004), "achieving many of ERP's benefit takes time". Frisk (2004), indicates that the time element associated with the realization of benefits of ERP implementation is one of the four major problems in IT benefit management. She states "benefits evolve over time, which implies that they are not stable. This makes it extremely difficult to create a comprehensive catalogue of potential benefits". It is not uncommon to find companies that continue to have problems and not fully take advantage of their system well past the first year after the implementation was complete (Tsung, 2004). Web (1998), believes that organizations cannot afford to spend years implementing technology solutions. He indicates that in some industries, lengthy implementation can provide competitors with enough time to threaten or even overtake the market position of the implementing organization.

A new approach to the element of time is required. As indicated by Parker (1982), it is time for industry to view investment into ERP as a long term capital investment.

Parker (1982), indicates that this investment unlike most other capital expenditures: (1) does not depreciate and, in fact, should appreciate as the number of applications is increased, (2) most probably cannot be sold as can other assets because of its unique implementation, but (3) can be copied with ease and provide to another function in the enterprise, with no development cost incurred by recipient.

Current Practices

Current practice consists of existing legacy systems that have been put together and utilized by the organization over a period of time. These systems could be both technical and or non technical in nature. Technical systems could consist of various software packages that have been purchased and utilized by the organization to provide a solution for a particular need of operations. Naturally any change from using the current ways will need re-thinking and re-training of the organizational structure its employees and culture. As indicated by Tsung, (2004), implementation of ERP systems requires a great deal of management change; it affects the whole organization and it is a people centered application. Numerous authors have commented on the fact that many IT investments fail to provide the productivity and efficiency benefits that are expected (Wilcocks et al., 2000), often because information systems are used simply to automate existing processes and practices, rather than radically rethink them. Organizational Change Management (OCM) is defined as the process of controlling changes to the infrastructure or any aspect of services in a controlled manner (Robins, 2001). It is a methodology that is used to aid in the implementation of approved changes so that there is minimum disruption (Lauden and Lauden, 2002). Avgerou (2002), divides changes in relation to IT projects into two different groups; planned radical changes and emergent, situated

changes. Planned radical change is described as "associating the development of technology – based information systems with radical organizational restructuring." (Avgerou, 2002). Tsung (2004) indicates that Business Process Re-engineering (BPR) would fall under this category and can be described as a radical re-design of business processes in order to eradicate repetitive and/or paper-intensive tasks to decrease costs, increase quality and services, and maximize utilization of the information technology in place. The implementation of ERP systems will encompass both 'planned radical 'and 'emergent, situated' changes.

In order for an ERP system to become fully operational and function in an optimum environment, it must take into account and match organization's business process. As previously mentioned, even though the majority of research indicates that in order for ERP system to be successfully implemented it must be fully and completely adopted, there are those organizations that, as indicated by Ghost, Howell, and Whittaker, (2002), have decided to avoid high maintenance costs or to deploy a standard corporate model in an international group by appropriately customizing both the ERP system and/or their organization; however, as predicted and indicated by Botta-Genoulaz et al., (2005), the current ERP systems are not as flexible as needed to support easily newly discovered customer trends. Technical and process change capabilities for customization are identified to propose a framework for supporting management decision-making about customization choices (Luo and Strong, 2004).

Implementation of an ERP system creates many issues that directly or indirectly deal with people and their interaction with the system. ERP impacts people within the organization as the nature of their work changes. Role responsibilities and processes change (Pereira, 2004). As indicated by Tsung, (2004), four issues that are centered

on the user are usability, acceptance, support, and involvement. The common element among all these issues is staff attitude. This attitude under goes measured changes, which has been studied in detail by Adam, et al., (2000). He indicates that as time passes, the staff's attitude rises and falls through four distinct segments. These segments deal with level of enthusiasm of the end users toward ERP utilization and range from lack of motivation to business as usual on one side and growing enthusiasm to total commitment on the other side. It has been documented that initially a staff is very enthusiastic about the new system ; however, as it becomes clear that they would need to learn new ways and cannot rely on the current legacy systems to meet the day to day needs of their job, their hesitancy increases. How organizations react and deal with this phenomenon will have significant impact on the success or failure of ERP implantation.

Section 2.1.3.2 Risk Assessment

When implementing an ERP system it is crucial to consider the risks and uncertainties associated with the project. "Risk is defined as situations in which the outcome is not certain but where the range of possible outcomes is known and the probabilities associated with these outcomes are known or can be estimated with some accuracy. Uncertainty relates to those situations when the range of outcomes is known, but where probabilities cannot be estimated accurately, or where even the range of possible outcomes is not known" (Parker, 1982). Elements that contribute to both risk and uncertainty associated with ERP utilization are impacted by the following items; financial decision, acceptance by staff, condition of legacy systems, technical complexity, and implementation process. A study by Ohlsson, et al., (2001), indicates that organizations conduct financial risk analysis because they are

concerned that the investment becomes so expensive that the company as a whole goes bankrupt. The same study reveals that a number of organizations performed a risk analysis on the risks inherent in the old or legacy systems to determine if these risks could be eliminated by investing in an ERP system. In some cases, the technical complexity of a system might necessitate equipment and experience to which the organization's investor or owner does not have access, and this might lead to unexpected costs and time delays. Finally, Ohlsson, et al., (2001), indicates that a number of organizations perform a risk analysis on the implementation process and its impact on the culture of the organization.

The issue of risks and uncertainties associated with ERP utilization has been investigated by numerous researchers in the past. Many papers that deal with the evaluation of risks and uncertainties use option theory oriented approaches that try to control and estimate the different optimal start times for various processes in ERP implementation (Frisk, et al., 2004). Other articles that completely ignore how the evaluation of risks and uncertainties should be performed and only state that it is important to consider them in evaluation (Banister, 2001). Ropponen and Lyytinen (1997), argue that software risk management can improve system development performance.

Section 2.1.4 Obstacles in Use of ERP by SMSCO

Reviewing the nature of benefits and pitfalls of ERP implementation in large construction organizations allows for a better understanding of these same issues in an SMSCO environment even though issues cannot be transferred directly from one environment to the other, but share significant similarities. Since one of the primary goals of this research is to define and analyze the obstacles in utilization of ERP by

SMSCO, a review of current literature that dealt with the validity and applicability of previously mentioned issues in an SMSCO environment was conducted, even though limited in number,

The current literature identifies the following major common obstacles;

1- Training

2- Time Scale

3- Evaluation

4- High Cost and Complexities

In addition, Anderson, et al., (2000), identifies the following additional obstacles in ERP adoption by SMSCO: conservatism of the ownership group, the high risk of litigation following the use of innovative solutions that subsequently fail, high rates of change in technology and business solutions, lack of user training investment, the overselling of benefits by IT solution providers, the lack of standardization leading to incompatibilities, conflict, and too many choices. Shi and Halpin (2003), indicate that a lack of additional practical functionalities that would suit SMSCO members such as functionalities for handling earned value, percent complete, cost forecasting for determining project progress, scheduling, budgeting, project tracking, procurement process, and reporting is also a problem. Shi and Halpin (2003), also indicate that the size of the system or its scale needs to be adjusted to fit the construction operations of SMSCO. Finally, Adam, et al., (2000), identifies the fact that ERP projects are complex and require reliance on many different types of expertise often sourced outside the organization. Clearly obtaining the services of such outside resources is not as readily obtainable for members of SMSCO.

Section 2.1.4.1 Prohibitive Criteria for SMSCO

As indicated previously, a review of current literature identified a number of failure criteria in the concept of ERP utilization by large construction organizations. In addition, the same review indicated that some of the same obstacles could also apply to SMSCO members however it was surprising to discover that due to lack of available research, no definite understanding of potential prohibitive criteria exists. Prohibitive criteria are defined to be criteria that prevent a SMSCO from proceeding with the purchase and implementation of an ERP system. Merely knowing the obstacles that might exist in the path of an organization is not sufficient to address the objective of this research. This lack of clear identification by existing research reinforced the particular goal of this research to proceed with the task of clearly identifying the prohibitive criteria that prevent members of SMSCO to proceed with utilization of ERP systems.

Section 2.2 ERP Research in Academia

ERP related research has experienced a steady growth pattern for the last decade. A number of articles, special journal issues, and dedicated sessions in international conferences published about ERP have been growing steadily. As indicated by Botta-Genoulaz, et al., (2005), this increase follows the progress of implementation of ERP systems in companies. It is noted that most of research is done on the periphery of the ERP (Botta-Genoulaz, et al., 2005). Within context of this research and in addition to research mentioned before, the current literature was reviewed along the following main categories:

2.2.1 - ERP Optimization

2.2.2 - ERP & Management Systems

2.2.3 ERP Tool

2.2.4 ERP & Supply Chain Management

2.2.5 ERP Case Studies

2.2.6 ERP Alternatives Systems

2.2.7 ERP in SMSCO

Section 2.2.1 ERP Optimization

ERP optimization issues are one of the main post-implementation areas of interest that have been researched by the academics. As indicated by Botta-Genoulaz et al., (2005), until recently, nearly all literature on ERP was focused on ERP projects and ERP implementation; the post implementation phase had been identified but very little attention had been paid to the real return on investment of such big projects. They define a successful ERP project as the one in which as result of it organization is able to better perform all its business process and when the integrated information system can support the performance development of the company. Botta-Genoulaz, et al., (2005), contend that the maintenance activity can be considered as one point of view of the optimization. ERP systems are very complicated and need to be maintained and upgraded on routine basis but unfortunately there are only few papers that focus on this critical task. Ng, Gable, and Chen, (2002), addressed this problem based on a case study of a large organization that implemented ERP. This study observed some distinctions of ERP maintenance and proposed a benefits-oriented taxonomy that better represents ERP maintenance activities, including ERP enhancement. Nicolau (2004), examines the process of system review during the post

implementation stage of an ERP implementation. Based on two case studies that were conducted he defines a construct of post implementation review (PIR) quality that could be used to re-examine performance relationships and more completely interpret their results, or lack of results, according to the extent to which organizations engage in high quality PIR.

The issue of end user utilization is a key factor in overall optimization and increase in productivity that could be caused by implementation of the ERP system. Orlikowski and Barley (2001), suggest that both the technological changes and the institutional contexts that are reshaping economic and organizational activity have contributed to the transformations currently occurring in the nature of work and organizing. Wu, Wang, Chang-Chein and Tai, (2002), conducted a survey to identify user satisfaction patterns. They identified several areas of low ERP satisfaction, like feelings of user involvement, system understanding, or system integrity. This aspect is also studied by Casilir and Calisir (2004), who from 51 end users in 24 companies, examined various usability factors affecting end user satisfaction with ERP system; their results indicate that both perceived usefulness and the ability learn determine the end user satisfaction.

Section 2.2.2 ERP & Management Systems

Botta-Genoulaz, (2005), indicates that ERP systems are the major managerial tool and technology that requires the multi-disciplinary attention of operations management, information systems, finance, marketing, organizational behavior, and human resources fields (Sarkis and Sundarraj, 2003). This observation was confirmed sby the importance of research publication in management and business journals - since 1997, half of the publications are including “enterprise resource planning” in

their abstract. Management's strategy for ERP adoption is a key factor in overall success of implementation. Bendoly and Kaefer (2004), show transaction efficiency is magnified when ERP implementation precedes B2B initiative. De Vaujany (2003), identifies "appropriative trajectories" of organizational change facing computer and software growth, linked to specific "logics of control".

The role of ERP in creating business best practices is also investigated from management's point of view. Gardiner, Hanna, and Latour (2002), indicates that a streamlined sales order process with managerial implications to pursue the reduction of marketing cycle times and enhances customer service results from the implementation of ERP system however as indicated by Botta-Genoulaz, et al., (2005), there are some studies that reveal the contrary, that ERP systems have led to relatively small changes in management accounting and control procedures. This seems to be linked with the extension of integration. As in most cases, advanced management accounting techniques as well as many traditional techniques are operated in separate systems (Granlund and Malmi, 2002).

Another important issue from management's point of view is the issue of the company's culture and sociologic dimensions. Studies by Yen and Sheu (2004), and Amoako-Gyampah and Salam (2004), cover the cultural issues in operational use of ERP such as shared belief that users form about the benefits of the technology, or national culture in a multi-national ERP setting, or cultural differentiation of Japan, where ERP includes an active interaction with institutional systems. Kumar, Maheshwari, and Kumar (2002), have studied in detail the unique culture of government organizations, their added social obligations, higher legislative, and

public accountability, and how that makes for a specific challenge to control the enterprise system.

Section 2.2.3 ERP Design Issues

Recently some studies dealing with ERP architecture, design, data model, and web services have been completed. As indicated by Botta-Genoulaz, et al., (2005), until 2002, less than 25% of ERP related research had a focus on IT aspects, however recently they indicate that this rate has increased to 40%.

The potential architecture of the information system has been one of the main areas of interest for various researchers. Maheshwarf, (2003); Smith, O'Brien, and Barbacci, (2002), indicate that the information system has to support distributed systems. Kovacs, and Paganelli, (2003), suggest that the requirements for planning and operations in networked organizations and supply chain are solved using web server (MES) using mobile software agents. Some research includes a multi-agent engine in the ERP architecture (Lea, Gupta, 2005; Symeonidis, Kehagias and Mitka, 2003). Kim (2004), cites process modeling as a key point for ERP control however Abdmouleh, Spandoni, and Vemadat, (2004), indicate that existing enterprise modeling methods like UEML or CIMOSA do not seem to be utilized for ERP, even though they could propose a distributed architecture definition.

Studies by Maheshwari, (2003); Carey, (2004); and Lam and Shankararaman, (2004) deal with languages, systems and norms for integration, and internal-use enterprise application. Commonly, integration uses XML languages (Maheshwari, 2003; Hu, 2003; Touir, Mathour, and Al-Naeem, 2003). Consequences for ERP of business

process management norms like BPML (Smith, et al., 2002), ebXML (Choi and Raghu, 2004), are also dealt with.

As indicated by Botta-Genoulaz, (2005), the design and engine of ERP logic are discussed beyond the traditional transactional server based on a relational database containing enterprise data. They further state that new approaches are proposed to enhance query (Carey, 2004; Chen and Chen, 2005;), to define a computational model suited to the data model using ontology (Hu, 2003), to reuse components with design patterns methodologies (Touir, et al., 2003), to include process mining to monitoring operational processes (Van Der Aslat, et al., 2004). Smets-Solanes and Atem, (2003), propose a radical re-engineering, redesigning ERP as a content management system, where each object is firstly defined as a document including data needed for transaction.

Section 2.2.4 ERP & Supply Chain Management

The relationship between ERP and supply chain management (SCM) has been subject of increasing research. The relationship created as a result of ERP being a platform for other core business applications such as SCM (Ragowsky and Somen, 2002), is not fully understood.

Some recent studies deal with integration between ERP and advance planning systems, or advanced planning and scheduling systems. Some of them have extended the integration to other software components, like manufacturing execution systems, warehouse management systems (WMS) and transportation management systems (TMS) (Botta-Genoulaz, et al. 2005). Liu, Chua, Lam, Wang, Cai, and Yin (2002) address the system integration of an APS system with ERP and MES. They propose

an integration model structure and illustrated it by the system integration mechanism taking into account the required frequency of data integration and different approaches of data transfer. Chen and Chen (2005) develop a tactical level decision model that solves the production scheduling problem, as analogous to the sale and operations planning, the authors proposed a scheme that can be used as a coordination centre of the APS system within a generic ERP framework, which integrates and coordinates distinct function within a firm. Verwijmeren (2004) presents software component architecture for supply chain management across dynamic organizational networks. The author proposes a local management in the architecture, which is done by existing ERP, WMS, and TMS systems, while the whole management is executed by supply chain engines. Gayialis and Tatsiopoulos (2004) utilize advanced IT systems to effectively support the planning and management of distribution operations, and particularly, the transportation process. The combination of SCM application with a geographical information system (GIS) integrated with ERP software resulted in a decision support tool (Botta-Genoulaz, et al. (2005).

Supply chain coordination, which is composed of several legal entities, and contribution of ERP to that has also been also studied as an issue. Akkermans and Van Helden (2002) studied the future impact of ERP systems on supply chain management. They observed that a panel of experts saw only a modest role for ERP in improving future supply chain effectiveness and a clear risk of ERP actually limiting progress in SCM. ERP was observed to be having a positive contribution to only four of the top twelve future supply SCM support. Botta-Genoulaz, et al. (2005) indicate that the first generation of ERP products has been designed to integrate the various operations of an individual firm, whereas in modern SCM, the unit of analysis

has become a network of organizations, making these ERP products inadequate in the new economy. Kelle and Akbulut (2005) state that even ERP software provides different tools that can support supply chain integration and at the same time it has several features that prevent the integration with business partners. They based their analysis on the inventory management aspects of supply chain coordination and their results can be used in enterprise software to measure the potential monetary value of policy coordination, to promote cooperation, and minimize the total supply chain system cost.

Kovacs and Paganelli (2003) state that the case of virtual (extended) enterprise, which is distributed in space and/or which are composed of a temporary joint venture of legally different units. They propose software solutions for designs, planning, and operation management of complex, networked organizations represented as nodes of networks, and proposed a complex, web-based solution to manage large, expensive, multi company projects using any type of ERP and flow management solutions.

Section 2.2.5 ERP Case Studies

Companies in general and SMSCO in particular are very reluctant to make their internal information available for review and analysis by an outside source therefore the number of case studies completed about ERP is limited. To the degree possible, researchers have attempted to complete studies that deal with various ERP issues. Yen and Sheu (2004) utilized direct observations and systematic interviews as a method to complete a case study at five U.S. and Taiwanese manufacturing firms to identify two variables, national culture, and government/corporate policies as being critical to ERP implementation in multi national settings. They considered the relation between implementation practices and the competitive strategy of the firms.

Sarkis and Sundarraj (2003) describe a case study at Texas Instruments, and Yusuf et al. (2004) discuss implementation issues at Rolls Royce. Van Merode, Groothuis, and Hasman (2004), discuss the interest of ERP systems for managing the planning process in hospitals. Mauldin and Richtemeyer (2004) discuss the issues of communication about ERP implementation. They consider a sample of firms which have or have not mentioned their ERP implementation in their annual report. Results suggested that the choice not to disclose about the ERP is significantly associated with capital market transactions, firm performance, firm size, and industry.

Section 2.2.6 ERP Alternative Systems

For the purpose of this research, definition of the ERP system has been expanded and defined to be any computer-based system that would allow the organization to optimize its operation and increase its profitability. This expanded definition has been so categorized to enable the particular needs and concerns of SMSCO to be addressed properly. As indicated previously, the focus of this study remains the lack of implementation of any ERP system by SMSCO. Under the definition above for ERP systems, applications currently in use by construction industry can be categorized into two separate groups: Web-based Project Management Systems (WPMS), and various pre-packaged software groups that can be purchased as a whole or in parts.

The current literature was reviewed not to catalog and analyze these systems in detail but rather to establish an understanding of overall systems and with what capabilities are available to be utilized by SMSCO. In addition, since various critical attributes will be analyzed, to study the impact via their utilization within these different systems, it was clear that a basic understanding of these alternative systems is required. These systems are considered to be a part of a solution that can be utilized.

Section 2.2.6.1 Web-based Project Management Systems (WPMS)

Web-based Project Management Systems (WPMS) are defined by Skibniewski and Nitithamyong (2004) to be any electronic project management system that is conducted through private network, which uses internet protocols to transmit information. O'Brien (2000), indicates that WPMS basically provide a centralized, commonly-accessible, reliable means of transmitting and storing project information. Mead (1997), points out that there are four general categories of construction project information that are normally carried out through WPMS: project, design, management, and financial information. Implementation of WPMS can be carried out via the following three options groups; those that provide full CPM service on-line, those that provide a comprehensive family of web-enabled PM software, and those that are created for a company and are project specific.

The first group includes vendors that are referred to as Application Service Providers (ASP) and provide various collaborative services via web access and the largest providers among them include Buzzsaw by Autodesk, Viecon, Project Talk by Meridian Project Systems, Vista 2020 by Market Street Technologies, e-builder, BuildOnline, and Hard Dollar. These services can be obtained for either an annual or monthly fees depending on the level of services and storage required. The key components of these systems include low start up cost, low maintenance cost, and remote data storage.

The second group consists of the group that provides a comprehensive family of PM software solutions. Among the largest providers in this group we could mention Microsoft Project, Primavera, Concentric, and Sage Timberline. The key components of these systems include ownership and localized storage of data.

The third group mentioned consists of in-house packages that have been created by various organizations utilizing outside consultants and for their own project specific use. The key component of this group is lower total cost, and project adoptability.

Among these groups there are a number of similar critical topics. The existing literature was reviewed for coverage on these critical topics that were identified to be: features, benefits, disadvantages, and reasons for failure.

Shi and Halpin, (2003) identify the following features as what typical WPMS should be: project-oriented, integrated, parallel and distributed, open and expandable, scalable, remotely accessible, transparent, reliable, and robust. Anderson, Christenson, and Howard (2003), indicate that WPMS has been mainly seen and used as a tool to enhance the exchange of information. Patterson, (2002) declares that WPMS needs to satisfy the following criteria; provide easy access to project information, offer an easy-to-use interface, minimize information overload, and provide for timely schedule updating. Skibniewski, et al., (2004), list the features that can be supported by ASP's as follows: document management, project overflow, project directory, central logs & revision control, advanced searching, conferencing & white-boarding, online threaded discussion, schedule & calendar, project camera, file conversion, printing, service, website customization, offline access, messaging outside the system, wireless integration, archiving of project information, information service, financial service, e-bidding, and procurement.

The common and dominant benefits that could be realized as a result of WPMS utilization vs. other alternative ERP systems are:

- More efficient information sharing & collaborative flexibility

- Increased efficiency in communication
- Operational optimization
- Lower cost of ownership

Skibniewski, et al., (2004), categorizes the advantages of web technologies in construction into three areas; the support of relevant information services, communication between project participants, and engineering and management computing.

Utilization of WPMS has been shown to increase the efficiency of communication and information sharing among all participants (Malcolm, Lai, 2001). Alshawi, et al (2003) indicates that more and more firms in the construction industry started to realize the benefits of improving communications between the projects and participants, which can lead to improved cost efficiency, better quality, and competitive advantage. Malcom and Lai (2001), indicate that it is considered that the use of web-based project management would facilitate the flow of information on the project between the members of the project's team and would release meeting time for synergy-generating activities such as brain-storming and team interaction, instead of the meetings being merely a vehicle for the transmission and understanding of information. Anderson, et al., (2003), conducted a study that reflected a lower total cost for utilization of WPMS to alternative ERP systems in completing project tasks.

Common disadvantages that have been observed and studied under current literature can be itemized as follows:

- Lack of standardization
- Security/access

- Ownership of data
- Legal complications

Extensible Markup Language (XML) as web language describing information and data has been utilized in various WPMS systems. Even though the construction industry has been able to make some progress by the adoption of aecXML, not enough standardization for AEC terminology has been developed (Cohen, 2000). This lack of standardization has resulted in unsuccessful attempts by project managers to easily access and manage project information (Alshawi, et al. 2003). According to Alshawi and Underwood, (2003) the IT systems that are available and currently used by industry do not consider the needs of widely dispersed participants in large construction projects. In addition Skibniewski, et al., (2004), indicate that the technical difficulties caused by the incompatibility of systems have become an important inhibitor to the adoption of PM-ASP, a type of WPMS.

Alshawi, et al (2003) declares security is a major issue, which need to be addressed for any online collaboration between project team members. They indicate that even though new technological advances have helped to provide security and prevent unauthorized access to sites, they impose a lot of financial constraints on project teams.

Skibniewski, et al., (2004), indicates that system security is one of the most important issues for AEC industry. They conclude that the current “schemes” to protect access to these systems are not adequate and thus have created a low confidence level in construction industry when it comes to security issues.

The construction industry as a result of its conservative nature, views the physical ownership of data as a big impediment. Alshawi, et al., (2003) indicates that designers perceive that holding data centrally (e.g. design information), downloading them when necessary (e.g. the case of 3COM phase II) from the server, and printing at the downloaded destination infringes their copyrights. In addition, they indicate that when designs are held centrally, they could lose control of the project. Skibniewski, et al. (2004), states that ownership and control of data after project completion is of considerable importance when implementing PM-ASPs.

Finally, as indicated by Skibniewski, et al., (2004), new collaborative tools such as PM-ASPs change the work method, making legal responsibilities in this new environment unclear. They continue with the fact that online contracts pose risks, particularly in the area of jurisdiction and enforcement. Results of case studies conducted by Anderson, et al., (2003) indicates that an important constraint in implementation of WPMS is that paper versions of documents were considered as the legally binding documents and this had significant impact on usage of WPMS.

An attempt was made to review the existing literature for documented reason for implementation failures of various WPMS systems. This review made it clear that lot more research needs to be conducted in this area. Common and most dominant reasons that have been identified by various researchers are as follow;

- Lack of Planning
- Lack of Clear Objective
- Lack of Compatibility among users
- Change Management & Corporate Culture

Case studies conducted by Anderson, et al., (2003) indicate that the companies that participated in the study all had limited success in implementation of WPMS and a common characteristic in the three case studies was that the companies rushed into execution of the WPMS, which resulted in the ill considered and imprecise planning and preparation of the WPMS.

They also made the observation that another critical factor in the unsuccessful implementation attempts made by the three companies was a lack of clear objective. Andersen, et al., (2003), further states that it is necessary to decide what the project should gain from a new approach. Does the company need (a) a faster exchange of digital information, (b) more accurate CAD-drawings or (c) a reduced number of plots? It was concluded that having an attitude of achieving whatever benefits that occur as a result of WPMS implementation in usage in all three companies not to be planned and coordinated and therefore only partially successful.

Compatibility among the participants in various WPMS schemes was identified by Alshawi, et al., (2003), as being one of the more significant problem areas. Their case studies indicate that technical issues such as inability to deal with large file sizes and various other issues had to be overcome and although systems worked well with the principle members of the team, some subcontractors found it difficult to match the technology.

These same case studies identified corporate cultural issues such as management of the change process as another one of the main reasons for unsuccessful implementation of WPMS. Alshawi, Et al., (2003), concludes that it will be extremely difficult for construction organizations to achieve the required results of

implementing web-enabled tools without fully addressing the management of change and how people can best be taken on board.

Section 2.2.6.2 Pre-Packaged Software

ERP packages have been defined by Laudon, et al., (2002), to be a system that aims to integrate the main business functions across all the departments within an organization. Smyth, (2001), further declares that these software packages have a high level of integration, with all applications sharing a single corporate database. These systems are designed for an on-line client/server environment. They found that these packages are also intended to provide the best practice, in a global sense, through a range of standardized business processes.

At this time, there are three major players that supply ERP systems via prepackaged software: they are Oracle, SAP and PeopleSoft. A survey conducted by Bradford and Richtermeyer (2002), indicate the following market share for the top three vendors;

- SAP 35%
- PeopleSoft 28%
- Oracle 10%

A brief description of the top three vendors has been provided by Tsung, (2004), as follows:

“SAP is a German company that was founded in 1972. The largest inter-enterprise software company and the third-largest software supplier, SAP is the recognized leader in e-business solutions for all types of industry.”

Oracle began business in 1977. “Today Oracle (NASDAQ:ORCL) is still at the head of the pack. Oracle technology can be found in nearly every industry around the world and in the offices of 98 of the Fortune 100 companies. Oracle is the first software company to develop and deploy 100% internet-enabled enterprise software across its entire product line: database, business applications, and application development and decision support tools. Oracle is the world’s leading supplier of software for information management, and the world’s second largest independent software company.”

PeopleSoft is the youngest company out of the three major competitors. It was started in the 1980s, founded by Dave Duffield and Ken Morris. “Today, PeopleSoft is the world’s second largest enterprise application provider, with $2.8 billion in annual revenue, 13000 employees, and more than 11,000 customers in 150 countries. And the visionary innovation that made PeoplSoft an industry leader continues to fuel its expansion into new technologies, new markets, and new industries. In July 2003 PeopleSoft acquired JD Edwards, creating the second largest enterprise application software company in the world.”

A study done by Ahmed, et al., (2003), indicates that following functions are provided by various ERP packaged programs: accounting, project management, construction management, scheduling, contact management, estimating, budgeting, historical cost tracking & projections, project documentation, CADD, photography management, office administration tools, messaging, project collaboration, human resources, payroll, corporate finance, fixed asset management, equipment/fleet purchasing, mailing lists, and document storage.

Utilization of these pre-packaged systems has the major advantage of either creating or strengthening the following: partnering, standardized reporting, common understanding of terms/functions, single data sources, wider integration opportunities, simplify contracting, subcontractor vendor interface, sharing contractor systems, and mapping work process (Tsung, 2004). In addition to the general benefits gained by an ERP system implementation pre-packaged software systems have the following advantages:

'Only one software vendor to deal with.'

'Comparability between systems within the organization.'

'A more unifying strategy for the organization.' (Tsung, 2004)

These same systems also have some major disadvantages that could occur as a result of their utilization. They are described by Curtis and Cobham (2002), as follows: "The high initial cost of purchase and subsequent maintenance…..The need sometimes for business to align itself with the off-the-shelf package….The lack of flexibility of the system when business need change." Additionally, as indicated by Forrester Research (2004), who conducted a software usability study, states that "several applications required 'inordinate patience and expertise' to complete the tasks, and many fell short on overall usability" (Gilbert, 2003).

A survey conducted by IBM indicated that "Chief financial officers do not make full use of their enterprise resource planning (ERP) systems" (Frauenheim, 2003). Finally, utilizing these pre-packaged systems will result in reduction of organizational innovations (Davenport, 1998; Prahalad, Krishnnan, 1999).

Section 2.2.7 ERP in SMSCO

A survey conducted by Everdingen, and Wiedersheim, (2000), among the mid size organizations in European market, indicated that potential size of ERP market just in Europe among SMSCO exceeds the staggering amount of $50 billion per year. As indicated by this study, the functional areas in which SMSCO members are interested consist of the following: purchase and sales order management, inventory and materials management, production and assembly, transportation, service and maintenance, marketing and sales, warehouse management, financial accounting, and human resource management (Everdingen, Hillegersberg, Waarts, 2000). In addition and contrary to the existing media reports that ERP systems are for large organizations because of the costs and implementation (Jeanne, 1999), a study by Adam and O'Doherty, (2000), indicates that a significant number of participants in their study were small to medium size organizations. This same study shows that large numbers of SMSCO were involved in the ERP implementation to a large extent.

In an article in the April, 2000 issue of *Communication of the ACM*, Everdingen, et al., (2000) present the results of a survey that was conducted to identify the selection criteria that are utilized by SMSCO to be the following items listed in an order of importance; fit, flexibility, cost, user-friendliness, scalability, and support. The results of this study show the most important criterion used in selecting an information system is the best fit with the current business procedures. In addition this same study's data shows that European midsize companies tend to focus on product characteristics rather than on the vendor of the product. It was concluded that it made little difference whether the vendor was a market leader, an international oriented company, or a company with a superior image.

Adam, et al., (2000), in an study that concentrated on lessons learned from ERP implementations in Ireland, indicated that the duration of ERP implementation for a small organization were far shorter than those reported for large organizations. It was concluded that the duration of the implementation of ERP software may be related to the size and complexity of the client organization and that SMSCO can expect to have an easier time implementing ERP. This fact was substantiated by results of the study conducted by Everdingen, et al., (2000), in which data revealed that SMSCO members mostly used one vendor to automate the various functional areas using one ERP vendor. This resulted in shorter implementation time and reduced complexities hence, some of the difficulties in integrating ERP software from different vendors often seen in large companies were not an issue for SMSCO members.

The effects of role and relationship with software implementers were studied and found to be critical, not only in technical terms, but also in managerial and political terms, because they can help their clients in correcting their expectations and perceptions of ERP systems and ERP implementations (Adam, et al., 2000).

Analysis of data collected by Adam, et al., (2000) revealed that the impact of actions taken by senior managers of participating companies was significant. They were shown to be pursuing a strong managerial rationale in implementing ERP rather than just following a trend. Based on this finding, Adam, et al., (2000), conclude that managers implementing ERP systems should pursue specific managerial targets through the acquisition of such systems and that deciding to acquire ERP software may not be sufficient in itself. Finally, it was mentioned that in order to obtain high efficiencies of the IT adoption the business process change needs to expand to a wider transformation of the entire process (Skibniewski, et al., 2004).

Section 2.3 Strategic Decision-making Process in Theory

Decision-making is an important part of any construction project manager's daily tasks. Hard decisions need to be made by good managers all the time. These decisions often will have a strategic impact on the overall success or failure of the project. A common definition used for these strategic decisions as provided by Mintzbereg, Raisinghani, and Theort (1976), states that a strategic decision is important, in terms of the actions taken, the resources committed, or the precedents set.

Strategic decision-making consists of three distinct categories that are as follows; rationality and bounded rationality, politics and power, and garbage can (Douglas, Von Garaguly, 2005). The rationality and bounded rationality models assume that manager's decisions are rational. The other two categories contradict the rational mode.

The political perspective on decision-making demonstrates that decisions are a result of the process where decision makers all have individual goals, and come together in groups and the group with most power will make the decision. The garbage can theory contends that decisions occur in random meetings of choices looking for problems, problems looking for choices, and solutions looking for problems to answer, and decision makers looking for something to decide (Eisenhardt, Zbaracki, 1992).

Douglas and Von Garaguly (2005), state that rationality is a concept from economics, which holds that individuals make choices that are utility maximizing. According to this theory, decision makers will never choose one feasible option over another if they prefer the second. This theory is normative, meaning that it shows what a decision maker should do, not because of morality but instead because of rationality.

In initial stages of the decision-making process, decision makers gather information needed to form an understanding about the various alternatives and then use this information to determine the final result (Dean, Sharfman, 1993). Dean and Sharfman (1993), define rationality within this context as “the extent to which [the] decision process involves the collection of information relevant to the decision, and the reliance upon analysis of this information in making the choice”. For the purpose of this research it is assumed that the rationality and bounded rationality theory apply to the process of decision-making framework, and this definition is adopted.

The research conducted by Dean and Sharfman (1996), showed that strategic decisions are influenced by the process used, more specifically, that managers who used analytical techniques made decisions that were more effective than those who did not, and that managers who engaged in the use of power or pushed hidden agendas were less effective than those who did not.

Frederic and Sammon (2002), indicate that the process whereby managers and, by extension, organizations make decisions has been one of the most researched topics in the extended management area. Dewey (1993), and Simmon (1960, 1977), state that a number of normative models of decision-making have been put forward that broke down this complex process into a variety of phases.

Mintzberg et al. (1976), and Langley et al. (1995), have presented excellent syntheses of this literature. These models are extremely useful in shedding light and putting some order onto managerial decisions that sometimes remain black boxes. March (1962), has claimed that some decision-making processes appear to be without any order and researchers may be tempted to assign them to the decision-making “garbage

can" (Cohen, March, and Olsen, 1972), as soon as their observations or case data lack coherence.

The decision-making models mostly consist of a number of different stages. For example Simon (1977), presents one of the simplest normative models, which consists of four separate stages: (1) intelligence, (2) design, (3) choice and (4) review. The application of this model to current studies of ERP implementations reveals how few research projects have looked at the first and fourth phases (Sammon and Adam, 2000). The first stage indicated by this model is very critical since, if alternatives are not considered initially, then it would be very unlikely to be brought into the picture at a later stage. In case of ERP it must be understood why managers decide to implement ERP and what alternatives they consider (Adam, Sammon, 2002).

The software selection process and its impact on ERP decision-making were also reviewed. Researchers have commented on the confusing nature of many recorded instances of ERP decision-making (Saint-Leger and Savall, 2001; Sammon and Adam, 2000; Sammon & Lawlor, 2001), and the presence of political decision-making (Shakir, 2000; Sammon & Lawlor, 2001). March and Olsen (1976), talk of 'reducing the confusion slightly in organizational' in their approach to organizational decision-making. Adam (1996), points out that the organizational decision process and the resultant outcomes can appear very difficult to understand and follow for an outside observer and Langley et al. (1995), have pointed out the short-cuts that many researchers take when describing such confusing processes.

Section 2.4 Chapter Summary

This chapter presented the current status and key issues of ERP utilization in the construction industry. The potential benefits of ERP use by SMSCO, and risks &

causes of ERP failure were also discussed. Researches dealing with both tangible and intangible benefits and ways to identify and quantify them were reviewed. Various elements that contribute to both risk and uncertainties were identified and reviewed. Obstacles impeding the use of ERP by SMSCO were analyzed. Optimization of ERP and its role in the management system were reviewed. Various ERP tools were identified and the relationship between ERP and supply chain management was discussed. A number of different case studies that dealt with issues of interest were reviewed. Research dealing with different ERP alternatives and their issues was completed.

Issues of evaluation and implementation of ERP in SMSCO were reviewed. Reasons for adoption of ERP by large organizations were identified and discussed. As anticipated, it was discovered that not much research had been completed dealing with failure factors of ERP implementation among SMSCO members. Most of the above mentioned and existing research had been completed based on the results obtained from various surveys.

CHAPTER 3 THEORETICAL FOUNDATION & RESEARCH MODEL

In order to establish a better theoretical understanding of ERP acceptance and adoption systems by SMSCO, previous research on user acceptance models for information technology must be reviewed. Venkatesh, V., Morris, M., Davis, G.B., and Davis Fred D. (2003 - 4.31) indicate that "explaining user acceptance of new technology is often described as one of the most mature research areas in the contemporary information systems literature". There are number of competing theoretical models that have been created as a result of previous research in information technology (IT) acceptance. These models each have different set of acceptance determinants and routinely explain over 40 percent of the variance in individual intention to use technology (Davis, et al. 1989; Taylor and Todd 1995). This research will review three of the most prominent of these models namely; Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), and Technology Acceptance Model (TAM). In addition a paradigm shift dealing with short comings of TAM is reviewed and adopted in creation of a new and proposed research model to be utilized by SMSCO.

Section 3.1 Theory of Reasoned Action Model (TRA)

Theory of Reasoned Action (TRA) is a general and very basic model based on intention based theory (Fischbein & Ajzen, 1975). According to TRA, beliefs influence an attitude, which in turn shapes intentions, which then guide or dictate

behaviors. TRA has been very well researched in predicting and explaining behavior across a wide variety of topics.

The main determinants in TRA are attitude toward behavior, and subjective norm. Based on TRA a users performance of a specified behavior is determined by his or her behavioral intention (BI) to perform the behavior, and BI is jointly determined by the persons attitude (A) and subjective norm (SN) concerning the behavior in question (***Figure 2***).

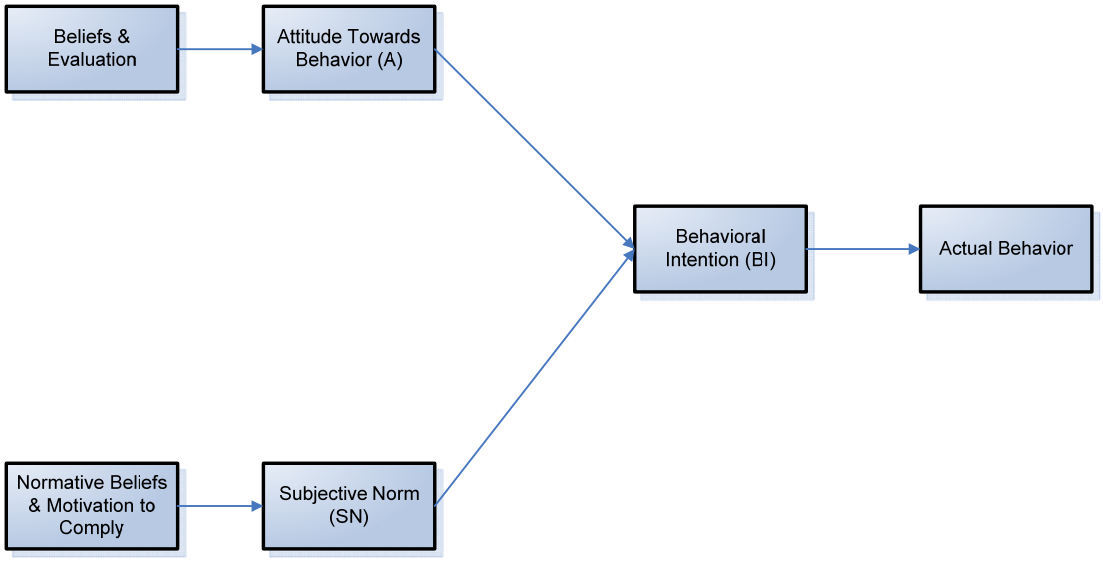

Figure 2 Theory of Reasoned Action

BI is a measure of the strength of one's intention to perform a specified behavior (Fishbein and Ajzen, 1975). Attitude (A) is defined as an individuals positive or negative feelings about performing the target behavior (e.g., Fishbein and Ajzen, 1975). Subjective Norm (SN) refers to "the person's perception that most people who

are important to him think he should or should not perform the behavior in question" (Fishbein, and Ajzen, 1975). As shown in ***Figure 2***, according to TRA person's attitude toward behavior is determined by his or her beliefs and evaluation of the consequences of performing the behavior. The evaluation term is defined to be "an implicit evaluation response" to the consequence (Fishbein and Ajzen, 1975). TRA theorizes that an individual's subjective norm (SN) is determined by a multiplicative function of his or her normative beliefs and his or her motivation to comply (Fishbein and Ajzen, 1975).

As indicated number of different research dealing with TRA has been conducted in the past that has resulted in a large amount of supportive empirical data (Ajzen and Fishbein 1980; Fishbein and Ajzen 1975; Ryan and Bonfield 1975; Shepard, Hartwick and Warshaw, 1980).

Section 3.2 Theory of Planned Behavior Model (TPB)

Theory of Planned Behavior TPB is a well establish intention model that establishes perceptions influence intentions which in turn influence the actual behavior of the individual. Theory of Planned Behavior model or TPB extends from TRA by adopting and additional construct element of perceived behavioral control, to account for situations in which a user does not have substantial control over the targeted behavior (Ajzen,1991). As indicated in ***Figure 3***

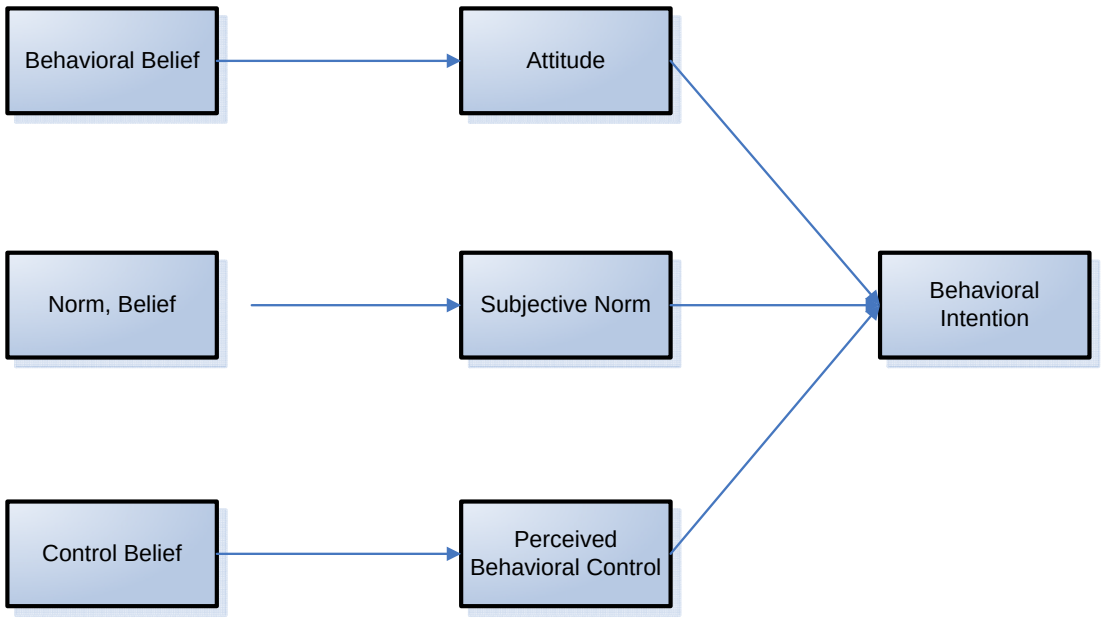

Figure 3 Theory of Planned Behavior TPB (Ajzen, 1991)

TPB has three main core constructs namely Attitude toward Behavior, Subjective Norm, and Perceived Behavioral Control. TPB exclaims that individual's behavior is influenced by his or her behavioral intention, which is jointly influenced by attitude, subjective norms, and perceived behavioral control. Perceived behavioral control is a unique construct in TPB and refers to an individual's perceptions of the presence or absence of requisite resource or opportunities necessary for performing a behavior (Ajzen & Madden, 1986).

Ajzen (1991) has presented a review of several studies that successfully used TPB to predict intention and behavior in a wide variety of settings. In addition TPB has been successfully applied to the understanding of individual acceptance and usage of many different technologies (Harrison et al. 1997; Mathieson 1991; Taylor and Todd 1995).

Section 3.3 Technology Acceptance Model (TAM)

TAM is based on the Theory of Reasoned Action or TRA. This model is among the most popular technology adoption models. It was designed specifically to explain computer usage (Davis, Bagozzi, Warshaw, 1989) and the role of behavioral intention to use the system. A key purpose of TAM is to provide a basis for tracing the impact of external factors on internal beliefs, attitudes, and intentions (Davis, Bagozzi, Warshaw, 1989). TAM proposes that perceived usefulness (PU) and perceived ease of use (PEU) are the main constructs in explaining the behavioral intention to use IS and therefore, systems (***Figure 4***). Davis (1989) defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" and defined perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort". TAM postulates that computer usage is determined by a behavioral intention to use a system, where the intention to use the

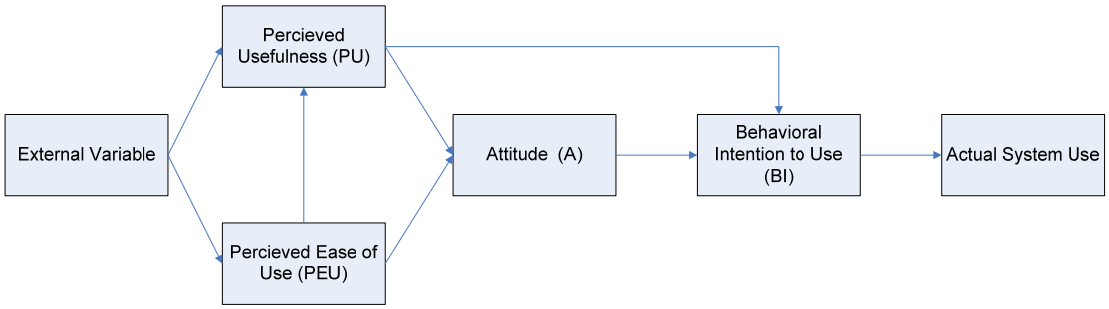

Figure 4 Technology Acceptance Model TAM (Davis et al. 1989)

system is jointly determined by a person's attitude toward using the system and its perceived usefulness.

As indicated before TAM is more focused on users of IT applications and therefore was singled out by this research for additional investigation and a basis of adoption. Simple structure of TAM and its flexibility made it that much more applicable to study of ERP adoption in an SMSCO environment.

Most of previous studies about TAM deal with relatively simple but important systems such as word processing, e-mail, personal computing and spread sheet software. Legris et al. (2003) found that most TAM studies examined the introduction of office automation software or systems development applications. They pointed out that TAM research would benefit from examining the introduction of business process applications and concluded that it would be better if it was completed in a business environment. Kwasi and Salam (2003 – 4.10) showed that both training and project communication influence the shared beliefs that users form about the benefits of the technology and that the shared beliefs influence the perceived usefulness and ease of use of the technology.

Number of other studies deal with role and impact of attitude on the main constructs. Venkatesh and Davis (1996) removed attitude from their revised model because attitude did not appear to mediate fully the effect of perceived usefulness and perceived ease of use on behavioral intention as originally anticipated (Chau, Hu, 2001 – 4.37). Rao (2001 -4.8) studied the importance of user motivations and perceptions in determining his behavior to use indigenous technology using TAM. He concluded that prior experience in handling innovations and purchase practices to have significant effects on user's extrinsic and intrinsic motivations.

Inclusion of Subjective Norm into TAM has created TAM2 (see ***Figure 5***).

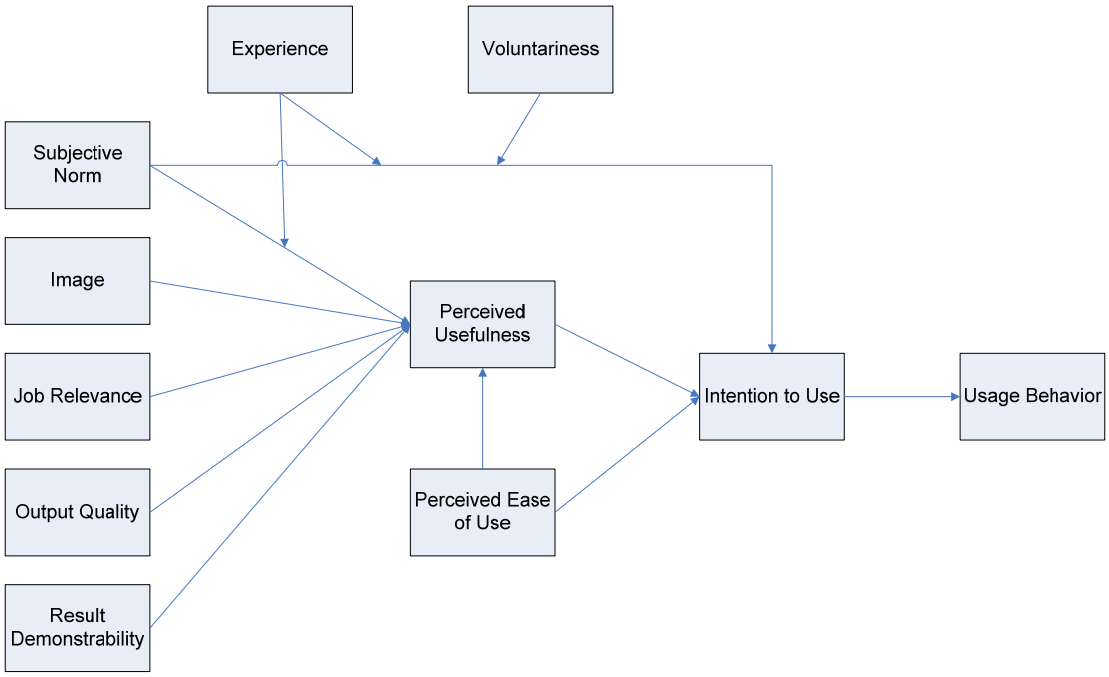

Figure 5 Updated Technology Acceptance Model, TAM2 (Venkatesh & Davis 2000)

Originally Davis did not include this into his model because of all the uncertainty associated with subjective norm's theoretical and psychometric status, and limited effect on TAM's main constructs. However Hartwick and Barki (1994) identified mixed findings about subjective norm, indicating that subjective norm had a significant impact on intention in mandatory system use but not involuntary settings. TAM2 includes subjective norm as an additional predictor of intention in case of mandatory system use, and additional theoretical constructs including social influence and cognitive instrumental processes (Venkatesh and Davis, 2000).

Section 3.4 Paradigm Shift

Among the existing technology adoption models, amount of either direct or related research for TAM is the most significant (Lee, Kazar, and Larsen, 2003). The reason for this can be attributed to the prominent role that TAM has been playing in defining technology acceptance in general and information technology in particular. TAM has been the leading model of technology acceptance for the last few decades. TAM's prominent role and its simplicity resulted in this research's selection of it as a basic model to be studied and adopted if possible.

Previous research has attempted to add and expand TAM in order to accommodate the uniqueness of different situations. Over a period of time long list of additional constructs have been added to the main simple model. However, Bagozzi (2007) indicates that no research has deepened TAM in the sense of explaining PU and PEU, reconceptualizing existing variables in the model, or introducing new variables explaining how the existing variables produce the effects they do. In the past some researchers have introduced moderators into TAM to qualify the effects of PU and PEU on intentions. According to Bagozzi (2007) these researchers have focused on demographic variables (e.g., gender, age), experience, or a crude classification into voluntary versus mandatory contexts of use (Venkatesh et al., 2003). Bagozzi (2007) continues with the fact that "the problem with most tests of moderating effects are that little theoretical insight is provided into the mechanism, or "the why", behind proposed interaction effects, and a potentially infinite list of such moderators exists, making such broadenings of TAM both unwieldy and conceptually impoverished". It is argued that introduction of any new variables should be based on theory and be with the goal of including policy variables.

The main strength of TAM lies in its simplicity, yet this same simplicity has been the main reason for its shortcomings. The simple structure of the model has made it possible for the researchers to over look its limitations. When an attempt was made to apply TAM to ERP adoption by SMSCO it was discovered that the many limitations exist that could not be overlooked. In addition the revised models that constituted extension of TAM not only did not provide any relief rather added to the confusion thereby creating an unwieldy process. Some of extended version of TAM is based on so many independent variables that make their application in construction industry impossible. A good example of this group of models is a proposed Unified Theory of Acceptance and Use Technology (UTAUT, Venkatesh et al., 2003) which has 41 independent variables for predicting intentions and at least 8 independent variables for predicting behavior. The shear number of variables creates an unmanageable process when applied to a construction setting. It became obvious that when dealing with technology adoption a more unified yet simple model was required. This finding was augmented by the findings of the study done by Bagozzi (2007). Bagozzi states that "the field is at the threshold of crisis, if not chaos, in regard to explaining technology acceptance, and a paradigm shift is needed if progress is to be made." He further states that "as it stands the field of IS is at risk of being overwhelmed by growing piecemeal evidence behind decision making in regard to technology adoption/rejection".

Section 3.4.1 Short Comings with TAM

In order to be able to propose a new model it became evident that a better understanding of TAM's short comings was essential. These short coming have been identified by Bagozzi (2007) to be the following; (1) two critical gaps in the

framework, (2) the absence of a sound theory and method for identifying the determinants of PU and PEU, as well as other bases for decision making, (3) the neglect of group, social, and cultural aspects of decision making, (4) the reliance on naïveté and over simplified notions of affect or emotions, and finally (5) the over dependence on a purely deterministic framework without consideration of self-regulation process.

Section 3.4.1.1 Critical Framework Gaps

Two significant gaps in the current framework of most adoption models including TAM, TPB, and TRA exists that have been identified by Bagozzi (2007). They are; (1) Gap between reaction to use information technology and intentions to use information technology, and (2) gap between intention to use the technology and the actual use.

Most models including TAM consider only two or three main constructs for the decision maker to take into account in the formation of an intention to act. However, as indicated by Bagozzi there could be many more constructs that can have an impact on the decision maker's intentions. Extensions of TAM or other models have attempted to clarify this problem without any success. In addition as per Bagozzi (2007), PU and attitudes do not have to contain or constitute motives to act for any particular decision maker. The other main issue to be considered, while discussing this gap, is how multiple reasons for acting or not, be reconciled and transformed into a decision or intention to act (Bagozzi, 2007).

The second gap that needs to be addressed is the gap between intention to use and actual use. Most Preeminent models including TAM treat behavior as an ending point in the process where in reality and especially in construction it is just the start of a

whole new set of processes in order to achieve a particular goal. When and if a member of SMSCO decides to adopt a particular technology it is usually with potential and associated increased in profit and productivity in mind. In addition Bagozzi (2007), indicates that “the use-to-goal-attainment gap is neglected in TAM except as an anticipated belief up-stream in the model”. Another major issue to consider is the existence and effect of a large time lapse between intention to use and the actual use. Within this time new obstacles might arrive that could alter intentions, and therefore create a significant impact on the actual use. Bagozzi (2007) states that, “it is important to consider various psychological and instrumental steps that go on between intention formation and action initiation”. Decision makers often anticipate problems and temptations that arise after they have made their decision. They anticipate uncertainty and plan for a fluid situation. As a result decision makers often focus on trying (Bagozzi, 2007), to adopt an action or buy into a new technology. This focus results in actions that are fundamentally different if the focus was only on behavior (Bagozzi, 2007).

Section 3.4.1.2 Problem with PU, PEU and other Determinants

The second short coming identified by Bagozzi was the theory and methodology for identifying determinants of PU, PEU, as well as of A, SN and PBC. These determinants consist of distinct salient beliefs, and under the TRA and TPB these beliefs are multiplied by corresponding evaluations or importance and the product terms summed to form an overall summary term (Bagozzi, 2007). Both Bagozzi (2007), and Benbasat and Barki (2007) recommend that focus in the future be placed on salient beliefs and their role in TAM and TPB. Bagozzi (2007) recommend that researchers abandon the summated multiplicative models so constitutive of the TRA

and TPB for the following four reasons. First, the summated models treat all belief-evaluation pairs as equal in importance and obscure the differential contributions of salient beliefs, if any, to PU, PEU, A, SN and PBC. Second, belief-evaluation representations fail to allow for or specify an underlying structure of salient beliefs. Third, the summative representations do not take into account or represent relationships among salient beliefs. Fourth, because measures of belief and evaluations are not ratio scaled, it is necessary to model all additive and multiplicative effects in summative models with multiple regressions.

Bagozzi (2007), deals with these problems by conceiving of a qualitative goal-setting methodology that can be used to "derive goal, motive, or value hierarchies, and the individual goals, motives, or values, plus their linkages, which can be treated as independent variables predicting PU, PEU". In this methodology determinants are functions of goals, motives, or values organized hierarchically, depending on the circumstances (Bagozzi, Bergami, and Leone, 2003). In this methodology according to Bagozzi (2007) if we think of decision making in goal-setting terms goal-setting becomes a precursor to goal striving, (goal-setting → goal desire → goal intention → goal striving). Goal striving in term consists of action desire → action intention→ planning → trying.

Section 3.4.1.3 Group, Cultural & Social Aspects

A quick review of TAM, TPB, and TRA reveals the fact that group, cultural, and social aspects of technology acceptance is not considered in any of them. As indicated by Bagozzi (2007) this is another one of the shortcomings of TAM.

Bagozzi (2007), indicates that decisions with regard to technology acceptance and actual usage are often made collaboratively or with an aim to how they fit in with, or

affect, other people or group requirements. However, TAM has been set up with a decision making by a single individual in mind (Venkatesh et al., 2003). Bagozzi (2007), further states that “social influence processes” have been addressed only in a limited sense of either a constraint or force on the decision maker and perceived as originating from other people whose opinion are important to the decision maker.

As indicated previously group, cultural, or social aspects of decision making has not been thoroughly considered in technology acceptance research. In order to integrate these aspects into technology acceptance Bagozzi (2007) recommends the following four issues that need to be discussed in more detail.

First, it is important to differentiate between social normative influence and role of group norms. Social normative influence is defined by Kelman (1974) to be the influence that is a species of compliance and is based on the need for approval, acceptance, or fear of reprisal, while group norm functions differently from compliance and works in group context.

Second, another social process important to technology acceptance that must be considered is identification. Kelman (1974) defines identification as self defining relationship a person has with another person or group. The influence of this social identity on the decision maker must be considered.

Third, issues of conceptualization and specification of decision making are neglected in TAM and must be considered. Intentions in TAM could be characterized as personal intentions, in that they refer to person’s individual decision or plan to achieve a goal. However, as per Bagozzi (2000, 2005, and 2007) group and social decision making involve what has been termed, based on discussions in philosophy on plural subject theory as collective intentions. It is further stated that one kind of

collective intention that must be considered is actually a personal intention to do something with a group of people or to contribute to, or do one's part of, a group activity.

Fourth, Bagozzi (2007) suggests that group, cultural, and social aspects must be integrated into technology acceptance by considering individual differences between cultures. Decision makers with different cultures react differently when it comes to technology acceptance and this fact needs to be considered.

Section 3.4.1.4 Emotions

Impact of emotions in technology acceptance has been treated in a very limited and unique way by TAM and extended version of TAM. Bagozzi (2007) argues that attitudes, classically constructed as evaluative responses, and emotions are distinct phenomena. He states that treatments of affect with respect to technology acceptance have not been grounded in theories most appropriate to the decision processes people go through, and the fact that new specific theories are needed.

As indicated by Bagozzi (2007) some recent developments in psychology are worth considering in this regard. One way to address the impact of emotions is by considering attitudes (Bagozzi, Moore, and Leone, 2004) and emotions (Bagozzi, Baumgartner, and Pieters, 1998) as pre-factual appraisals of achieving and failing to achieve one's technology use goals. Pre-factual attitudes are posited to be dynamic construction of how a decision maker feels about anticipated effort and outcomes related to a personal goal (Bagozzi, 2006, Bagozzi et al., 2004). There have been number of other studies about pre-factual attitudes. Finally it must be pointed out that affective commitment is an essential component of social identity.

Section 3.4.1.5 Self-Regulation

Lack of concept of Self-regulation in TAM is identified by Bagozzi (2007) to be the final shortcoming of TAM. TAM, TPB, and TRA are deterministic model, meaning that there exists a cause and effect relationship in the model. Bagozzi (2007) points out that in TAM the mechanisms governing the dependence of an effect on a cause are built into the rationales linking causes to effects. TAM does not allow human agency, which is rooted in casual powers, to be alternatives or compliment to their specifications. Human agency is defined by Bagozzi (2007) to be the fact that a decision maker is capable at times of choosing to act in a way that is neither impulsive, compulsive, habitual, coerced, nor bribed, but rather results as an intentional response.

Bagozzi (2007) concludes that deterministic theories of behavior explain it as physical processes going on in the brain in the form of either automatic reactions to outside stimuli, or hard-wired responses following law-like information processing, while self-regulation operates on felt deterministic urges or desires via reasoning processes.

Section 3.4.2 New Core

A new and unified apparoach explaining technology adoption/acceptance/rejection has been introduced by Bagozzi (2007). This new approach consists of a common core of basic variables and processes that are universal in scope. Bagozzi (2007) brands this core as the technology user acceptance decision making core (see ***Figure 6***).

As indicated in Fig. 6 the main elements of this new core consist of goal desire → goal intention → action desire → action intention. They each have causes and effects

(A, B, C, and D). This process also spans the entire spectrum between goal setting and goal striving, making overall goal directed behavior the center of focus for user acceptance. This core as mentioned before represents a fundamental process of a universal kind because it addresses the essential decision making processes that occur in most user acceptance situations.

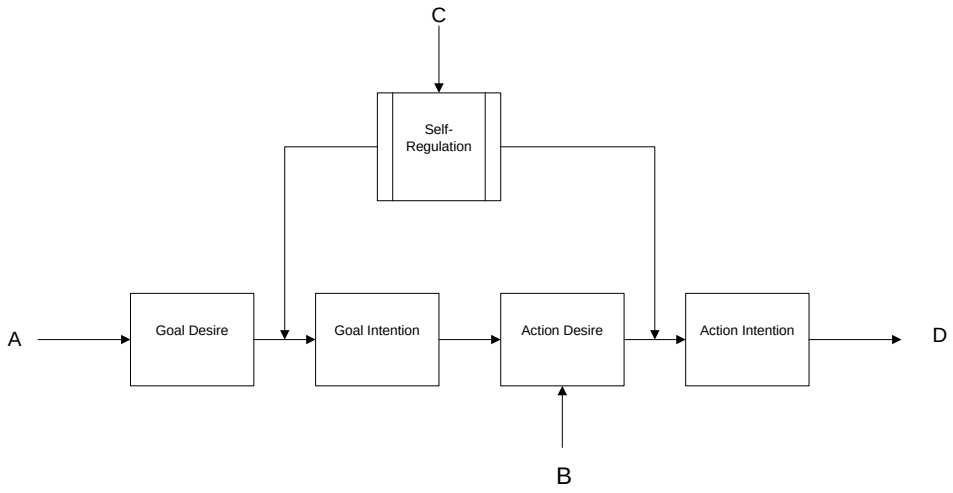

Figure 6 The Decision Making Core (Richard Bagozzi, 2007)

Up to this point the new core has had a unique but only a deterministic approach. Bagozzi (2007) introduces the element of Self-regulation as a feature of human agency with an aim to engage in practical decision making.

Self-regulation consists of two separate categories namely; reflectivity and reflexivity (Bagozzi, 2007). Bagozzi (2006) defines Reflective self-regulation, to be the active imposition of personal moral or self-evaluative standards to a felt or possible goal

desire or action desire. Emphasis in this research is placed on Self-evaluative standards. As indicated by Bagozzi (2007) self-regulation can also occur reflexively. This means that learned values, dispositions, traits, virtues, and vices can function as moderators of desires on intentions.

Section 3.5 Conceptual ERP Adoption Model (EAM)

The paradigm shift proposed by Bagozzi (2007) was adopted by this research because it represented practical and realistic solution to an existing problem. The new decision making core was incorporated into the new and proposed ERP Adoption Model (EAM) as shown in ***Figure 7***.

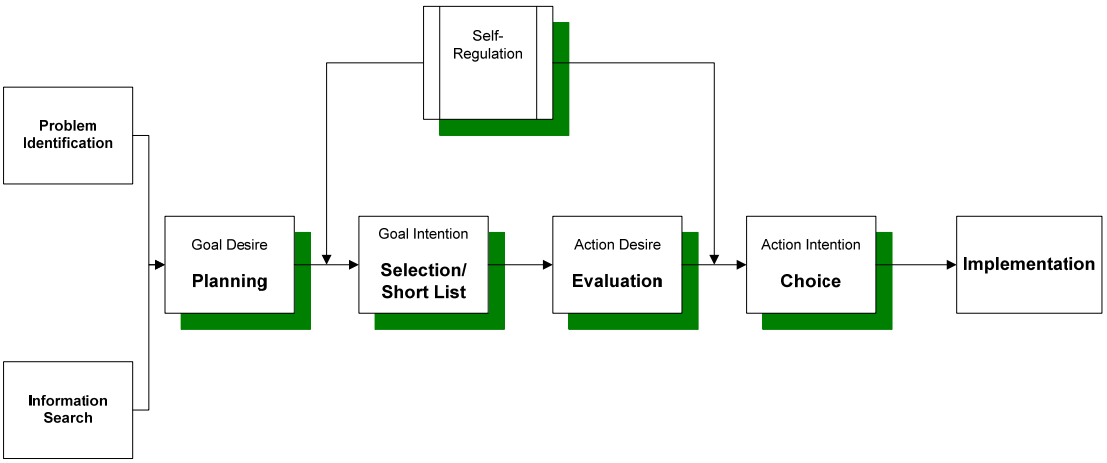

Figure 7 The Proposed ERP Adoption Model

The elements of the proposed model were superimposed on top of Bagozzi's decision making core. Additional causes and effects where also identified that would play a role in the adoption process by SMSCO.

Section 3.5.1 Adoption of Paradigm Shift

Applicability of existing technology adoption models in construction industry is highly questionable. The existing models deterministic approach to the process of decision making while very simple does not offer adequate solutions for the problems encountered in the process. Decision making process in an SMSCO is a rather complicated process that is driven by number of construction specific variables. These variables and their unique nature can not be very clearly and completely be defined by existing technology acceptance models. In addition the extensions that have been developed for the existing models, have just added to the confusion.

Shortcomings that were previously identified by Bagozzi as “TAM’s short comings” easily apply to the scenario of technology adoption in an SMSCO. Realizing that present models were not providing any relief it became apparent that a new methodology was needed. Bagozzi’s paradigm shift was adopted since it was based on solid theoretical understanding and made practical sense.

Section 3.5.2 Structure of the Model

EAM as shown in ***Figure 7*** consists of 8 different elements namely; Problem Identification, Information Search, Planning, Selection/Short List, Evaluation, Self-Regulation, Choice, Implementation. EAM begins with Problem identification and ends with implementation. EAM has a deterministic core but some of the processes are iterative and could be done concurrently. Each process is casual and results in deliverables that are used by another process.

As indicated activity between some of the processes is highly iterative even though the EAM overall has a sequential progression that take the organization from the

problem identification to implementation. Iterative sequence of activities is associated with the Self-regulation element of the model.

Section 3.5.2.1 Problem Identification

This element as discussed previously by Bagozzi represents a cause to the planning element (Goal Desire). Problem identification must be initiated by formation of an investigative/project team that can complete an organizational review and verify or nullify existence of a problem. Initially a project leader must be selected. This person must be a senior member of organization's management level and familiar with the concept of ERP. Other members of the team must be selected so that the following skills are present; user-area defined/function-specific, technical, leadership, managerial, organizational, problem solving, decision making, administrative, and negotiation.

If possible each individual team member needs to have skills that enable them to assume a specific set of tasks or responsibilities within the project. In order to achieve this goal cross-functional and multidisciplinary team members should be selected.

Role of individual must be identified and defined. The following roles should be included: project leader, task-specific for information search, role of liaison between the vendors and project team, department/user-area-specific roles such as for finance, human resources, etc., role of technical team leader, role of users on the team, roles of department like purchasing, etc.

An assessment must be made to see if services of outside consultants to complement the project team are necessary. It is critical to have members on the team that are familiar with purchasing and IT in addition to member of departments that will be affected. When selecting team members their long term availability and commitment

must be considered. These same members should be involved in the remaining processes of decision making process.

Various methodologies can be utilized to verify the nature and scope of problem if any. In house self evaluation or outside reviews could be viable alternatives. Existence of “No Problem” answer must be considered and accepted if that be the case. However, if a problem is identified by the team it must be clearly defined and tabulated.

Section 3.5.2.2 Information Search

Information Search also is considered to be a constraint to the element of planning (Goal Desire). This element should consist of an iterative process since information always will be feeding the planning process. It could consist of two principal elements: information screening and information sources. Information sources, both internal and external sources, provide the planning process with differing types of information. This information must be screened in accordance with the level of scrutiny warranted by the stage at which the acquisition team is in the process. Some of the key factors that must be considered are as follows: (1) the type and nature of the information that is to be gathered, (2) the credibility of the sources whether internal or external, (3) the credibility of the information that was obtained, (4) reliability of the sources whether internal or external, (5) reliability of the information obtained, (6) outside references, (7) client referrals from the vendors, (8) and possibility of information overload and confusion.

Section 3.5.2.3 Planning

EAM’s Planning element represents the Goal Desire process of Bagozzi’s decision making core, where activities lead to formation of a focal goal. Organizations must

commit and spent significant amount of time in planning process with planning and preparations being done for other parts of the utilization process. Planning should start shortly after the decision is made to investigate the possible purchase of an ERP system. In planning process organizations must address as many issues as possible and plan for various activities and processes of EAM.

Each organization must develop an acquisition strategy that reduces uncertainty associated with the process. Some of the strategies that should be consider are briefly as follows: visit vendors sites, contact vendor references, have vendors provide for on site demonstration, request that vendors respond to the same RFP, make the acquisition process a two step process consisting of technical and price section.

The planning team must define the organization's requirements for the ERP solution. Each team must analyze and define: (1) their organization's existing technological environment; (2) the functional requirements; (3) the security requirements; (4) the cost limitations; (5) the time allocation; (6) the technical requirements; (7) the organizational (business, procedural, and policy) requirements; (8) existing processes in the areas that were to be affected by the new software; (9) technical staff role definition; (10) project team training requirements; (11) required maintenance program; (12) role of outside consultants.

Each team must establish their individual criteria for selection, evaluation, and choice stages prior to contacting any vendors or looking at ERP solutions. These criteria must be based on information that is gathered from users and other sources. Each stage must be broken down into its finer subcategories and criteria that would help zoom in on achieving the associated objectives of these subcategories be established. The defined criteria then need to be utilized to complete various processes within

each stage such as market analysis, grid/matrices for selection and choice processes. Each organization must take into account realistic goals and limitations as it applies to its operations. Above mentioned criteria must be chosen in order to enhance planning team capabilities in accomplishing and measuring their particular tasks.

Organization's planning team must consider as many applicable issues as possible at this stage. One of the major issues to be considered should be business process reengineering (BPR). It must be understood that ERP implementation would require new BPR that will result in standardization and improvement in efficiency of operation. ERP adoption should not be used to just enhance the existing systems rather to change them for the better.

Another issue to consider would be the process of change management. Difficulties in accepting significant required changes in the existing operating process by the staff should be anticipated and planned for. Initial participation of representatives, for various end user groups, in this stage is a critical element that must be accomplished.

During market analysis, the acquisition team should determine who the major players are in the marketplace for the ERP system that they are seeking. Within this analysis functionalities provided and technical features presented for each vendor must be reviewed and ranked. Ultimately a short list of vendors to be contacted must be produced.

There must be a fixed number of deliverables that are to be produced at the end of process. These deliverables need to be result oriented and applicable to each particular stage, for example deliverables could consist of formation of the acquisition team, the compilation of RFP, creation of list of criteria for review of various stages, and formation of potential vendors list.

Section 3.5.2.4 Selection/Short List

The Selection/Short List element of EAM represents Bagozzi's Goal Intention process. This element is the intermediary stage between the planning/filtering processes and the evaluation stage. Within this process the following two principal concepts must be considered: "Evaluate RFI/RFP/RFQ Responses" and "Create Short list of Vendors/Technologies."

Completion of proper evaluation of RFI/RFP/RFQ must be the main concern of project team at this stage. It is anticipated that some recursive activities between this process and planning process will occur. These activities will result in teams revisiting their plans and refining their criteria. Decisions arising from adjustments in their plans will lead the teams to revisit the information search process. The recursive nature of the these activities will also cause the planning team to re-contact the vendors with request to resubmit in part or in full, their RFI/RFP/RFQ responses according to the teams refined criteria. Then when amended responses are received from the vendors, the team will have to repeat the evaluation process. Responses that are provided by various vendors must be reviewed once again so that a short list of vendors can be generated.

The second concept or deliverable of this stage must consist of generation of a short list of vendors that need to be thoroughly evaluated. It is recommended that the number of vendors included in this short list be realistic and no less than three. Once this short list is generated each vendor must be notified and be requested to participate in the full evaluation process.

Section 3.5.2.5 Evaluation

Evaluation is a very critical and complicated process that must be conducted by the project team. It is not the intention of this research to cover this topic in detail however some of the critical elements that are to be considered must be mentioned. The topic of evaluation is very well covered by previous research and there exist number of different ways that any team can conduct an evaluation of any ERP system. Critical factors to be considered by the team must include the following: strategic match, stakeholders influence, system specific, organizational impact, life cycle approach, financial criteria. Each of these critical factors has been previously discussed in detail.

Within this process vendors, the functionalities provided by ERP system, and technical issues must be evaluated. It must be anticipated that vendor evaluation will be carried out over several of the stages within the EAM processes. As for the functional and technical evaluations, they should be carried out, in part, during the selection process and then, more intensively, during the functional and technical evaluation processes. The criteria and strategies that are established during the planning process should be utilized to complete the evaluation process. The deliverables of this stage must consist of a vendor and functionalities/modules that should be utilized.

Section 3.5.2.6 Self-Regulation

Within this research particular attention has been paid to the nature of this element, with its variables and constraints. Self-Regulation was introduced into EAM in order to account for possible impact of “human agency” into the decision making process.

Self-Regulation when properly conducted will allow for a reality check that is critical to the success of the technology adoption.

It is anticipated that within this process SMSCO members will have to deal with factors that would impact their decision making process. These factors collectively represent prohibitive criteria that could result in failure of adoption for an ERP system. It is the intent of this research to identify these criteria and also rank them as to their hierarchy of importance.

Section 3.5.2.7 Choice

This stage is the natural culmination of the evaluation process. Once the deliverable of the evaluation process has become clear it must be recommended to the entire ownership group. In the case of SMSCO it is of the utmost importance to obtain the approval of, if not all of ownership group, at least the majority of them. This stage was singled out so that the ownership group has an opportunity to independently review the finding of the process and make a full commitment to the implementation process.

Section 3.5.2.8 Implementation

Implementation, like evaluation, is a topic that should be investigated in full detail. As the last stage of the EAM it represents the final series of activities that are required to successfully select and implement an ERP system by SMSCO.

The negotiation part of this stage should consist of the business and legal segment. As many issues as possible must be addressed in the business negotiation between the SMSCO members and the potential vendor. Then, once tentative agreements are reached and the choices made, legal negotiations between parties must be conducted that culminates in singing of final contract.

Section 3.6 Chapter Summary

This chapter presented the current status and key issues of three major technology adoption models namely, TRA, TPB, and TAM. Each model was discussed in some detail and their theoretical background was investigated. Some of the major shortcomings associated with these models were identified and reviewed. Particular attention was given to TAM since it was deemed to be the most applicable to ERP adoption or rejection within SMSCO.

Bagozzi's paper (2007) identifying the short comings of TAM was reviewed and major points highlighted. The paradigm shift proposed by him was investigated and adopted for the purpose of creating a new ERP Adoption Model (EAM) for SMSCO.

Taking into consideration the proposed decision making core by Bagozzi a new model for ERP adoption for SMSCO was created. This model consisted of 8 different elements. Each of these elements and their content were discussed in detail.

CHAPTER 4 PROHIBITIVE CRITERIA CONFIRMATION

One of the initial objectives of this research was to identify the reasons for SMSCO's failure to utilize and or implement ERP systems. A review of literature identified number of criteria that hereafter are referred to as "Prohibitive Criteria". Prohibitive criteria are defined to be those criteria that cause the process of ERP implementation by a member of SMSCO be terminated for a cause.

In order to reaffirm these criteria with real life experiences of members of SMSCO it was decided to conduct a paper based questionnaire (see Appendix A: Prohibitive Factors Questionnaire). This chapter presents the process that was followed to design, collect, analyze data and validate/confirm the existence of prohibitive criteria.

Section 4.1 Design of Field Questionnaire

The Prohibitive Criteria Confirmation Questionnaire is divided into four sections. Section one consists of four questions to collect the following general information about the respondent: business category, organization's size, familiarity with internet, contract profile, and familiarity with various functionalities provided by ERP.

Section two consisted of six questions that dealt with issues of potential ERP acceptability by members of SMSCO. The level of available IT infrastructure within the organization and familiarity with Web-Technology and ERP was investigated, as was the attitude of senior managers in the organization and their willingness to adopt ERP's new approaches. The member's opinion about the impact of having ERP on the success of business was also investigated.

Section three consisted of five questions that investigated the perceived benefits to be gained from ERP adoptability. Respondents were asked to identify the areas of functionality that would be most utilized by them. In addition they were asked to indicate their opinion about what other project functions would benefit from ERP implementation. Finally, they were asked to expand on the impact of ERP implementation on project communication.

Section four consisted of five questions that were arranged to either confirm or identify all of the major prohibitive criteria that are at play. Respondents were asked to identify the most significant prohibitive criteria affecting their utilization of an ERP. Concerns about security and legality were further examined. Attitude and the opinions of respondents with regard to number of project conditions were measured.

Section 4.2 Choice of Data Collection Method

Qualitative & quantitative methodologies are two principle ways to conduct scientific research. Qualitative research has been utilized in the human and social science disciplines (Denzin, Lincoln, 1998). As indicated by Denzin and Lincoln (1998), qualitative research is a "multi-method in focus, involving an interpretive, naturalistic approach to its subject matter". It attempts to study things in their natural settings and interpret the meanings humans bring to them. Qualitative studies also provide researchers with a rich description and help them gain a comprehensive understanding of the socially structured nature of reality by building an intimate relationship between researchers and what they studied, capturing the individual's point of view, and examining the constraints of every day life (Denzin and Lincoln, 1998). Examples of the qualitative methods include case studies, action research, and ethnography.

“Quantitative research emphasizes the measurement and analysis of causal relationships between variables, not process” (Denzin, Lincoln, 1998). It is most often used in positivist studies to test hypotheses objectively or to test models that are built based on theories (Kaplan and Duchon 2000). It is a robust and systematic way to examine and measure developed research models significantly (Denzin and Lincoln, 1998). The most common examples of quantitative methods include survey, laboratory and field experiments and mathematics modeling (Shadish, Cook, and Campbell, 2002).

Before deciding on what method to use for data collection for this research, a number of factors were considered. As indicated by Ohlsson, et al., (2001), it is common to make a distinction between two different types of data, namely primary and secondary data. They have identified primary data as the information collected and used for the first time, and usually through direct examination, whereas secondary data consists of information already available, i.e. it has been collected or produced by a third party and perhaps for a different purpose (Eriscsson & Wiedersheim, 1999). Because of the nature of topic and the unavailability of relevant information this thesis will use primary data to address and analyze various research problems.

For the collection of primary data a number of collection methods were investigated, e.g. experiments, surveys, and case studies. Based on the nature of this research and at this stage of investigation it was decided that a paper-based questionnaire would generate the best results. Surveys/questionnaires are commonly used for research projects that are based on descriptive and explorative research approach (Ohlsson, et al., 2001). This collection method was also impacted by time frame, data availability, and characteristics of the respondents.

The list of targeted respondents was created utilizing several sources, i.e. construction related organizations, personal knowledge, trade magazines, and the local business network. A combination of electronic mail and postal mail was used to distribute the questionnaires. After the questionnaires were sent to each respondent, it was followed up with a phone conversation that promoted and solicited their ultimate response.

The size of the population and the nature of research questions in play dictate the type of data that needs to be collected. Data types are divided into two groups, namely quantitative and qualitative. Quantitative data is primarily used when the aim of the research project is to answer questions like, “How often?”, “How much?”, “How many?”, or “How usual?”, meaning that there is an aspiration to quantify the result (Ohlsson, et al., 2001). The collected data is then analyzed in a quantified way. On the other hand, qualitative data is better suited for research projects that use data that cannot easily be quantified, and qualitative data is often suited for research projects that aim to understand or find a specific pattern (Ohlsson, et al., 2001). This research utilizes a combination of both qualitative and quantitative data to address research questions.

Section 4.3 Data Collection

Before the questionnaire was sent out, it was reviewed by three SMSCO executives and two academics. Several detailed meetings were held to ensure that that the questionnaire was comprehensive and understandable.

Section 4.3.1 Targeted Respondents

Two hundred participants that included SMSCO construction industry executives, construction management personnel, A/E construction managers, and resident

engineers, with detail working knowledge of operation for a small to medium size construction company were contacted. To gain access to all targeted respondents, executives from each organization were contacted and a brief explanation of the purpose of the questionnaire was given. In the majority of cases, these executives were helpful but non-committal.

The common denominator among all participants was their knowledge of the day to day operation of an SMSCO. In addition their familiarity with general web technology applications was targeted. Since it was anticipated that ERP utilization among this group was to be limited, their detailed knowledge of it was not selected as a targeting critical factor.

Section 4.3.2 Questionnaire Distribution & Responses

A combination of electronic mail, postal mail, and personal deliveries was chosen as the means to circulate the questionnaire. The questionnaire was delivered to every participant with instructions on how to complete and return the questionnaire. A follow up phone call was made to encourage and increase the number of participants. The questioning was conducted between January and April of 2004, and 29 responses were obtained. In addition 15 respondents indicated that since they did not have any experience with the use of ERP or web-technology in their business and therefore could not complete the questionnaire ; however, they requested that they receive a summary of results. The rate of response to the questionnaire was 14.5%. Given the state of ERP utilization among SMSCO, this response rate was not unpredictable. There were significant number of participants that were not familiar with the concept of ERP.

Section 4.3.3 Problems Encountered

During the process of data collection, a number of problems were encountered. The most significant problem that was confronted was the lack of familiarity of members of SMSCO with concept of web-tech/ERP applications in their business. Most participants, even though familiar with the internet and its reach, were not quite sure about how it could help or impact their venture.

The other significant problem that was raised had to do with the conservative nature of construction organizations and their resistance to share any information that could be constituted as competitive. Participants were reluctant to answer questions that dealt with possible operational procedures and or cost benefit analysis.

Finally the last problem that was identified by some respondents had to do with the time that it took to complete the questionnaire. Even though the whole process was set up to be completed in about only 10 to 15 minutes it was considered as “long time”. These phenomena can be attributed to the fact that, in today’s competitive environment, members of SMSCO are under constant time constraints to finish their daily work routines quickly and handle emergencies that arise within various projects.

Section 4.3.4 Validity of the Questionnaire

Validity is a key quality that is measured for this questionnaire. This quality determines whether a questionnaire is good or bad (Nachimas, Nachimas 1992; Alreck, Settle 1995; Litiwn 1995).

As indicated by Nachimas and Nachimas (1992), validity is concerned with how well a question measures what it intends to measure. Three basic methods utilized are content validity, empirical validity, and construct validity.

Content validity is defined to be a subjective measure of how appropriate the questions seem to a set of reviewers who have some knowledge of the subject matter. Two common tests of content validity are face validity and sampling validity. Face validity is based on the investigator's subjective evaluation. Sampling validity is concerned with whether a given population is adequately sampled by a questionnaire and is commonly used when investigators attempt to construct a questionnaire and employ it for the first time (Nachmias, Nachmias 1992).

Empirical validity is concerned with the relationship between a questionnaire and its outcomes. Two methods of empirical validity are concurrent validity and predictive validity. Concurrent validity assesses the validity of a questionnaire by comparing it with a "gold standard" for measuring the same subject. Predictive validity is the correlation coefficient between the results of a questionnaire and an external criterion, and is also considered as the ability of a questionnaire to forecast future outcomes (Nachimas and Nachimas 1992).

Construct validity is concerned with the relationship between a questionnaire and a general theoretical framework; whether a questionnaire is tied to the concept and theoretical assumption employed (Nitithamyong, 2003). Litwin (1995), commented that this type of method is the most valuable, yet is the most difficult to assess, and often is determined only after years of experience with the survey.

For the purpose of this questionnaire, validity assessment was performed using the content validity method since the other two methods, empirical validity and construct validity, were not applicable due to the lack of a "gold standard" survey in the research area and limited time available. This assessment positively validated the

questionnaire. As indicated previously, the two methods of content validity are face validity and sampling validity and are discussed below:

- Face Validity: In order to establish face validity for the field questionnaire, a comprehensive literature review and the unstructured interviews with industry practitioners were conducted to ensure that reasons or criteria that cause members of SMSCO not to utilize ERP were adequately included in the questionnaire. The feedback that was obtained from these steps was incorporated into the design of the questionnaire.

- Sampling Validity: The targeted respondents of the questionnaire were construction management personnel who are familiar with the day to day operation of and SMSCO organization. The questionnaire itself included a question asking whether the respondents were familiar with project management tools based on web-technology. In order to overcome the unfamiliarity of the SMSCO with the concept of ERP application, the questionnaire did not refer to ERP, rather it attempted to utilize the general terminologies such as “project management tools based on web-technology”.

Section 4.4 Descriptive Analysis of the Questionnaire Results

For the purpose of this analysis the content of the questionnaire was divided into the following four categories; profile, applicability, perceived benefits, and prohibitive criteria. The questions were then segmented into the above-mentioned categories and each category and its associated questions were analyzed, in turn, to establish a clear understanding of the respondent’s message.

Section 4.4.1 Respondent's Profile

Within this category, questions were organized to establish some facts about the respondents. The nature of the organization, size of the organization, familiarity with internet, and scale for utilization opportunity were the prime area of interest. ***Figure 8*** illustrates the nature of the respondents' organization.

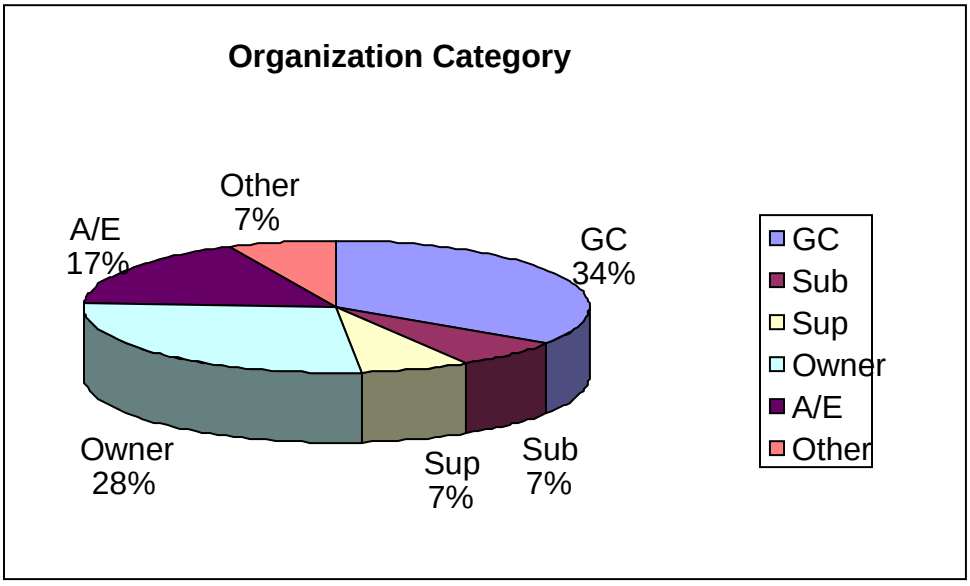

Figure 8 Organization Category

As indicated by the results, a majority of respondents consisted of contractors, in one form or the other. A combination of general contractors and subcontractors constituted 41% of respondents, indicating a high degree of familiarity with the day to day operation of the SMSCO organization. The next largest group was owners or owner's representatives. ***Figure 9*** summarizes the distribution of the organizations according to their fiscal size. Fiscal size was chosen as a measure to decide if they could be considered to be a member of SMSCO. For the purpose of this research and

utilizing the federal guidelines defining small to medium size business, an upper limit of $20 million dollars of gross billing was chosen to be the defining limit for members of SMSCO.

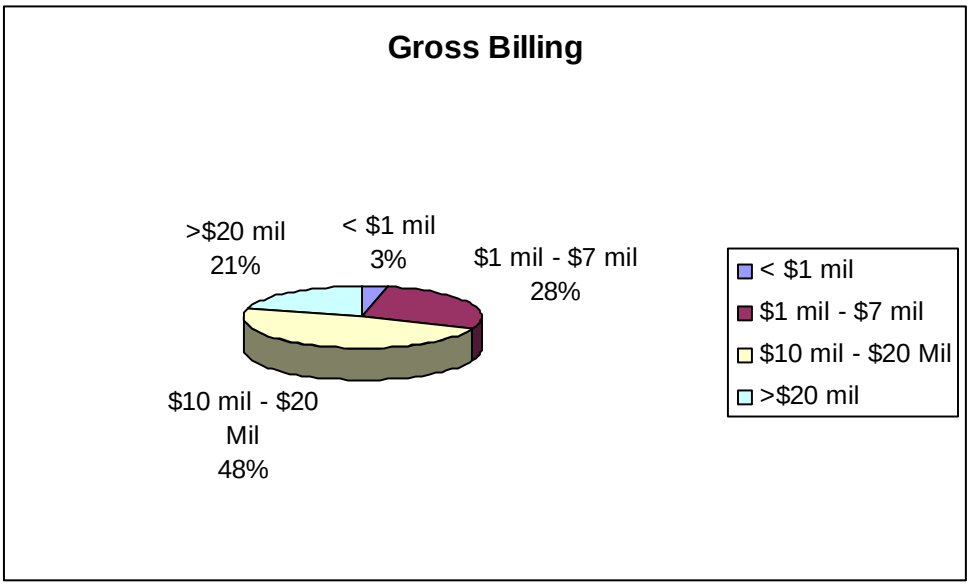

Figure 9 Gross Billing

Based on this definition, 79% of respondents were identified to be members of SMSCO. This was a clear indication of sampling validity of this questionnaire. Clearly this group was very familiar with issues facing SMSCO, either as contractors or as other professional categories such as A/E, Suppliers, or Owners.

The status of the respondent's familiarity with web/IT was investigated, and as shown by results indicated in ***Figure 10***, a majority of respondents, 76%, were very familiar with web technology.

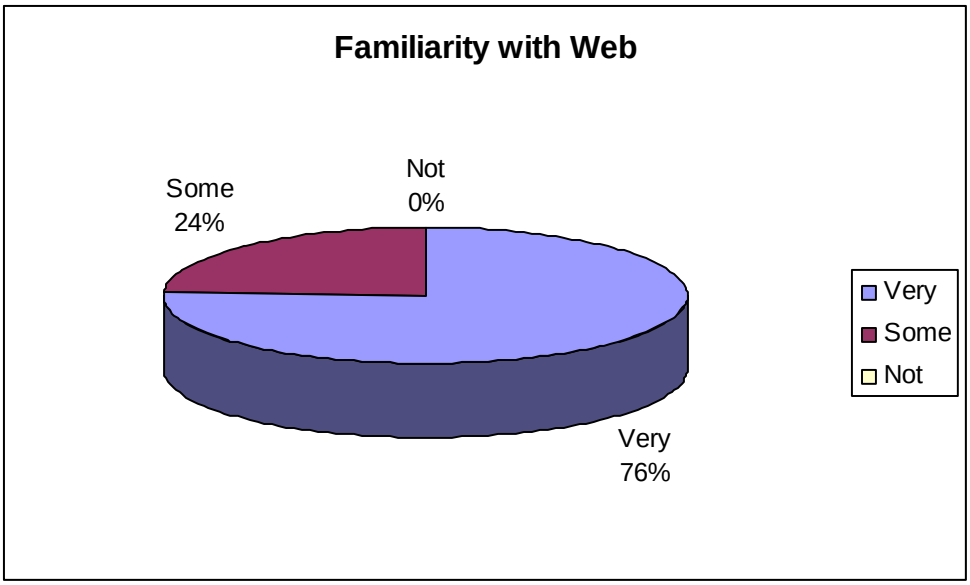

Figure 10 Familiarities with Web

Since initial interviews had indicated a minimal familiarity level with ERP terminology, it was decided to measure the conceptual understanding of the subject by measuring respondents' familiarity with web technology first. Conversations with SMSCO executives had indicated that this would be a good starting point to define the profile of respondents.

In order to obtain a better understanding of respondents' thinking of the potential contract size that could provide an opportunity for the use of ERP/project web applications, they were asked to indicate the fiscal value of a contract that they would be willing to use these tools for.

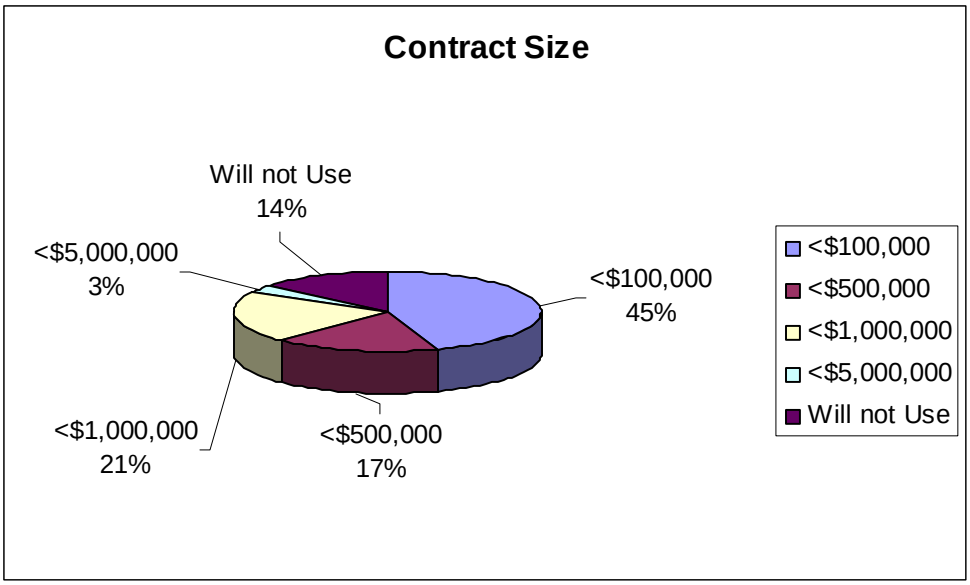

Figure 11 Contract Size

It was surprising to discover that 45% of respondents would be willing to use project web application for projects of even less than $100,000.00 (***Figure 11***). Even though this finding was encouraging, it must be pointed out that these results might be skewed by the fact that the respondents were not familiar with the total cost of implementing an ERP system ; however, it still indicates a willingness to implement ERP tools.

It was the intent of this questionnaire to reach valid members of SMSCO and utilize their understanding to validate existence of potential prohibitive factor. A profile established by the first segment of this questionnaire clearly defines the respondents to be members of SMSCO with understanding of web/IT technology.

Section 4.4.2 Attitude & Understanding of Project Management Systems

The next area of interest to investigate was the understanding and attitude of respondents towards project management systems. Initially, it was important to see if respondents had access to internet at their job site.

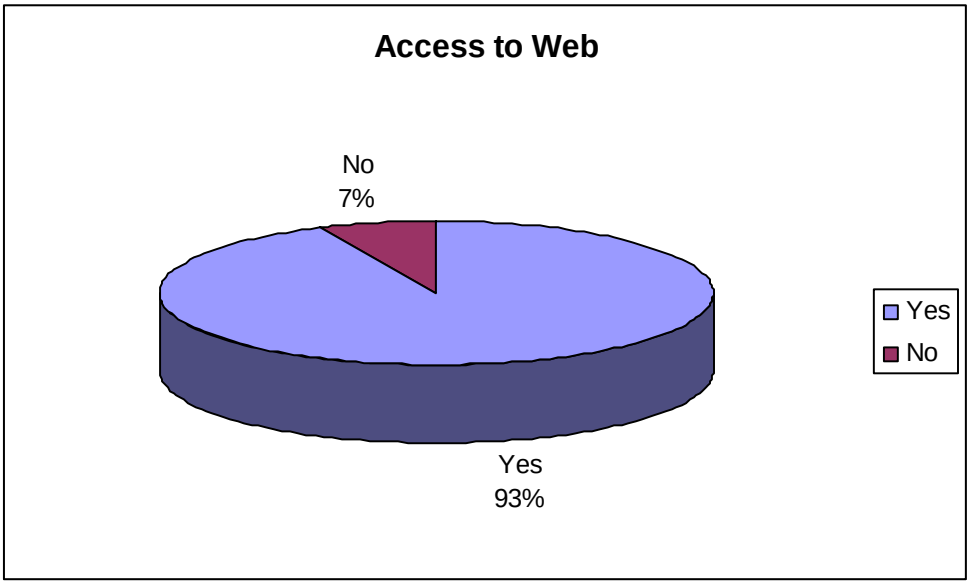

Figure 12 Web Access

As indicated by the results shown in ***Figure 12***, the majority of respondents had access to internet at their job site. This indicates the existence of an adequate level of infrastructure within the construction industry. Existence of this infrastructure is a critical element in the possible future implementation of ERP application for SMSCO.

Since the attitude of senior management towards the use of IT/web technology within the organization has been shown to be a critical element in a successful implementation of project management tools, it was measured. Results are shown in ***Figure 13***.

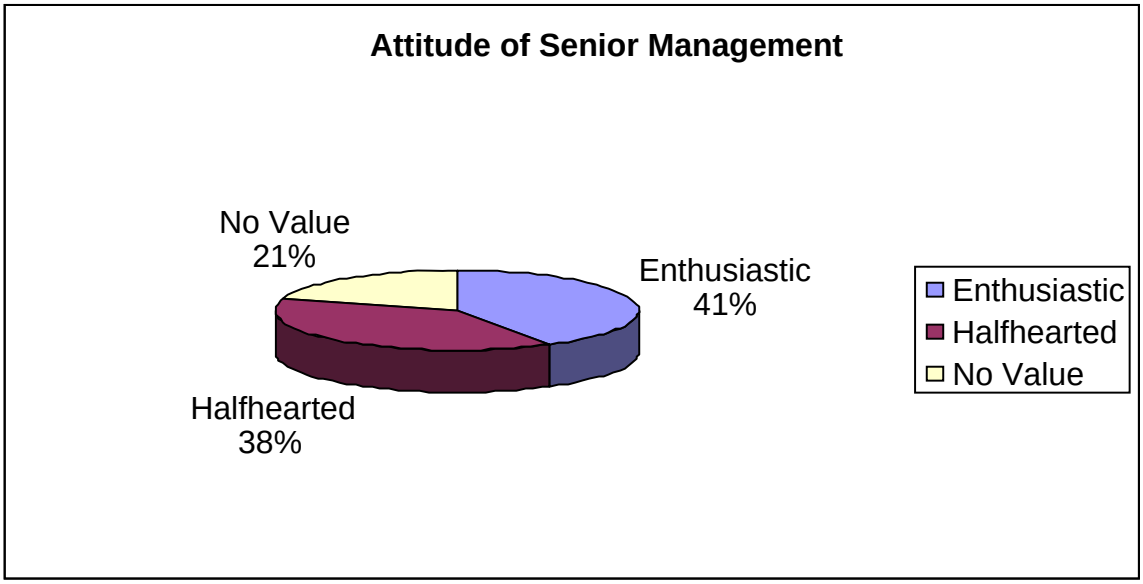

Figure 13 Senior Management's Attitude

Unfortunately, as indicated by the results still a majority, 59%, of senior managers in these organizations do not have a clear understanding or are not willing to commit to implementation of IT related project management tools within their organization ; however, it must be pointed out that results also reflect an existence of a significant portion of the respondents that enjoy an enthusiastic support of their senior managers in implementation of IT related project management in their projects. If the contractor sub-group within the respondents is singled out, the fact becomes more evident that a larger percentage of senior managers have a positive and more enthusiastic attitude. This indicates that a potential for the acceptance and implementation of various IT related project management tools among SMSCO does exist and needs to be enhanced.

The next question investigated the level of familiarity with project management tools based on Web-Technology. As indicated by ***Figure 14***, the majority of participants indicated no familiarity at all.

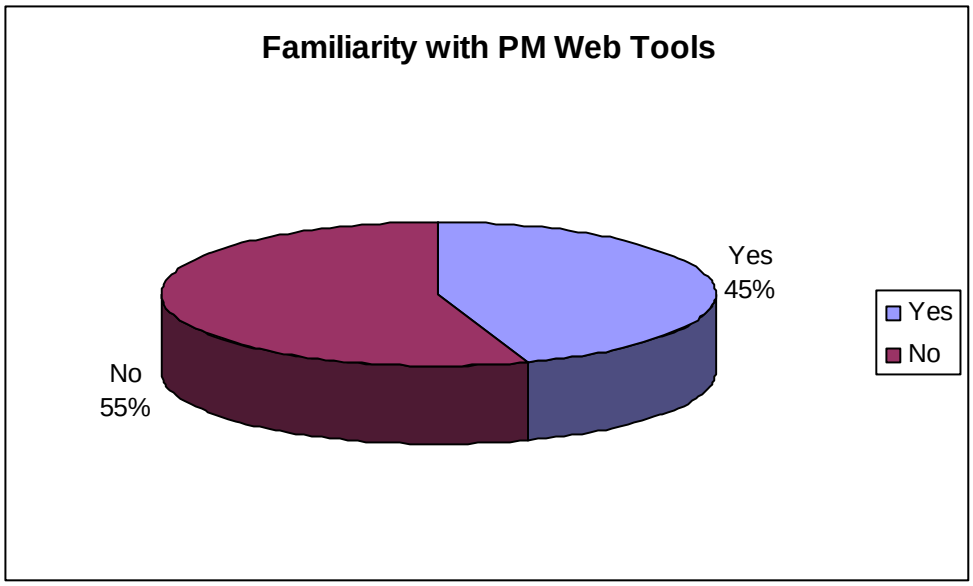

Figure 14 Level of Familiarity with Project Management Web-Technology Tools

The result of this question closely follows that of the senior manager's attitude towards the use of web technology within their operation. It is apparent that the same 41% of senior managers of SMSCO who enthusiastically supports the implementation of ERP/web technology are also familiar with the capabilities of these systems. It can therefore be concluded that familiarity is a key component; that once established it creates acceptance of ERP and other project management tools.

In order to investigate this familiarity, the next question was proposed and put to the participants. In this question, the concern was to investigate the level of acceptance and utilization of various alternative project management tools.

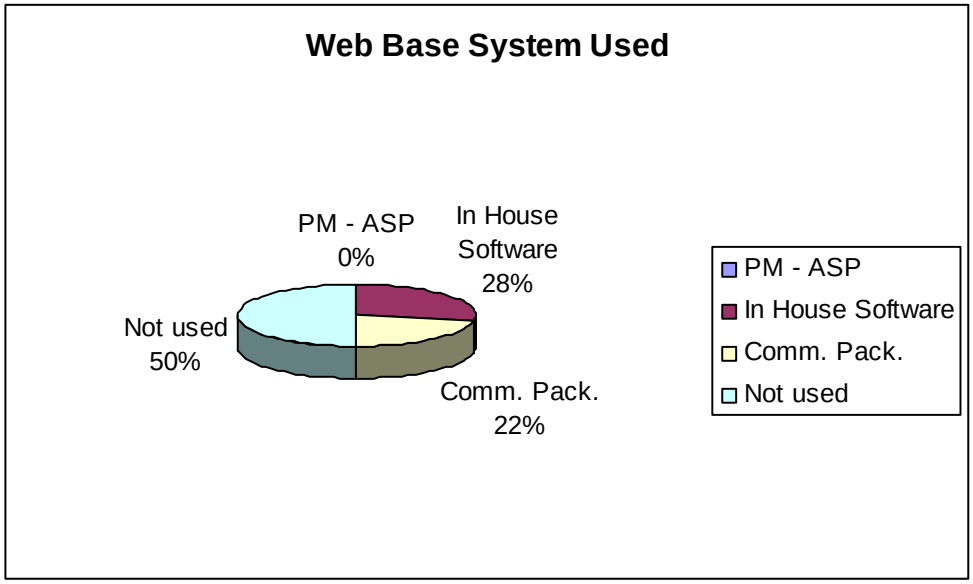

Figure 15 Alternative Project Management Tools Utilization

Once again, as indicated by ***Figure 15***, the majority of the same group that is familiar with and enthusiastic about the utilization of various project management tools, utilizes in-house software packages that have been created by their own organizations in a very rudimentary and basic way. This fact indicates an existence of great potential for project management tool utilization among members of SMSCO.

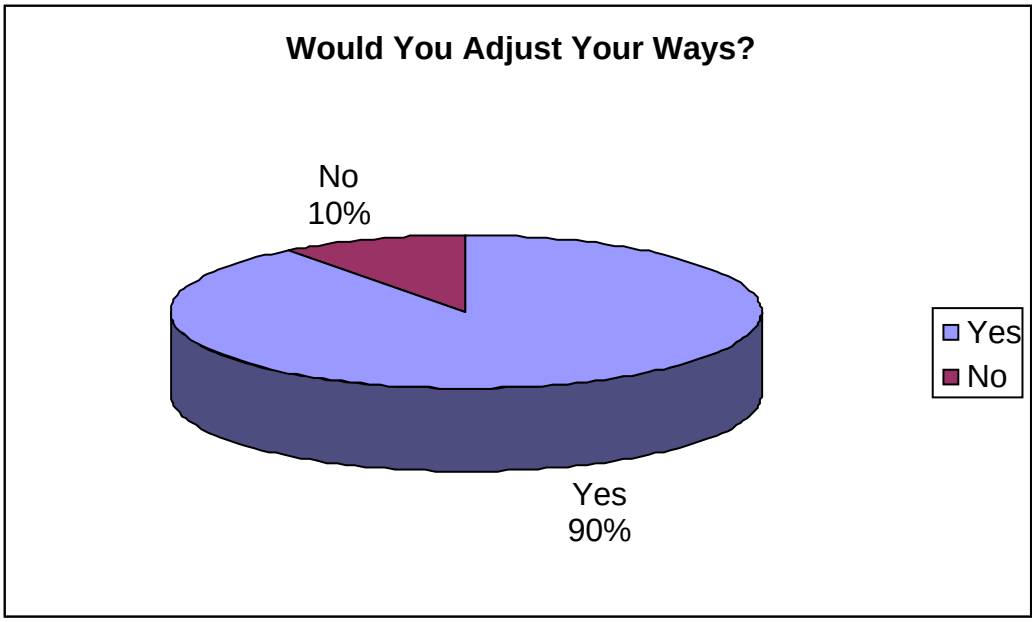

Figure 16 Respondent's Willingness to Adopt New Systems

It is a known fact that the construction industry is very conservative in nature and does not adopt changes easily. In order to investigate the impact of this phenomenon on ERP/Project management tools utilization among members of SMSCO, the next question was formulated. As indicated by ***Figure 16***, the majority of respondents indicated a willingness to adopt new systems.

The answers reveal the fact that even the senior managers who do not know about the project management tools are willing to revamp their existing business procedures and systems so that web-technology could be implemented. This level of willingness to change could be result of their understanding for potential benefits that could improve their bottom line. This thinking or impression could be an indicator of pent up demand or willingness to adopt new ERP/Project management tools.

The perceived impact of project management tools on the bottom line of the business was further investigated. Respondents were asked to indicate if they are of the opinion that their lack of commitment to utilization of ERP/Project management tools has resulted in reduction in their profit (***Figure 17***).

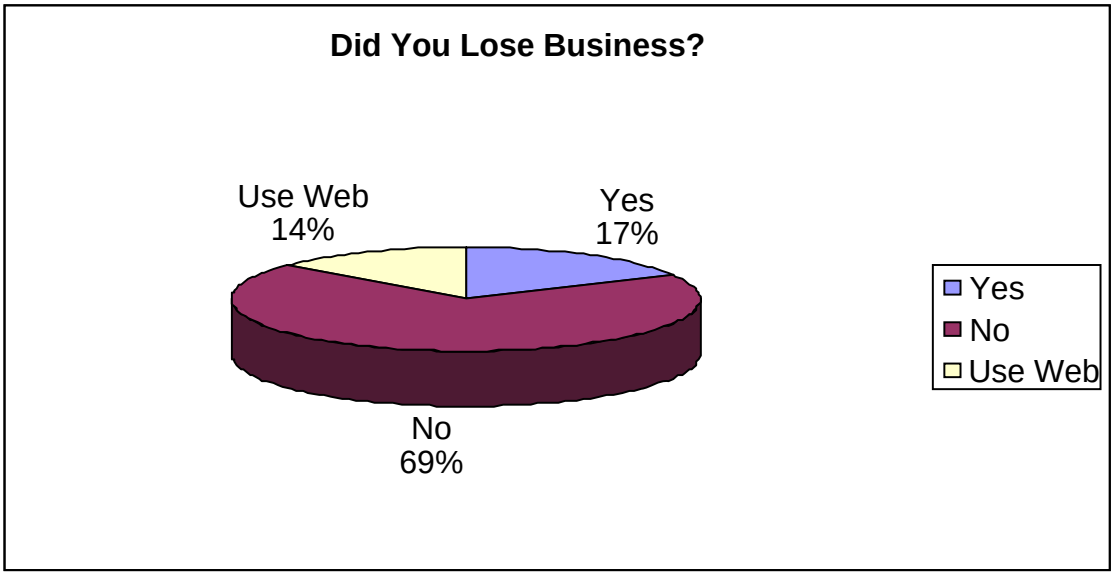

Figure 17 Perceived Impact on Profit

As could be anticipated, a majority of respondents indicated no impact on their profit as a result of lack of utilization of ERP tools. It must be noted that as stated previously, a significant percentage of the participants had indicated that they are not familiar with these tools in totality therefore, these results should have been anticipated; however, the interesting fact lies in the group that indicates that they either have seen an increase in their profit and or can perceive an increase in their profit.

Overall, as indicated by previous literature review it can be concluded that even though majority of participants had access to web, they were not familiar with various ERP/project management tools; however, they also indicated a willingness to adjust their business procedures in order to utilize IT oriented project management tools.

Among these participants a majority did not enjoy the broad and full support of their senior management. Those who were familiar with project management tools only utilized rudimentary and basic in house software packages that had been developed by them.

Section 4.4.3 Perceived Benefits

In order to measure the understanding and applicability of the benefits that could result from the implementation of IT related project management tools among SMSCO, the next section of questionnaire was designed to first identify those benefits. The nature and impact of perceived benefits on the operation of members plays a critical role in acceptance of ERP/project management tools by the decision-makers. It was the intent of the questionnaire to identify and study the particular areas that could benefit most from the implementation of various ERP/project management tools.

Figure 18 indicates the level of familiarity of the respondents with various IT related tools that have been utilized on various project.

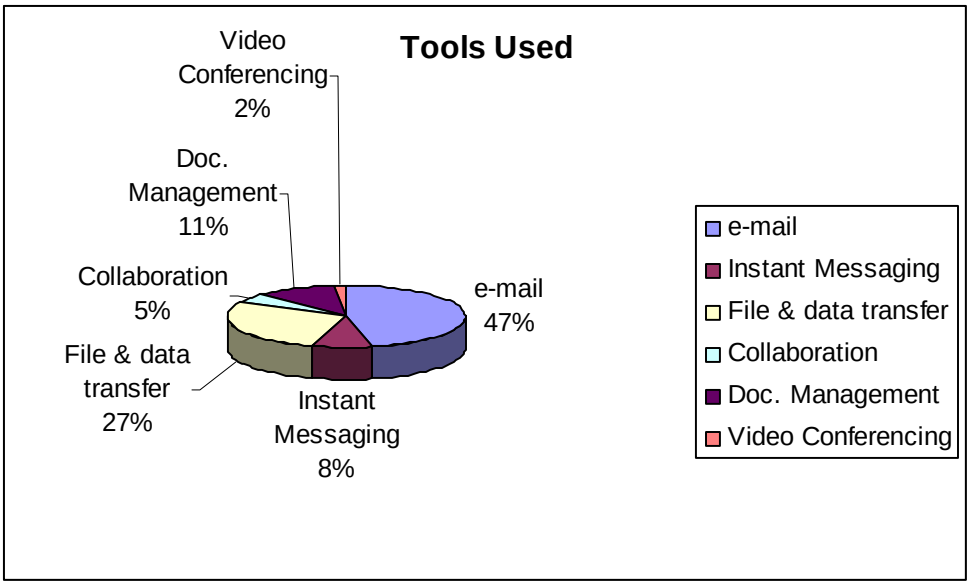

Figure 18 Level of Familiarity with IT Tools

As indicated, the majority of respondents were very familiar with e-mail and its applications. A significant portion, 27%, was aware of and had worked with file & data transfer applications. Unfortunately, only 5% had indicated any familiarity with collaborative tools. This result confirms the thinking that was presented previously as part of defining the problem that members of SMSCO are not familiar with the potential benefits that could be gained thru the proper implementation of ERP/project management tools.

The next question was generated in order to identify what particular areas would best benefit from ERP implementation in an SMSCO organization. Areas that are most critical to the operation of an SMSCO were singled out (see ***Figure 19***).

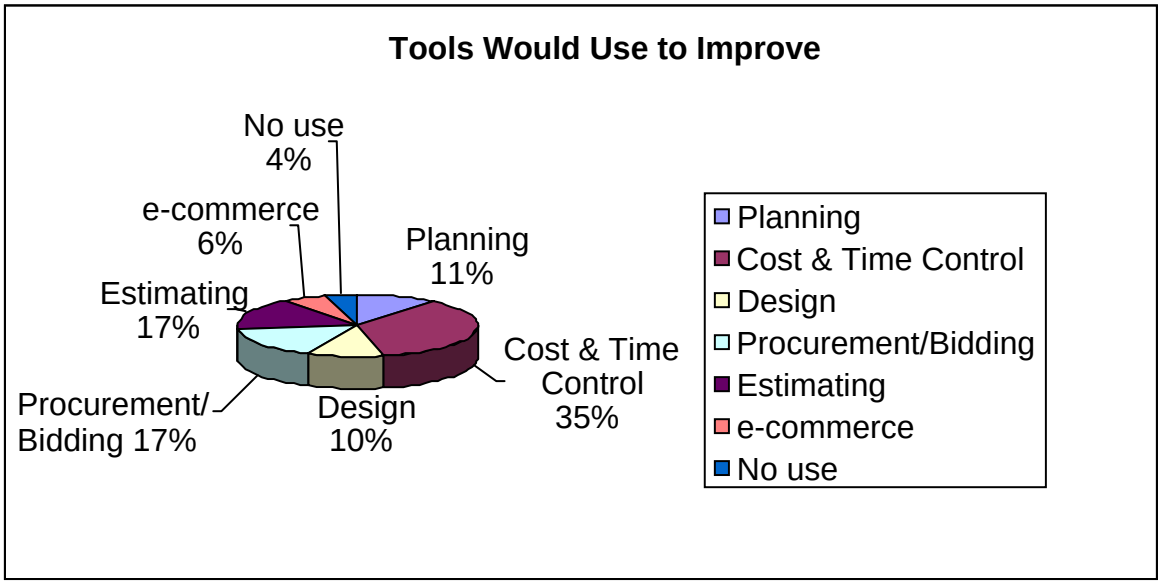

Figure 19 Perceived Improvements in Operational Areas

A majority of respondents indicated that cost & time controls were the areas that could benefit the most by application of ERP tools. This was followed by procurement and estimating. Design, e-commerce, and planning completed the list. Cost & time, as could be anticipated, play the most prominent role in thinking of senior managers of SMSCOs.

In the next question, further investigation of this concept was attempted by asking participants to identify what areas would benefit most from the application of ERP/project management tools. The following four major areas were identified to be communication, control, administration, procurement (***Figure 20***).

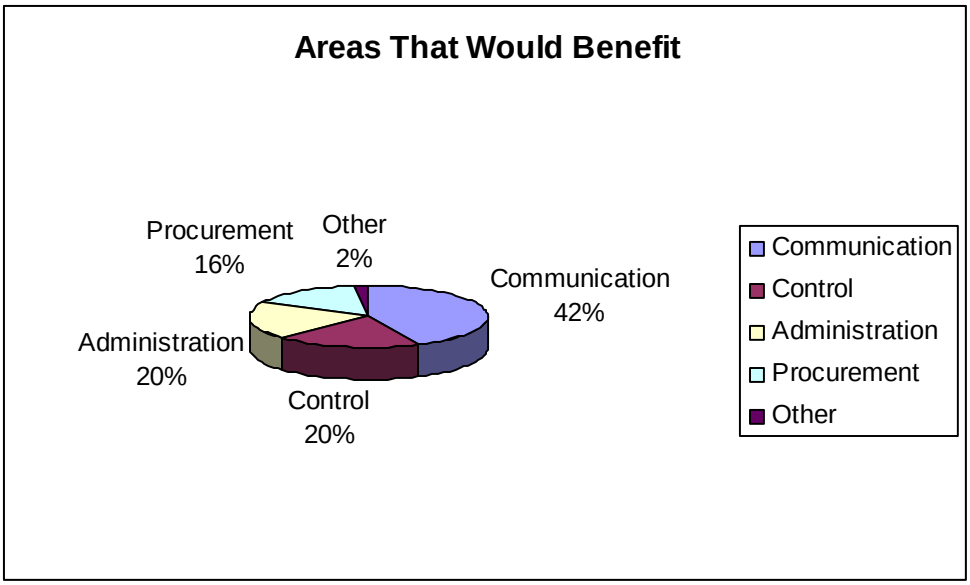

Figure 20 Potential Benefits

Communication was singled out to be the area that could benefit from implementation of ERP/project management tools the most. It was followed by controls, administration, and procurement. The main reason for this result could lay in the fact that everyone has become very familiar with and utilizes e-mail. Issues of communication needed further investigation and analysis therefore another question was dedicated to achieve this goal.

Figure 21 breaks down communication issues and possible outcomes. Respondents were asked to indicate their opinions about number of statements dealing with implications of ERP/web tool application within the organization. The results indicated that a significant majority of respondents believe that ERP implementation in their organization will result in a more standardized procedures.

Compared to the issue of standardization, the other criteria were measured to be not as significant. Respondents indicated that communication will still play a critical role, face to face meetings will not be eliminated, and communication issues will still remain critical.

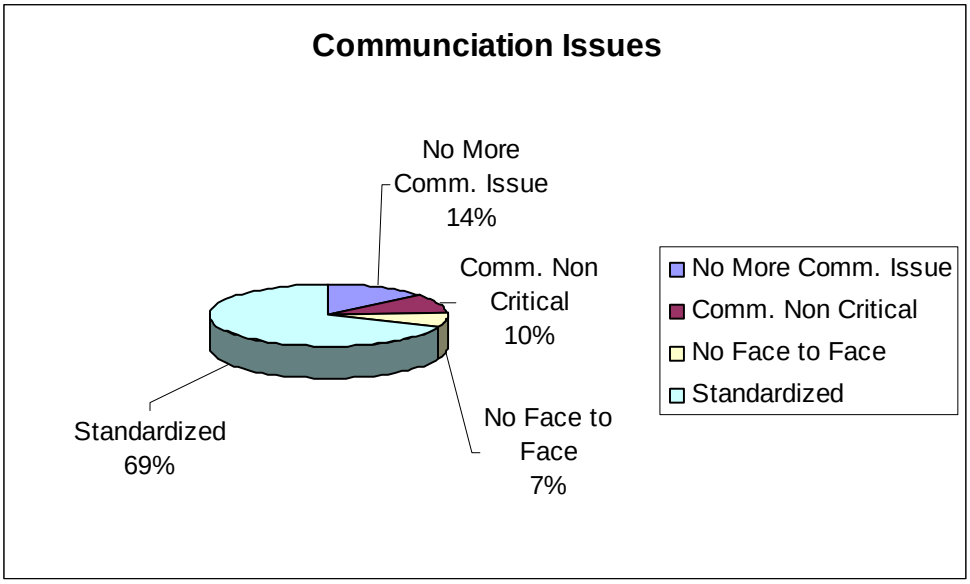

Figure 21 Communication Findings

The next question investigated the impact of ERP/project management tools on the ultimate profits of the operations. As indicated by ***Figure 22*** and as could have been anticipated, the majority of the participants indicated that they had not utilized these tools to a point that they could gage the impact on their profit however interestingly enough, if we consider the fact that ***Figure 14*** indicated that 45% of participants were familiar with PM web tools, ***Figure 22*** indicated that majority of this group have seen an impact on their bottom line.

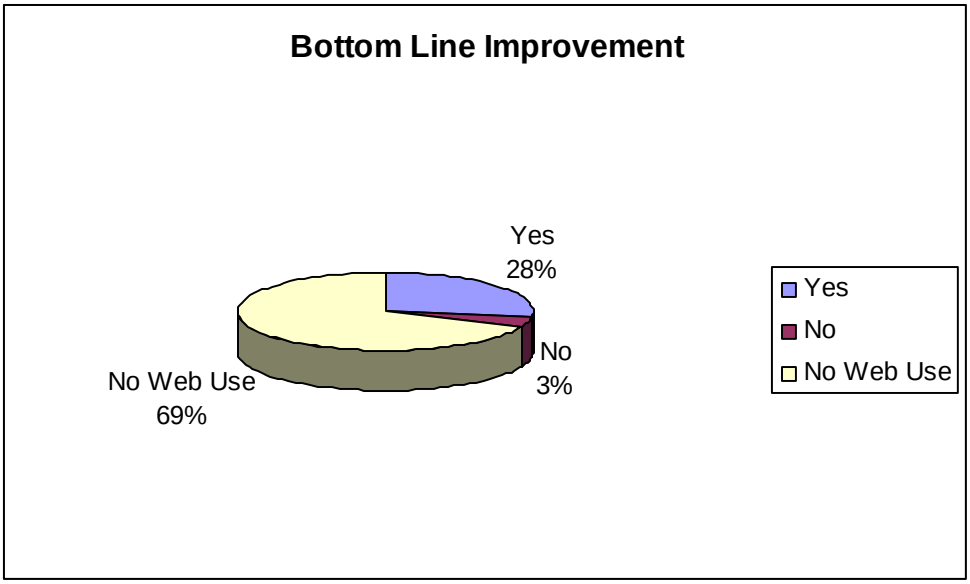

Figure 22 Impacts on Bottom Line

Overall, it can be concluded that majority of participants were familiar with some ERP/web project management tools, with e-mail being the most prominent one of the group. Participants also indicated that cost and time related areas were the areas that could improve most positively as a result of tool implementation. In addition, they indicate that communication is another area that could improve substantially from

implementation of these tools; the issue of standardization was identified as the one that would benefit the most. Finally, even though the majority, when asked, stated that they had neither used these tools nor would not anticipate any increase in their profits, of the group that had utilized these tools, the majority indicated an improvement to profits levels.

Section 4.4.4 Perceived Prohibitive Criteria

Hypothesis #1 of this research stated that "it is evident that there are number of critical/prohibitive criteria that lead to a failure or lack of utilization of ERP by SMSCO". Completed literature review supported this hypothesis and in order to further investigate the nature and extend of these criteria, the next series of questions were designed. The goal was to those who completed this questionnaire to present a set of questions that would help them identify the perceived prohibitive criteria. In preliminary interviews with some SMSCO executives it was indicated that the level of familiarity of potential participants with technical terminologies within this segment of the industry is very primitive thus knowing the fact that participants would not be very familiar with highly technical terminology, an attempt was made to address the questions in terms more familiar to them. The criteria that had been identified by the literature review to be of a prohibitive nature were considered. The most prominent ones were as follows; training, time scale, evaluation, high cost, complexities and security.

Initially participants were introduced to the following three criteria: cost, training, and infrastructure. Cost was designed to be a comprehensive category that would be further studied at later stage. Infrastructure was addressed to discover its relative importance against cost and training.

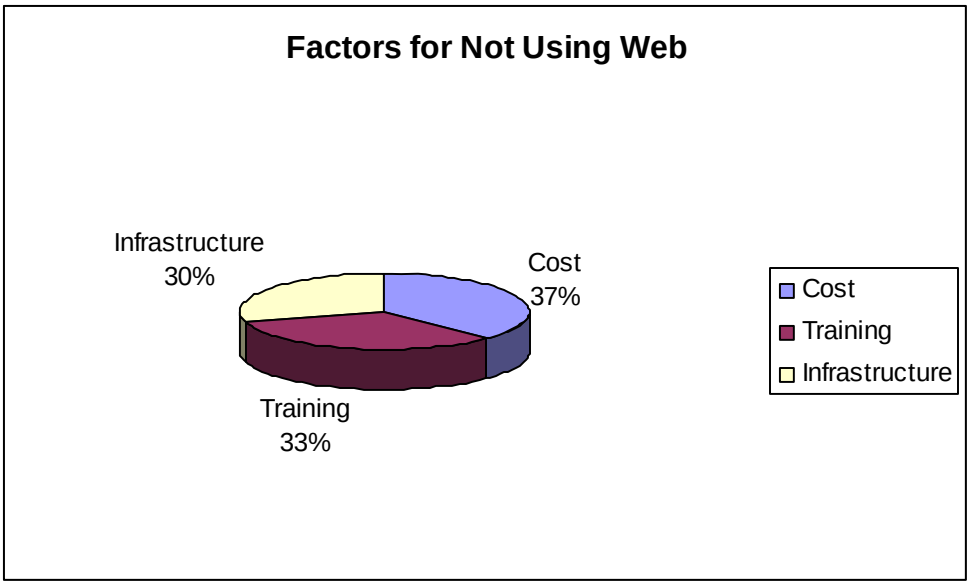

Figure 23 Cost Criteria for Not Using ERP/Project Management Web Tools

Results shown in ***Figure 23*** indicate the agreement and confirmation that cost is one of the main prohibitive criteria. Strong response to training that encompasses time and complexity, suggests it to be a prohibitive factor. In contrast, only 30% of participants indicated that infrastructure could be a potential prohibitive factor. The findings that can be concluded as a result of answers obtained from this question further support findings of the literature review with regard to existence of cost, time, and functional complexities as a prohibitive factor.

Cost, being such an important prohibitive factor, was designated to be investigated further therefore the next question was designed to study the impact that respondents placed on different types of existing cost. Cost categories that were singled out were initial cost, maintenance cost, and training cost.

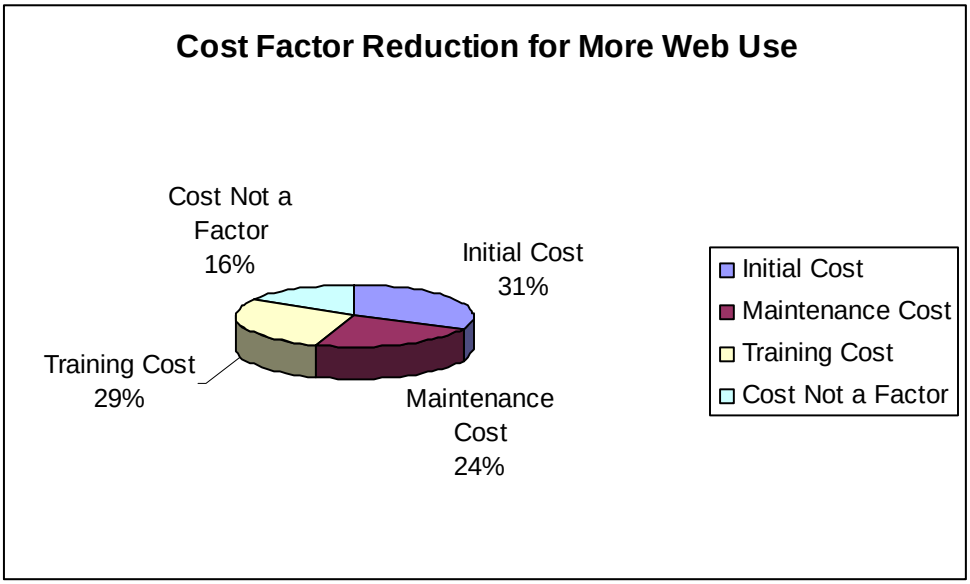

Figure 24 Relative Importance of Cost Categories as Prohibitive Factor

As revealed by ***Figure 24***, the majority of respondents indicated that in their opinion, initial cost was the most prominent obstacle to overcome. This was followed by training and maintenance costs. This result was anticipated since most of the time, members of SMSCO are working with very small margins on jobs that cannot carry large overhead items. The view of capital expenditure and accounting methodology they utilized, within which all costs are assigned to a particular project, makes it very difficult to justify the initial cost of implementation of ERP/web project management tools.

The literature review and initial interviews had identified legal liabilities, security, and level of complication of functionalities as potential prohibitive criteria therefore the next questions were design to clarify some of the related issues.

As indicated by ***Figure 25***, data reliability was identified to be a major factor. This was followed by level of complication, security, and legality as potential prohibitive criteria.

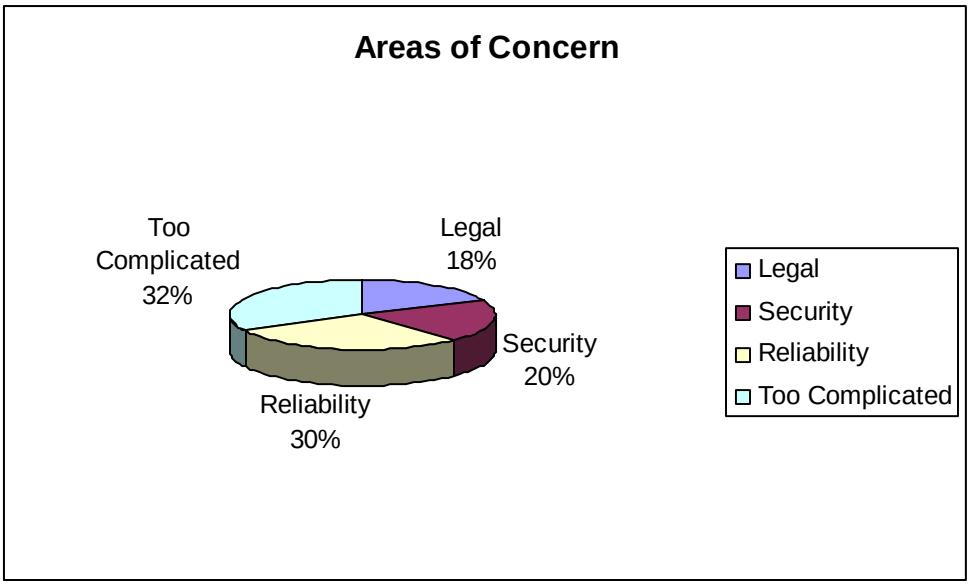

Figure 25 Additional Prohibitive Criteria

Once we isolated the contractors as a sub group in the respondents, it became evident that they were more concerned about the level of complication of functionalities followed closely by reliability of data. The level of concern shown by respondents reaffirmed the fact that these criteria all could be considered as prohibitive factors.

The respondents were asked to indicate their level of concern for security of information when utilizing web tools as an issue, in order to get a better handle on its

depth and nature. When security was isolated, a significant majority expressed a high level of concern.

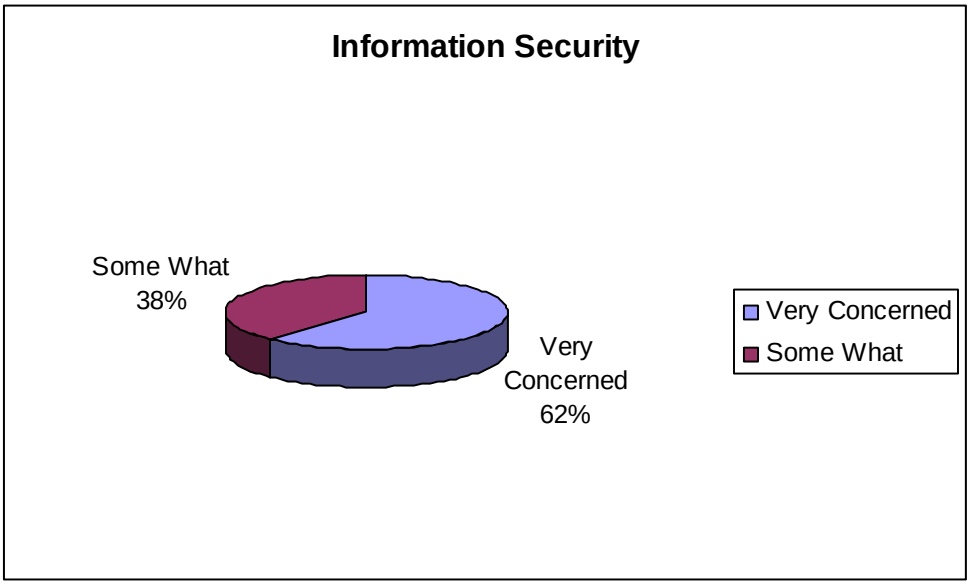

Figure 26 Security as a Prohibitive Factor

As indicated by ***Figure 26***, 62% of participants indicated that they were very concerned about security. Physical ownership and the location of a company's sensitive data, has always been a major concern of the construction industry, and the results obtained by the answers given to this question confirms this fact.

The construction industry, as indicated before, is very conservative in nature. Changes occur very slowly. Knowing what events would motivate participants to accept changes and comparing that to the existing procedures for actual happenings of the same events is critical in identifying potential prohibitive criteria. To this end, the next question was designed to investigate three issues in further detail. Owner's

requirements, market competition, and level of complication of available tools were chosen. As indicated by ***Figure 27***, the majority of respondents indicated that if the available tools were made less complicated or more user-friendly, they would become more desirable to use.

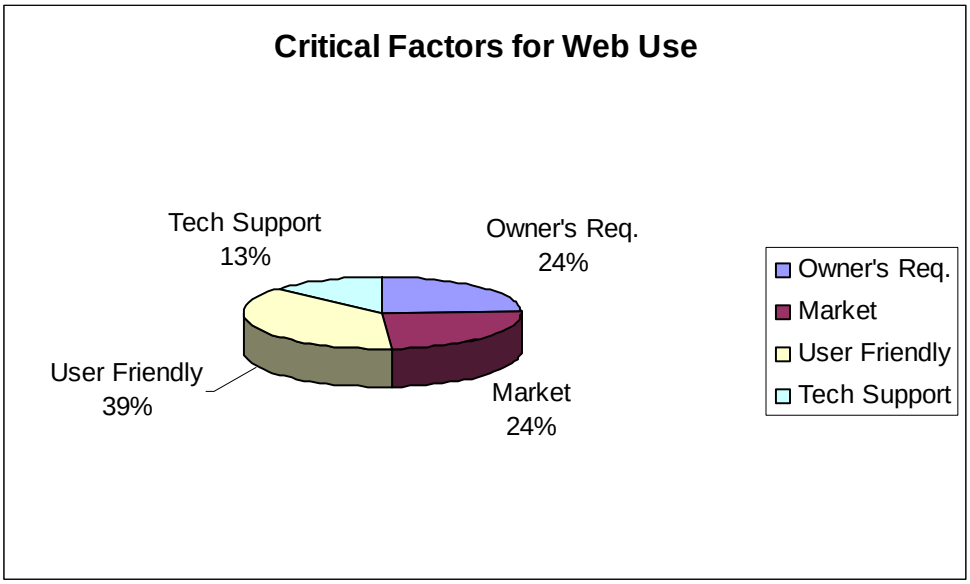

Figure 27 Additional Critical Prohibitive Criteria

This further enhances the role of functionality as a prohibitive factor. Market trends and owner's requirements were selected as other criteria. At the present time, the majority of owners for whom SMSCO perform various projects, do not see enough benefits for the project to require implementation of ERP/web project management tools. Their fear arises from the opinion that additional cost and time would be required to implement ERP/web project management tools. This fact affirms the role of cost and time as potential prohibitive criteria. Among the contractors subgroup, the

role of owner's requirements and market competition/trend were identified as more significant factors than level of complication of functionalities.

Overall, it can be concluded that the significant majority of participants confirmed cost as a primary prohibitive factor. This was followed by training and infrastructures. Within cost, the subcategory of initial cost was selected as a primary concern among all cost sub groups. Respondents also expressed their significant concern about security reliability and level of complications associated with different functionalities. Finally, it can be concluded that since the common denominator among most criteria is time, it becomes another significant prohibitive factor.

Section 4.5 Critical Determinants Identification

Results of the field questionnaire confirmed the existence of prohibitive criteria that were identified by a literature review. This same fact verified the true nature of Hypothesis #1 of this research.

Hypothesis #2 had been summarized as the attempts that must be made to evaluate the levels of contribution of these criteria in order to obtain a hierarchy of importance. Completing this task required a selection of certain critical determinants that could be utilized to measure a hierarchy of importance. Based on the following criteria, findings of questionnaire, initial interviews, literature review, and practical applicability, the following prohibitive criteria were selected and set as critical determinants:

- Cost
- Time
- Functionalities
- Security

In order to satisfy the second objective of this research each of these critical determinants needed to be analyzed further to discover their subcategories and their role in various ERP system performance measures.

Section 4.5.1 Cost

A review of answers given to the field questionnaire dealing with identifying and confirming prohibitive criteria clearly delineated cost as a major factor that needs to be addressed. Respondents singled out the initial cost, maintenance cost and training cost as other sub categories that needed to be considered.

The literature review indicated that the actual cost of ERP implementation, consisting of its various sub categories, is very high considering the economic realities of an SMSCO. Chen (2001), reports that the cost of implementing an ERP system could be as high as 2% to 3% of total organization's revenue. A new ERP implementation can range anywhere from $2 to $4 million for small firm to over $1 billion for a large company (Chen, 2001). ERP systems in general, are expensive and very complicated to implement. According to a survey of 15 implementations, the ERP implementation costs ranged from $2 million to $130 million, (Ross, 1999). Assuming that implementing an ERP system for an SMSCO member will have a cost closer to the lower range of this survey, it still would represent a significant financial burden. In order to overcome this obstacle members of SMSCO need to view the expenditure required by implementation of ERP more as a long term capital investment rather than direct job cost. Parker (1982) indicates that as database-oriented systems grow they provide increasing intangible benefits and perhaps the system should be treated as a long term capital investment, since it can no longer be readily expensed to

products or product lines because of its sphere of influence over the total management structure of the enterprise.

The complicated nature of intangible cost items also create a problem for SMSCO members, since they do can not readily identify and deal with all of them. This lack of identification becomes a problem when, as part of evaluation of ERP implementation, SMSCO members attempt to get a full picture of the financial impact on their organization. Knowing that potential cost items that cannot be identified exist, senior managers are reluctant to commit the organization.

As previously mentioned respondents to the field questionnaire identified the following cost categories as important; initial cost, maintenance cost, and training cost. This finding was supported by the literature review that was conducted. In order to further isolate the relationship and the impact that the initial cost item might have, it was decided to divide cost in two separate groupings - implementation cost and initial cost. Each was respectively defined to be as follows:

- Implementation cost – Cost to implement the program and to include items such as software & licenses, procedural changes, consulting, new hires, data digitization, and related overhead costs.
- Initial Cost – cost to evaluate systems, complete planning, buy and install all hardware and other accessories necessary to activate the program.

Section 4.5.2 Time

Literature review identified the time scale as a major prohibitive factor. A study of 14 organizations conducted by Adam and O'Doherty (2000), indicated 8.5 months as the average duration for implementation of ERP project. A case study of an organization conducted by Ding (2001) indicated that total time for integrating the whole ERP

system was 10 to 15 months. Web (1998), believes that organizations cannot afford to spend years implementing technology solutions. Tsung (2004), indicates that in some industries, lengthy implementation can provide competitors with enough time to either threaten or overtake the market position of the implementing organization. This phenomenon presents itself for members of SMSCO as limited project duration, which does not allow enough time to implement complete ERP package. Once implemented, to realize the full benefits of these systems takes far too long for the relatively short time frame allowed SMSCO to complete projects. Tsung (2004), indicates that it takes an average of 12 months, after implementation is initiated, to realize tangible and intangible benefits. The benefits of ERP still may not be shown until after companies have had it running for some time (Calogero, 2000). Ahmed, et al., (2003), identify the delayed return on investment as a major disadvantage of implementing the ERP systems. Most SMSCO are not in financial position to make an investment that would take a year to bear fruit. Literature reviewed also indicated that since quantification of benefits to be gained from ERP implementation is rather complex, it creates another problem for SMSCO to establish a complete picture of them, thus reducing their applicability.

A number of concerns that were identified by the field questionnaire also had time as a common thread running through them. Cost, security, and complication of functionalities all are impacted by time, which is the most common shared denominator.

Having confirmed and selected time as another prohibitive criterion, it was decided that time needed to be subdivided into the following subcategories: production time, implementation time, training time, and technical durability time. These subcategories

were identified and thus they could be scrutinized in more detail so that their impact on the ultimate framework solution can be measured.

Section 4.5.3 Functionalities

Since one of the objectives of this study was to generate a practical framework to be utilized by SMSCO to implement ERP systems, it was decided to analyze the impact of various functionalities that are offered by these systems. Complexities of various functionalities offered by major ERP systems were identified by literature reviewed to be another one of prohibitive criteria (Ahmad, et al., 2003). Shi and Halpin (2003), state that it will be hard to sell the current ERP systems to the construction industry for two major reasons: high cost and suitability. They indicate that existing ERP systems emphasize standardization and automation that are well suited for large scale and repetitive operations and management process. Project management functions have been widely researched on projects, processes, and activity levels covering many areas such as project controls and administration however research is still incomplete with integrating these findings into an ERP environment that could be utilized by SMSCO. The ranking or level of importance assigned to each functionality was not clearly identified by literature reviewed however a number of authors dealt with their taxonomy (Ahmed, et al., 2003), and role as a prohibitive factor (Skibniewski, et al., 2004).

The field questionnaire also verified the level of concern that SMSCO have for various functionalities such as project administration, project controls, project collaboration, and project contract management. Respondents expressed their concern about standardization, complications and communication issues. Based on the literature reviewed and results obtained from the questionnaire, it was decided to

identify the following as subcategories of functionality; project collaboration, modularity/flexibility, project controls, project administration, project contract management.

Section 4.5.4 Security

Literature reviewed identified system security, data reliability, and legal issues as major prohibitive criteria. Skibniewski, et al., (2004) and Shear and Everdingen, et al., (2000; 2004), identified system security as the most important issue considered by A/E/C firms when implementing PM-ASPs and participating in e-commerce. They declare that the current security scheme provided by PM-ASPs, an alternate ERP system, to protect unauthorized access to their site is too simple and inadequate.

The construction industry relies heavily upon data generated as a result of project completion, therefore data reliability and accessibility is of utmost importance to them. A case study completed by Irani and Love (2001), identified poor data reliability as one of the major failure criteria in implementation of ERP system. In the case of PM-ASP, Skibniewski, et al., (2004), indicate that data reliability is a prohibitive factor since, when servers are down, users become disconnected and unable to work online.

At the present time almost all SMSCO members manage their work in an environment that is paper-based. All binding issues dealing with legality of contracts are dealt with in a paper format. Responsibilities are not accounted for unless a paper trail is generated therefore the potential confusion that would be created as a result of implementation of ERP systems creating electronic accountability is a major prohibitive factor. This finding was verified by declarations such as the one provided by Skibniewski et al., (2004) which state that, “...new collaborative tools such as PM-

ASPs change the work method, making legal responsibilities in this new environment unclear".

Respondents to the field questionnaire also confirmed the existence of security and legal issues as major prohibitive criteria. In two different occasions they expressed significant concern for these issues. Based on the literature review and answers obtained from the field questionnaire, it was decided to select the following subcategories for further analysis; data access, data control, data reliability, and legal issues.

Section 4.6 Chapter Summary

This chapter presented the research approach and processes that were followed to design, collect, and analyze data, and validate/confirm the existence of prohibitive criteria. The idea behind the design of each section of the field questionnaire was discussed. Both quantitative and qualitative data were utilized to answer research questions. The field questionnaire was presented to a select group of industry executives and experts, and 29 responses were received. Lack of familiarity of the SMSCO member with the concept of ERP was the most significant problem that was encountered in the process of obtaining answers from participants. The validity assessment for the questionnaire was performed using the content validity method. The findings affirmed the validity of the questionnaire. For the purpose of this analysis the content of the questionnaire was divided into the following four categories; profile, applicability, perceived benefits, and prohibitive criteria. Responses obtained for each question were individually discussed and analyzed. Prohibitive criteria were identified to be cost, time, functionalities, and security.

CHAPTER 5 PROHIBITIVE/SELF-REGULATION CRITERIA ANALYSIS QUESTIONNAIRE

This chapter discusses the development and data collection processes of the field questionnaire utilized to gather the necessary data to establish a hierarchical ranking of previously identified prohibitive/self-regulation criteria and the relationships of forces at work between them. The architecture of the questionnaire, targeted respondents, questionnaire distribution, responses received, and the problems encountered during the data collection process are discussed, as well as the validity and reliability of the questionnaire.

Section 5.1 Design of Questionnaire

This research called for application of the prohibitive/self-regulation criteria in self-regulating process of EAM. The proposed research model recommended that SMSCO utilize these criteria in order to self regulate their requirements and perspective for a potential new ERP system. Therefore, following the confirmation of prohibitive criteria, a more in-depth investigation of each of these criteria was warranted. This investigation was necessary to measure the relative strength, hierarchical ranking, and impact of the criteria.

In order to examine the impact of these criteria on the level of acceptance and adoptability of existing ERP systems for an SMSCO environment, it was decided to design a questionnaire that would be distributed among select group of construction industry professionals who are familiar with ERP systems and their applications. A self-administrated web-based field questionnaire (Appendix B: Prohibitive Criteria

Analysis Questionnaire) was selected because it offered the most cost effective, yet efficient, method to reach the respondents that were located all across the world.

Section 5.1.1 Structure of the Field Questionnaire

The field questionnaire began with an introduction page explaining its objectives, and completion instructions. Following the introduction page, the questionnaire was then separated into ten sections. Section 1 consisted of four questions to collect general information about the respondents, including, industry type, years of experience, and familiarity with ERP and its implementation. Questions were selected so that the validity of the questionnaire could be verified. In section 2, separate alternatives for ERP systems were identified, and defined to be as follows:

- ERP – existing software packages that aim to integrate the main business functions across all departments within an organization, such as SAP3, Oracle, and IFS program.
- Web-based Project Management Systems (WPMS) – any electronic project management system that is conducted through a private network that uses internet protocols to transmit information.

These two systems were utilized as a measuring vehicle for determining the impact of various criteria on the operation of organization. In the following sections each critical criteria, the prohibitive criteria, were measured across the platform of two alternative systems.

Section 3 consisted of four questions that dealt with cost criteria. Cost as prohibitive criteria was broken down to the following sub-components which were defined to be as follows:

- Initial Cost – the cost to evaluate systems, complete planning, and buy and install all hardware and other accessories necessary to activate the program.
- Implementation Cost – the cost to implement the program and to include items such as software & licenses, procedural changes, evaluation, consulting, new hires, and related overhead costs.
- Maintenance Cost – the cost to update and maintain the system once implemented, and to include cost of upgrade purchases, staff time, and associated administrative overheads.
- Training Cost – the cost to setup and train necessary staff to utilize the system project wide.

Section 4 consisted of questions dealing with time-sensitive criteria. Time as a prohibitive criterion was broken down into the following sub-components which were defined to be as follows:

- Production Time – the time savings that result from higher operating efficiency.
- Implementation Time – the time that it will take to evaluate, purchase, install, and go live with the system company wide.
- Training Time – the time required for training the project staff to learn how to utilize the system for the day to day operations of the project.
- Technical Durability Time – the length of time for which the current software will be useful before requiring a major upgrade.

Section 5 contained five questions that dealt with functionality criteria. Functionality as a prohibitive criterion was broken down into the following sub-components which were defined to be as follows;

- Project Collaboration – the capabilities that enable team members to work jointly in reviewing and completing project tasks, both internally and externally.
- Modularity/Flexibility – the availability and the ease with which one uses the options to purchase and implement independent modules to complete different tasks.
- Project Controls – the tasks associated with items such as schedule, budget, change orders, RFI, shop drawings, and the document management process.
- Project Administration –all tasks that were directly or indirectly required for proper administration of the project such as payroll, human resources, and associated main office operations.
- Contract Management –all tasks necessary to manage contractual obligations such as subcontract agreement, purchase orders, insurance requirements, and safety compliance.

Section 6 dealt with the security criteria and was composed of four questions. Security as a prohibitive criterion was broken to the following subcomponents which were defined to be:

- Access – the means and methods provided for protection of data from internal and external threats.

- Control – the accessibility and dependability of existing and historical project data.
- Reliability – the degree of accuracy and availability of data in a timely manner.
- Legality – the issues dealing with accountability and responsibility of various personnel's interface with the system.

Section 7 initiated the pair-wise comparison analysis of the criteria. A brief description of the correct way to answer the questions was given. Sections 8 through 11 were designed so that a pair-wise data comparison for each of criteria could be obtained.

Section 5.1.2 Initial Review of the Field Questionnaire

The field questionnaire was initially shared with a number of construction industry experts, academicians, and SMSCO executives. Detailed discussions about the questionnaire were held utilizing web, e-mail, and face to face meetings. This preliminary review confirmed the structure, wording, format, and the concept of measuring the criteria across the two separate alternative systems. It also ensured that the questions were understandable, comprehensive, and clear. The comments received from the initial reviewing group resulted in some modifications that ultimately confirmed that all data required for the research could be obtained.

Section 5.2 Web Based Field Questionnaire

After reviewing the comments provided by the initial review group it was decided to administer the field questionnaire through the internet via the services provided by SurveyMonkey. The advantages of using this service to make the questionnaire

available to all respondents included cost reduction, quick turnaround time, ease of access, global availability, and respondent's convenience. SurveyMonkey provided a platform via the web that could easily be accessed. This service allowed for flexibility of design for the questions from multiple choices, to rating scale, to open-ended text. It also provided a simple yet very effective collection. A simple link was sent to participants via e-mail that gave them access to the questionnaire.

Section 5.3 Data Collection

The field questionnaire was designed and distributed to participants starting from December 1, 2006 thru April 20, 2007. SurveyMonkey's platform was utilized to collect data. In addition to its previously-mentioned benefits, use of this system also provided for the possibility of simultaneous response collection.

Section 5.3.1 Targeted Respondents

The target respondents of the questionnaire were construction industry personnel and executives of SMSCO who had experience with various ERP systems. To gain access to all of the targeted respondents, organizations, industry advisory councils, and companies whom have either utilized ERP systems or are familiar with its application were contacted. Within each organization an expert was identified, who was then contacted to participate in the questionnaire. Respondents were asked to answer all of the questions. The common thread among all participants was their familiarity with ERP. Since the opinions provided by these experts were so heavily relied upon, their extensive familiarity with ERP represented a key prequalification that had to be met by each participant.

Section 5.3.2 Questionnaire Distribution & Responses

The field questionnaire was made available to thirty participants. Of the total number of potential participants invited, 24 responded (80%). The questionnaire, distributed via the SurveyMonkey platform, was completed by representatives of the following organizations: SAP AG, Oracle, Laing O'Rourke, BAM Groep nv, High Concrete Structures, Inc., Bechtel Corporation, Flatiron Construction Corp, Dassian, Beutler Corp., and PGCSite. The majority of respondents, 87.5%, indicated that they were affiliated with the following industries; IT, consulting, construction.

79.2% of respondents indicated that they had more than 10 years of experience working in the construction industry. 50% of the respondents were currently working in construction industry. A significant part of the group, 83.3%, indicated that their company currently utilizes ERP systems as previously defined. 92% of respondents indicated that they have been involved in ERP implementation projects.

Section 5.3.3 Problems Encountered

Problems were encountered during the data collection process that led to some discussion back and forth with the respondents. Most problems were detected via e-mails that were received from respondents while completing the questionnaire online.

Most problems reported by respondents were related to internet congestions and the unavailability of the link. It was found that internet congestion was the most common problem encountered by the respondents at peak hours. The time selected to complete the questionnaire was the main factor.

Another problem faced by some respondents was the interpretation of the definitions provided for ERP system alternatives. Two respondents indicated some confusion

with the definition of WPMS. These problems were solved by providing additional e-mail information.

Section 5.4 Validity of Questionnaire

Validity is concerned with how well a questionnaire measures what it intends to measure. The method of content validity was utilized to verify the validity of the questionnaire. Since content validity, as indicated in Chapter 3, consists of face validity and sampling validity tests, both were applied to this questionnaire as follows:

- Face Validity: to establish the Face Validity for this questionnaire, results obtained from the previous questionnaire and unstructured interviews with industry experts were utilized.
- Sampling Validity: the targeted respondents of the questionnaire were, by large percentage, members of construction industry that were very familiar with ERP utilization and implementation. A number of questions in the questionnaire were dedicated to this issue, since extensive knowledge of ERP by participants was deemed so important.

Section 5.5 Chapter Summary

This chapter presented the process that was followed to design, distribute, and collect the field questionnaire. The findings of this questionnaire were to be utilized in the creation of a decision framework to be used by SMSCO. The structure of the field questionnaire was discussed and each of its 10 separate sections reviewed. The initial review conducted prior to distributing the questionnaire was discussed. It was decided that the survey services available via web such as SurveyMonkey, provided the best

platform to conduct this questionnaire. Data was collected between December of 2006 and April of 2007. Construction industry personnel and executives of SMSCO who had experience with various ERP system application and implementation were chosen to participate. The field questionnaire was made available to thirty participants, of which 24 responded. The organizations that were represented were among industry leaders. Internet congestion represented the most significant problem encountered while collecting data. The validity of the questionnaire was confirmed using method of content validity.

CHAPTER 6 PROHIBITIVE CRITERIA DATA ANALYSIS

This chapter reviews the analysis that was performed for each of prohibitive criteria and their relationships. Comparative analysis for each alternative system was also performed.

Section 6.1 Cost Criteria

Four cost criteria were considered for this analysis. The types of costs were initial cost, implementation cost, maintenance cost and training cost. These four criteria were ranked in a 9-point Likert scale, with a 1 implying that the item had a "Very Low" value as a criterion for the choice of ERP, and 9 implying that the item had a "Very High" value as a criterion for the choice of ERP. The following table shows descriptive statistics for the responses to these items:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CostInitialERP	21	5.00	9.00	6.4762	1.40068
CostImplemERP	21	5.00	9.00	7.0476	1.39557
CostMaintERP	21	3.00	9.00	5.8095	1.50396
CostTrainERP	21	3.00	9.00	5.8571	1.45896
Valid N (listwise)	21				

Table 1 Descriptive Statistics for Cost Criteria ERP

As can be seen in Table 1, the item that had the highest average value as a criterion for the choice of ERP was implementation cost, for which the average response was

7.04. Following this item was initial cost (M = 6.47), training cost (M = 5.85) and maintenance cost (M = 5.80).

Although the means provide a hierarchy for the value of this items (in this case, implementation cost had the highest value, while maintenance cost had the lowest one), it is possible that the difference in the average scores were due to normal sampling variability. In order to assess whether either of the items had a *significantly* higher or lower value than the other items, multiple paired *t* tests were carried out. The objective of these tests was to assess whether the observed differences among the average scores were significantly different from zero. This test is useful for comparing two responses that were given by the same subject or rater. One assumption for this test is that the variables are normally distributed. A *Kolomogorov-Smirnov* test was used in order to assess whether the variables were normally distributed. For all variables, the null hypothesis that the data followed a normal distribution was not rejected at the 0.05 level, the minimum *p* value was 0.08, and therefore there is evidence to support of the idea that the assumptions for the paired *t* tests were satisfied.

A 0.05 significance level was used for this analysis. Table 2 shows the *p* values associated to each pair of variables that was compared. A *p* value lower than 0.05 would imply that the difference between the two average scores was significantly different; while a *p* value higher than 0.05 would imply that the difference was not significant.

	Initial	Implementation	Maintenance
Implementation	0.062		
Maintenance	0.059	<.001	
Training	0.05	0.001	0.867

Table 2 *P* Values for Cost Criteria ERP

As can be gleaned from this table, the difference between maintenance and training was not significant ($p = 0.867$) so there is no evidence to conclude that maintenance would rank higher than training in terms of its value as a criterion for the choice of ERP. For all other comparisons, the *p* value was either lower than 0.05 or very close to it. This would suggest that all other differences were significant. With no significant differences in the average values of these items it appears that maintenance and training costs were considered the lowest valued criteria. Both of these items had a significant higher value than initial cost, which, in turn, had a significantly higher value than implementation cost. The hierarchy among these items could thus be defined as:

1. Implementation
2. Initial
3. Maintenance and Training (at the same level)

This ranking matches well with the previous understandings established in the literature reviewed. Since the magnitude of the implementation cost could be so much greater than the other cost criteria, it seems that its financial impact on the organization is most significant. The ranking presented here is strongly affected by

the associated and actual monetary amounts, from the most expensive to the least expensive. This fact makes perfect sense for any construction company. Construction, being bottom line oriented industry, has always paid particular attention to costs at all levels.

This same analysis was also conducted for the choice of WPMS. The methodology that was followed was identical to the one for ERP. Table 3 shows descriptive statistics for cost criteria related to the choice of WPMS:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CostInitialWPMS	21	3.00	8.00	5.0000	1.44914
CostImplemWPMS	21	1.00	9.00	5.4286	1.71963
COstMaintWPMS	21	2.00	8.00	4.9524	1.39557
CostTrainWPMS	21	1.00	7.00	4.8571	1.71131
Valid N (listwise)	21				

Table 3 Descriptive Statistics for Cost Criteria WPMS

As outlined in this table, the highest average score was associated with implementation costs (M = 5.42), followed by initial costs (M = 5), maintenance costs (M = 4.95) and training costs (M = 4.85).

Again, paired *t* tests were carried out in order to assess significant differences among these items. The results are presented in Table 4:

	Initial	Implementation	Maintenance
Implementation	0.196		
Maintenance	0.871	0.066	
Training	0.642	0.069	0.748

Table 4 *P*-Value for Cost Criteria WPMS

According to the results in this table, there were no significant differences between any pair of items at the 0.05 level. This would suggest that all items were at the same level in terms of value for the choice of WPMS.

Results indicate that cost as criteria is not as significant as other prohibitive criteria while utilizing WPMS. This could be the result of lower monetary values associated with tangible cost items, and not having a clear value for intangible cost items.

Section 6.2 Time Criteria

Four time criteria were considered for this analysis. The types of time criteria were production time, implementation time, training time, and technical durability time. These four criteria were ranked in a 9-point Likert scale, with a 1 implying more "negative" levels of the attribute (i.e. longer implementation time, or shorter durability time) for the choice of ERP, and 9 implying more "positive" levels (i.e. shorter implementation time, or longer durability time). Table 5 shows descriptive statistics for the responses to these items:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
TimeProdERP	18	3.00	9.00	5.1111	1.64098
TimeImpERP	18	1.00	9.00	3.5000	2.28164
TimeTrainERP	18	1.00	9.00	4.6111	2.09028
TimeDurabERP	18	4.00	9.00	6.7778	1.62899
Valid N (listwise)	18				

Table 5 Descriptive Statistics for Time Criteria ERP

As evidenced by the data in this table, technical durability time had the highest average value (M = 6.77), production time had the second highest (M = 5.11), followed by Training Time (M = 4.61) and Implementation Time (M = 3.5).

Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 6:

	Production	Implementation	Training
Implementation	0.005		
Training	0.421	0.004	
Durability	0.007	<0.001	0.002

Table 6 *P*-Value for Time Criteria ERP

As stated by the data in Table 6, all average scores, except for the pair production-training (p = 0.421) were significantly different at the 0.05 level. These results suggest that technical durability had a significantly higher average score than all other variables. The next highest score would correspond to both production and training times. Both of these scores were significantly higher than implementation time. The hierarchy among these items could thusly:

1. Technical Durability
2. Production and Training (at the same level)
3. Implementation

The pace of advances made in the applicable IT science in ERP is the main reason for technical durability having such a significant impact. The major concern highlighted here deals with the fact that the industry is very concerned with making a major investment in a system that will be outdated in short order. As indicated by the above ranking for ERP, technical durability is followed by production and training as other prohibitive criteria. Same concern that is reflected in technical durability can be observed in these criteria. Organizations are not willing to commit to the program if they fear that time required to train staff and produced a product will be wasted since the whole system will have to be updated in short period of time. The reason implementation as prohibitive time criterion is last among the other criteria could stem from the fact that this time is seen by the management as “part of the job” and therefore not as significant as others.

This same analysis was conducted for the choice of WPMS. The methodology that was followed was identical to the one for ERP. The following table shows descriptive statistics for time criteria related to the choice of WPMS:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
TimeProdWPMS	18	1.00	7.00	4.3333	1.49509
TimeImpWPMS	18	1.00	7.00	5.0000	1.78227
TimeTrainWPMS	18	1.00	7.00	5.2778	1.60167
TimeDurabWPMS	18	2.00	8.00	5.7778	1.59247
Valid N (listwise)	18				

Table 7 Descriptive Statistics for Time Criteria

As seen in Table 7, the highest average score was associated with technical durability (M = 5.77), followed by training time (M = 5.27), implementation time (M = 5) and implementation production time (M = 4.33). Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 8:

	Production	Implementation	Training
Implementation	0.175		
Training	0.063	0.311	
Durability	0.006	0.172	0.337

Table 8 *P*-Value for Time Criteria

While production-training was close to significance, the results show that the only pair that was significantly different at the 0.05 level was production-durability. The hierarchy for these items could thus be defined as:

1. Technical Durability
2. Training
3. Implementation and Production (at the same level)

In the case of WPMS, technical durability remains the most significant prohibitive criterion; however, training moves up into second position alone. This could be a result of the fear that organizations have about required staff training in order to become familiar with the particulars of any new provider, and its cascading effect on their subcontractor and back office communities.

Overall it is very clear that in both alternative systems technical durability is the main prohibitive criterion. Since the pace of advances in IT science will not be slowed down, SMSCO organizations need to approach this not as prohibitive criterion but as a "reality check". The objective should be systems that can perform and produce meaningful results; these systems need not be updated for every new gadget.

Section 6.3 Functionality Criteria

Five functionality criteria were considered for this analysis. The types of functionality criteria were collaboration, modularity, project controls, administration and contract management. These five criteria were ranked in a 9-point Likert scale, with a 1 implying that the item had a "negligible" importance as a criterion for the choice of ERP, and 9 implying that the item had an "imperative" importance as a criterion for the choice of ERP. Table 9 shows descriptive statistics for the responses to these items:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FunCollabERP	18	3.00	9.00	6.2778	1.48742
FunModulERP	18	3.00	9.00	6.3889	1.78684
FunControlERP	18	5.00	9.00	7.7222	1.52646
FunAdminERP	18	5.00	9.00	7.4444	1.58011
FunContractERP	18	4.00	9.00	7.1667	1.68907
Valid N (listwise)	18				

Table 9 Descriptive Statistics for Functionality Criteria ERP

The highest score in this table corresponded to project controls (M = 7.72), followed by administration (M = 7.44), contract management (M = 7.16), modularity (M = 6.38) and collaboration (M = 6.27).

Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 10:

	Collaboration	Modularity	Controls	Administration
Modularity	0.777			
Controls	0.005	0.017		
Administration	0.013	0.006	0.368	
Contract Mgmt.	0.053	0.059	0.066	0.056

Table 10 *P*-Values for Functionality Criteria ERP

In all cases (except for the pairs Collaboration-Modularity, with p = 0.777 and Administration-Controls, with p = 0.368), Table 10 shows all the p values were either lower than 0.05 or very close to that level. This would suggest that the hierarchy of importance of these functionalities would be:

1. Project Controls and Administration (at the same level)
2. Contract Management
3. Collaboration and Modularity (at the same level)

Project controls & administration present themselves as most significant of prohibitive criteria for ERP in this category. The reason behind this stems from the fact that organizations are very concerned with relying on a particular system for their controls and administrative functions. These functions require a high degree of familiarity among team members thus increasing the size of the circle of people that need to be trained and be able to operate the system.

Contract management is the next prohibitive criterion presented in the ranking produced for ERP alternate. Since most of the tasks associated with this criterion also involve members from different part of the team, getting them familiar with and efficient in operating within the systems could be the cause for its ranking.

Results indicate that for ERP systems collaboration & modularity are very close when it comes to ranking as a prohibitive criterion and in fact, they rank on the bottom. In comparison to other three criteria in the case of ERP alternate, these two are not as significant as others because they spread the management responsibilities and risks.

This same analysis was also conducted for the choice of WPMS. The methodology that was followed was identical to the one for ERP. Table 11 shows descriptive statistics for functionality criteria related to the choice of WPMS:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FunCollabWPMS	18	3.00	9.00	6.7222	1.70830
FunModulWPMS	18	3.00	8.00	5.5000	1.72354
FunControlWPMS	18	3.00	9.00	6.7778	2.28950
FunAdminWPMS	18	2.00	9.00	5.5556	2.38185
FunContractWPMS	18	3.00	9.00	6.1667	2.17607
Valid N (listwise)	18				

Table 11 Descriptive Statistics for Functionality Criteria WPMS

The highest average score in Table 11 was assigned to project controls (M = 6.77), followed by collaboration (M = 6.72), contract management (M = 6.16), project administration (M = 5.55) and modularity (M = 5.5).

Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 12:

	Collaboration	Modularity	Controls	Administration
Modularity	0.018			
Controls	0.918	0.01		
Administration	0.069	0.908	0.05	
Contract Mgmt.	0.263	0.062	0.119	0.179

Table 12 *P*-Values for Functionality Criteria WPMS

Given these results, the hierarchy for these items could be defined as:

1. Controls, Collaboration, and Contract Management
2. Administration and Modularity

In the case of WPMS, controls still remains as one of the main prohibitive criteria ; however, the difference between it and collaboration & contract management is reduced. The reason behind controls being a prohibitive criterion remains the same, as in the case of ERP. Collaboration and contract management became critical because the issues of access to WPMS and efficient operation of by all team members became critical. Since the administration function required for this alternate is provided by outside sources, it does not have the same individual impact on the ranking. Finally, modularity was ranked as the lowest criteria because, in the case of WPMS, modularity is provided by the providers and is not so essential to the organization that it would be considered an option.

Overall, project controls ranked the highest for both alternates. Project controls, which consist of items such as project budget, project schedule, change orders, RFI processing, and shop drawing management, are very important to proper management and successful completion of all projects therefore any issue related to this topic is very sensitive to the organization. The possibility of any impact on controls by any outside source would alter the results of the operation so significantly that its risk can not be tolerated.

Section 6.4 Security Criteria

Four security criteria were considered for this analysis. The types of security criteria were access, control, reliability and legality. These four criteria were ranked in a 9-point Likert scale, with a 1 implying the lowest degree of concern about those

security criteria, and a 9 representing the highest degree of concern for the choice of ERP. Table 13 shows descriptive statistics for the responses to these items:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SecAccessERP	18	1.00	9.00	6.5000	2.33263
SecControlERP	18	1.00	9.00	6.2222	2.34033
SecReliabERP	18	1.00	9.00	6.9444	2.31294
SecLegalERP	18	1.00	9.00	6.1667	2.64019
Valid N (listwise)	18				

Table 13 Descriptive Statistics for Security Criteria ERP

As can be gleaned from Table 13, reliability had the highest average score (M = 6.94), followed by access (M = 6.50), control (M = 6.22) and legality (M = 6.16). Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in the following table:

	Access	Control	Reliability
Control	0.263		
Reliability	0.238	0.033	
Legality	0.513	0.902	0.039

Table 14 *P*-Values for Security Criteria ERP

In Table 14, the only significant differences were observed for the pairs reliability-control (p = .033) and reliability-legality (p = 0.039). All other pairs were not significantly different. This would suggest that the hierarchy of importance of these security criteria would be:

1. Reliability
2. Access, Control and Legality (at the same level)

Reliability was defined to be the degree of availability of data in timely manner. The results indicated that not having confidence in this matter is a significant prohibitive factor for ERP users. Data availability is one of the most critical elements of any construction operation. These operations consist of various tasks such as, estimating, bidding, negotiating, material ordering and availability, resource allocation, and equipment availability. It can easily be understood how this would take precedent in the ranking of security criteria. As indicated by the results, other criteria were very close and could not be ranked individually.

This same analysis was also conducted for the choice of WPMS. The methodology that was followed was identical to the one for ERP. Table 15 shows descriptive statistics for Security criteria related to the choice of WPMS:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SecAccessWPMS	18	2.00	9.00	6.2778	2.08088
SecControlWPMS	18	2.00	9.00	6.3333	1.78227
SecReliabWPMS	18	3.00	9.00	6.7222	1.96456
SecLegalWPMS	18	1.00	9.00	5.8889	2.54116
Valid N (listwise)	18				

Table 15 Descriptive Statistics for Security Criteria WPMS

As shown, the highest average score was associated to reliability (M = 6.72), followed by control (M = 6.33), access (M = 6.27) and legality (M = 5.88). Again, paired *t* tests were carried out in order to assess the significant differences among these items. Results are presented in the Table 16:

	Access	Control	Reliability
Control	0.842		
Reliability	0.354	0.274	
Legality	0.415	0.367	0.105

Table 16 *P*-Values for Security Criteria WPMS

As shown in Table 16, there were no significant differences between any pair of items at the 0.05 level. This would suggest that all items were at the same level in terms of value for the choice of WPMS.

Even though the results obtained in this research highlighted a significant level of concern for security criteria by WPMS, users it did not reveal a tangible difference among individual criterion.

The most significant prohibitive criterion identified in this category was reliability. Lack of confidence in the availability of data is a detrimental factor for any construction organization.

Section 6.5 Inter-criteria comparisons

Similar analyses were conducted in which the relative importance of cost, time, functionality, and security criteria as a whole was compared. In order to do this we, computed overall cost, time, functionality, and security scores by averaging the responses to the items within each category. In this way, the overall importance of cost was computed as the average of the responses to initial cost, implementation cost, maintenance cost, and training cost. A similar procedure was carried out for each of the other criteria. In order to verify that the items within each criterion were actually measuring the same construct, we computed Cronbach's alpha for each of them. Values close to 1 in this statistic suggest that there is a high correlation among the items that compose each construct, and thus it can be assumed that they are all measuring the same. Values of 0.7 or higher for Cronbach's alpha are usually considered high enough to assume that the items measure the same construct. In all cases, we found that Cronbach's alpha was relatively high (the minimum was 0.83), which implies that the items within each construct are measuring the same dimension. This implies that it would be conceptually correct to average all items in order to generate overall cost, time, functionality, and security scores.

The following table shows descriptive statistics for these overall scores (related to ERP):

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CostScore	21	3.50	8.00	5.2976	1.17691
TimeScore	18	3.25	9.00	5.0000	1.29479
FunScore	18	5.00	9.00	7.0000	1.26305
SecScore	18	1.00	8.75	6.4583	2.20169
Valid N (listwise)	18				

Table 17 Overall Descriptive Statistics ERP

In Table 17, the highest average score was assigned to functionality (M = 7), followed by security (M = 6.45), cost (M = 5.29) and time (M = 5). Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 18:

	Cost	Time	Functionality
Time	0.338		
Functionality	<0.001	<0.001	
Security	0.056	0.021	0.211

Table 18 Overall *P*-Values for ERP

As shown, functionality-security (p = 0.211) and time-cost (p = 0.338) were not significantly different. All other pairs were significantly different. This would suggest that the hierarchy of importance of these criteria would be:

1. Functionality and Security
2. Cost and Time

Correlation coefficients were computed among these overall variables in order to assess whether there were significant relationships between each of the pairs. Results are presented in Table 19:

		CostScore	TimeScore	FunScore	SecScore
CostScore	Pearson Correlation	1	-.021	.310	.313
	Sig. (2-tailed)		.934	.210	.206
	N	21	18	18	18
TimeScore	Pearson Correlation	-.021	1	.322	.111
	Sig. (2-tailed)	.934		.193	.661
	N	18	18	18	18
FunScore	Pearson Correlation	.310	.322	1	.597(**)
	Sig. (2-tailed)	.210	.193		.009
	N	18	18	18	18
SecScore	Pearson Correlation	.313	.111	.597(**)	1
	Sig. (2-tailed)	.206	.661	.009	
	N	18	18	18	18

** Correlation is significant at the 0.01 level (2-tailed).

Table 19 Correlation Coefficients ERP

The only correlation that was significantly different from zero was the correlation between functionality and security. The correlation coefficient was positive, at 0.597. This coefficient would imply that subjects that assigned higher scores to the functionality criteria also tended to assign higher scores to security criteria. For all other pairs, the correlations were not significantly different from zero, so it was not possible to conclude that there was a relationship among them. It is possible; however, that the non-significant result is due to the fact that the sample size was relatively low, which would cause the test for significance of the correlation to be low powered.

This inter-criteria comparison was also carried out for the items related to WPMS. The methodology used was the same as for ERP. Table 20 shows descriptive statistics for the four criteria, as related to WPMS:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CostScoreWPMS	21	1.75	7.25	5.0595	1.34607
TimeScoreWPMS	18	1.75	6.50	5.0972	1.08851
FunScoreWPMS	18	3.40	8.80	6.1444	1.63031
SecScoreWPMS	18	2.75	8.75	6.3056	1.79574
Valid N (listwise)	18				

Table 20 Overall Descriptive Statistics for WPMS

The highest average score was assigned to security (M = 6.30), followed by functionality (M = 6.14), time (M = 5.09) and cost (M = 5.05).

Again, paired *t* tests were carried out in order to assess significant differences among these items. Results are presented in Table 21:

	Cost	Time	Functionality
Time	0.886		
Functionality	0.004	0.019	
Security	0.004	0.011	0.629

Table 21 Overall *P*-Values for WPMS

Except for functionality-security ($p = 0.886$) and cost-time ($p = 0.629$), all other pairs were significantly different. This would suggest that the hierarchy of importance of these criteria would be:

1. Functionality and Security
2. Cost and Time

It is interesting to note that this hierarchy was the same as that for the choice of ERP alternate.

Correlation coefficients were computed among these overall variables in order to assess whether there were significant relationships between each pair. Results are presented in Table 22:

		CostScoreWPMS	TimeScoreWPMS	FunScoreWPMS	SecScoreWPMS
CostScoreWPMS	Pearson Correlation	1	.185	.596(**)	.506(*)
	Sig. (2-tailed)		.463	.009	.032
	N	21	18	18	18
TimeScoreWPMS	Pearson Correlation	.185	1	.249	.304
	Sig. (2-tailed)	.463		.320	.221
	N	18	18	18	18
FunScoreWPMS	Pearson Correlation	.596(**)	.249	1	.674(**)
	Sig. (2-tailed)	.009	.320		.002
	N	18	18	18	18
SecScoreWPMS	Pearson Correlation	.506(*)	.304	.674(**)	1
	Sig. (2-tailed)	.032	.221	.002	
	N	18	18	18	18

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 22 Correlation Coefficient WPMS

As can be seen in Table 22, three correlation coefficients were significantly different from zero: cost-functionality (r = 0.596, p = 0.009), cost-security (r = 0.506, p = 0.032) and functionality-security (r = 0.674, p = 0.002). In all cases, the significant coefficients were positive, suggesting that high levels of one member of the pair were usually associated with high levels in the other members, for example, subjects that valued cost highly also tended to value functionality highly. For all other pairs, the correlations were not significantly different from zero, so it was not possible to conclude that there was a relationship among them. It is possible; however, that the

non-significant result is due to the fact that the sample size was relatively low, which would cause the test for significance of the correlation to be low powered.

As indicated by the results the following overall ranking can be established for both alternates;

1- Functionality & Security

2- Cost & Time

Among functionality criteria, as indicated previously, controls represented the most significant prohibitive criterion. Practitioners of both systems indicated that not having confidence in a system that would allow effective utilization of project controls would result in its ultimate failure.

Reliability as a security criterion represented the most significant prohibitive criterion in this category, and once again this was the same for both alternative systems. Indicating that in this case, the platform for ERP application is not the critical factor, rather the availability of data, becomes a cause for acceptance or rejection of any system.

Implementation cost was the most significant criterion in cost category. Based on literature reviewed and initial interviews conducted, it was anticipated that the cost criteria in general, and implementation cost in particular, would rank higher in the overall ranking of all prohibitive criteria. This finding contradicted that thought by confirming cost as a secondary prohibitive criterion.

Technical durability was confirmed as the most significant prohibitive criteria in time category. As indicated, it is evident that the fear of having to adjust or upgrade existing procedures to accommodate for new versions of ERP systems, regardless of

its platform, represent the main reason for technical durability being ranked the highest among other criteria in this segment.

Section 6.6 Alternative Systems Comparison

Paired *t* tests were carried out in order to assess whether there were significant differences in the value of each criteria between ERP and WPMS. Table 23 shows the mean score for each criterion and for each alternative, and the *p* value corresponding to the paired *t* test. Values lower than 0.05 would imply that the difference in value between ERP and WPMS for the corresponding criteria was significantly different from zero. Criteria with significant differences are shown in boldface.

Table 23 shows that no significant differences were observed in most of the criteria. The cases where significant differences were observed were administration, a criterion of functionality, for which the value for ERP was higher than the value for WPMS, and all the cost criteria (initial, implementation, maintenance, and training). In these cases, the value for ERP was higher than the value for WPMS, suggesting that cost criteria are more important for the choice of ERP than for the choice of WPMS. On the other hand, there were no significant differences for any of the other criteria.

	ERP	WPMS	*p* value
Cost Initial	**6.476**	**5.000**	**0.000**
Cost Implementation	**7.048**	**5.429**	**0.002**
Cost Maintenance	**5.810**	**4.952**	**0.041**
Cost Training	**5.857**	**4.857**	**0.025**
Time Productivity	5.111	4.333	0.159
Time Implementation	3.500	5.000	0.057
Time Training	4.611	5.278	0.255
Time Durability	6.778	5.778	0.095
Funct. Collaboration	6.278	6.722	0.331
Funct. Modularity	6.389	5.500	0.167
Funct. Control	7.722	6.778	0.077
Funct. Administration	**7.444**	**5.556**	**0.010**
Funct. Contract	7.167	6.167	0.076
Security Access	6.500	6.278	0.726
Security Control	6.222	6.333	0.854
Security Reliability	6.944	6.722	0.562
Security Legal	6.167	5.889	0.688

Table 23 Mean Values for Alternative Systems

The fact that all four cost criteria were significantly more important for the choice of ERP than for the choice of WPMS stems from the fact that there is significant monetary difference between them. In case of the ERP alternate, organizations need to commit to a far larger financial investment. The magnitude of this investment and

the way it is viewed in the organization is the main reason for it being labeled as a prohibitive criterion.

Section 6.7 Chapter Summary

This chapter presented the statistical analysis that was conducted on the results obtained from field questionnaire. Each prohibitive criterion and their subcategories were reviewed and analyzed. In addition comparative analysis for each alternative system was conducted.

Rankings were established for each of the criteria based on multiple paired *t* tests. All possible pairs of criteria were assessed for significant differences. Criteria that were not significantly different were placed in the same ranking level.

In the case of Cost Criteria (ERP alternate) following ranking was established:

1- Implementation

2- Initial

3- Maintenance and Training

In case of cost criteria for the WPMS alternate, no significant differences were found among the four cost criteria.

Results from the analysis conducted for time criteria for the ERP alternate indicated the following ranking:

1- Technical Durability

2- Production & Training

3- Implementation

The only difference observed for the WPMS alternate was the fact that production as a prohibitive criterion dropped to the bottom level.

Functionality criteria ranking for ERP alternate was as follows:

1- Project Controls & Administration

2- Contract Management

3- Collaboration & Modularity

The same criteria's ranking for WPMS alternate was as follows:

1- Project Controls, Collaboration, and Contract Management

2- Administration & Modularity

Security criteria ranking for the ERP alternate was as follows:

1- Reliability

2- Access, Control & Legality

In the case of the WPMS alternate, no significant differences were found among the four security criteria.

Overall criteria rankings for both alternates were discovered to be the same. They were as follows:

1- Functionality & Security

2- Cost & Time

It was also observed that all four cost criteria are significantly more important for the choice of an ERP alternate than for the choice of an WPMS alternate. Administration functionality was also significantly more important for the choice of the ERP alternate than for the choice of the WPMS alternate.

CHAPTER 7 CASE STUDY

Since the topic of interest in this research dealt with contemporary events within which the relevant behavior can not be manipulated and available empirical data are limited, it was decided to use the case study method to apply and validate the research model.

Section 7.1 Case Study Methodology

Case study methodology is a qualitative and descriptive way to examine the participation of an individual or an organization in a specific context. The case study method has been used in various domains, particularly in sociological investigations (Yang, Wu, Tsai, 2007). The case study research is not sampling research (Yin, 2003). However selecting suitable cases must be done so as to maximize what can be learned in the period of time available for the study (Yang, et al., 2007).There are three types of case study method: exploratory, explanatory, and descriptive (Yin, 2003).

This methodology was selected since it would allow for an in-depth investigation of application of EAM within a particular member of SMSCO. In this research since issues of interest dealt with operation of the organization it was decided to utilize exploratory types of questions. In addition the case study was utilized to verify the applicability of EAM in general and components of Self-Regulation element in particular.

Section 7.2 Case Description

In order to address the issues of interest it was decided to convince a sample member of SMSCO to commit their organization to application of EAM in investigating the possible adoption of an ERP system.

Section 7.2.1 Selection Criteria

In order to be able to successfully conduct a case study utilizing an organization it was critical for the organization to meet certain criteria. The most important and obvious criteria was the size and the nature of the organization. For the purpose of this study the organization had to be an SMSCO. In addition it was of paramount importance to have commitment from the ownership group to participate fully in the case study and be willing to share the findings of the study. Finally this organization had to be in a financial and operational position to realistically implement an ERP system. Company X, a regional general contracting was identified to have met the above mentioned criteria and therefore was selected for the case study.

Section 7.2.2 Company General Information

The studied company is a regional general contracting firm operating in mid Atlantic region of the United States of America. The company was established in 1980 and has a staff of about 150 persons. Company X annual revenue is about $40 million dollars, which would rank them as a mid size member of SMSCO grouping. Their portfolio of works consist of a mix of infrastructure, highways, hi-tech buildings, and educational institutions projects. Company X had two offices in the region.

Section 7.2.3 Existing Operating Systems

Company X had developed and purchased several single-functionality programs to facilitate independent management. For example their payroll and accounting system was managed by a software package named Computerease, while scheduling for various project was prepared utilizing Microsoft Project and Primavera. Microsoft Outlook acted as the platform for conducting various communication tasks required by the operation. In addition numerous company oriented templates (Excel base) were created and utilized. Despite being out of date and uncoordinated, the systems were able to meet the basic requirements of a conventional construction organization.

However, Company X had experienced significant growth in its annual work load, which had resulted in pushing the existing operating systems to their maximum limit. The ownership group had become concerned about being able to handle the growth utilizing only the existing systems. Having realized the need to be able to provide more timely and coordinated information to both the senior level management and the staff, Company X decided to utilize EAM to decide if it would be advisable to adopt an ERP system.

Section 7.2.4 EAM Stages

Various elements/stages of EAM were studied by the ownership group in order to establish an overall understanding of the process and its possible findings. Having understood the process, company's ownership group decided to play an active role in the day to day activities associated with EAM utilization. Decision was made to follow the stages of EAM as closely as possible and document the process and its findings.

A project team under the direct supervision of an executive partner of the firm and consisting of three other members representing various affected departments of the organization were assembled. The criteria for selection of project team members consisted of the following conditions: (1) an individual must have experience with application of computer technology in construction, (2) an individual must be a senior level staff with sufficient computer skills, (3) an individual must represent a department that would be affected by ERP implementation directly or indirectly, (4) an individual had to be an employee of the organization for sufficiently long enough time to be familiar with business processes to be modified or eliminated.

Section 7.2.4.1 Problem Identification

The project team identified “Problem Identification” as the first task to analyze. In order to be able to properly evaluate the current company systems, the project team created an evaluation form as shown in ***Figure 28***. Critical criteria that needed to be measured in order to properly evaluate the necessity of change and existence of a problem were identified. Previously defined prohibitive criteria were taken into account and project team considered their impact within the existing system. The objective of this task was to identify any problem with the current systems and measure the level and severity of the required changes to the same systems.

Company X			
Evaluation Items		Weight	Score
Necessary Change on Existing Systems	System Completeness	10	
	System Compatibility	10	
	System Usability	10	
	System Functionality	10	
Necessary Changes on existing business processes	Organization needs to be adjusted	5	
	Process needs to be improved	5	
Necessary Changes for competitiveness	Bidding	10	
	Estimating	10	
Decision Mechanism	Information accuracy & effectiveness	5	
	Information retrieve speed	5	
Change necessary for knowledge management	Knowledge can be used to	5	
	improve competitiveness	10	
	Experience accumulation and sharing	5	

Figure 28 Self Evaluation Form

the relative weight associated with each item was decided by the majority vote of the project team members so that sum of all weightings in all items equals 100. This scale was selected so that a higher score would represent the higher need for changing the current system. Company X set the average value of 80 as a threshold for advancing the ERP adoption process. Self evaluation of the system was conducted by team members on an independent basis within a one week period. The average score

obtained for this evaluation was 85, therefore requiring Company X to proceed to the next stage of the process.

Section 7.2.4.2 Information Search

Since previously in this research it was decided to divide the ERP systems into two classifications namely, prepackaged and WPMS, project team began their work by adopting the same classification. After a limited review of the current vendors in each category was completed it was decided to select 3 vendors in each category to be further studied in detail. The plan called for short listing of one in each category, so that the ultimate decision can be made between the final two.

The following vendors were selected to be studied;

Prepackaged Software:

1- Oracell

2- SAP

3- JDEdwards

WPMS

1- Net Suite

2- Plexus

3- Ace Project

General information on each vendor was obtained and reviewed. Sources utilized for this purpose consisted of, internet, technical journals, and trade publications.

Since the element of Information Search is a precursor to the element of planning, it was decided to collect enough information at the preliminary level so that proper planning for detail evaluation be completed. Project team realized that activities

within this element will have iterative nature, meaning that they might have to be re-visited based on activities in planning element.

Section 7.2.4.3 Planning

In planning process project team attempted to address as many issues as possible and made plans for various activities and processes of EAM. Initially a project leader was selected. This person was a senior member of organization's management level and familiar with the concept of ERP. Other members of team were selected so that the following skills were present; user-area defined/function-specific, technical, leadership, managerial, organizational, problem solving, decision making, administrative, and negotiation.

Role of individuals were defined. The following roles were assigned: project leader, task-specific for information search, role of liaison between the vendors and acquisition team, department/user-area-specific roles such as for finance, human resources, etc., role of technical team leader, role of users on the team, roles of department like purchasing, etc.

An assessment were made to see if services of outside consultants were necessary to complement the project team. Long term availability and commitment of the team members were considered before their selection.

Project team then developed a strategy that reduced uncertainty associated with the process. Some of the strategies that were considered were briefly as follows: visit vendors sites, contact vendor references, have vendors provide for on site demonstration, request that vendors respond to the same RFP, make the acquisition process a two step process consisting of technical and price section.

The project team defined the organization's requirements for the ERP solution. Team defined: (1) their organization's existing technological environment; (2) the functional requirements; (3) the security requirements; (4) the cost limitations; (5) the time allocation; (6) the technical requirements; (7) the organizational (business, procedural, and policy) requirements; (8) existing processes in the areas that were to be affected by the new software; (9) technical staff role definition; (10) project team training requirements; (11) required maintenance program; (12) role of outside consultants.

Project team then established criteria for self-regulation, selection, evaluation, and choice stages prior to contacting any vendors or looking at ERP solutions. These criteria were based on information that was gathered from users and other sources. Each stage was broken down into its finer subcategories and criteria that would help zoom in on achieving the associated objectives of these subcategories were established. The defined criteria were then utilized to complete various processes within each stage such as prohibitive criteria impact analysis, market analysis, grid/matrices for selection and choice processes. The organization accounted for realistic goals and limitations as it applied to its operations. A realistic schedule and a scoring methodology to be used for evaluation of the potential vendors were discussed and adopted.

Issue of business process reengineering (BPR) was considered by the team and it was understood that ERP implementation would require a new BPR that would result in standardization and improvement in efficiency of operation. ERP implementation was used not to just enhance the existing systems rather to change them for the better.

Another issue that was considered was the process of change management. Difficulties in accepting significant required changes in the existing operating process by the staff was anticipated and planned for. Initial participation of representatives, for various end user groups, were sought out to address this issue.

The current market place for ERP providers was analyzed. During this analysis, the acquisition team determined who the major players were in the marketplace for the ERP system.

Deliverables for the planning stage consisted of formation of the planning team, the compilation of RFP, creation of list of criteria for review of various stages, scoring methodology, schedule, and formation of potential vendors list.

Section 7.2.4.4 Self-Regulation

Particular attention was given to the progress of Self-Regulation element. This stage was utilized by the organization to introduce a dose of reality into the entire process. During the planning stage it was decided to use the process of Self-Regulation to account for and match the critical requirements of the organizations with the capabilities offered by various products. Project team adopted the previously identified prohibitive criteria as individual factors that had to be considered in this element as a filtering process. In addition the hierarchy established by the findings of previous questionnaire was adopted. It was concluded that for the purpose of evaluation, weighting factors reflecting the ranking of particular criterion, be assigned and utilized. By adopting this methodology the organization accepted the relative impact of each criterion on the process.

Project team considered the functionalities that were essential for their particular operation. These Functionalities included the criteria that have been discussed as part

of the previous sections of this study. Project Controls and Admin functions were ranked the highest among functionalities considered. Project controls consisted of items such as a project budget, project schedule, change orders, RFI processing, and shop drawings management. While Admin functions consisted of items such as payroll, HR, and other associated back office tasks.

Much discussion was held about the reliance on the particular system for performing the functionality tasks. Initially there was substantial misgiving about accepting the changes that would be required. However over period of time and as result of providing internal studies that reflected the problems with current systems and possibilities for improvement the team decided to accept the proposed functionalities as organization's requirement.

Security was the second of the self-regulation categories to be reviewed. Project team reviewed the security related issues for their organization and established criteria and standards that would have to be satisfied. Since company X conducted most of its business with various government related organization security was of prime concern. Reliability of data and access to it was identified to be the most prominent of sub-criteria considered. Information items that were considered to be included in this data consisted of bidding, estimating, budgeting, resource allocation, and scheduling values. The current systems were evaluated and their short comings were identified. Among the most prominent short comings were; multiple entry of data, timely availability of data, organization of data, and historical perseverance of data. It was decided to list requirements to be addressed by a new system.

Cost was the next self-regulation criteria to be reviewed. Cost as criteria was broken down to its subcomponents, which were ranked according to their level of impact.

Implementation cost was identified to be the most prominent among the group. Other cost categories considered were initial cost, training cost, and maintenance cost.

Project team proposed a realistic budgeted amount for each cost category that was accepted and approved by the ownership group. Factors that played major role in defining these numbers included; current financial position of the company, item breakdowns for each category, and result of internal cost benefit analysis.

Budget numbers that were proposed and accepted, set the marker for project team when it came to evaluation of a particular system. It was understood that systems with cost over budgeted amount would not be considered.

Time was the last of self-regulation criteria to be considered by the project team. Majority of projects conducted by company X were of short duration. Quick turnaround time of their jobs forced the project team to establish realistic time tables for various time criterions that were considered. Project team proposed an implementation schedule that span the period of one year.

The most critical of time sub-criteria considered was technical durability. Technical durability was defined to be the time that the current software will be useful before requiring major upgrade. Ownership group had substantial problem with this issue. Their major concern was the technical viability of a system over a period of time. Considering the fact that it was anticipated that the entire implementation process would take about one full year, major concern had to do with advances that would be made in the field that would not be reflected in the particular software package. In order to address this issue it was decided to have vendors respond in their proposal with specific information about the updating procedures and cost for their particular systems.

Section 7.2.4.5 Selection/Short List

Project team utilized the findings of self-regulation element to create an RFP that could be sent to various vendors. As indicated in ***Figure 29***, each vendor was requested to address each of RFP requirements.

ERP Purchase - RFP Requirements for Company X
Vendor Information
Company Name
Address
Contact
Tel. No.
e-mail
Fax. No.
Package Information
Name
Capabilities
Functionalities (Collaboration, Modularity, Controls, Admin, Cont. Mmgt.)
Security (Data Access, Data Control, Data reliability)
Cost (Purchase Price, Maintenance Cost, Training Cost)
Time (Implementation, Update)
Terms
References
Tech Support Services
Training Programs

Figure 29 RFP Requirements

Having defined the critical criteria to be considered in the remaining parts of EAM, project team utilizing the information that was gathered in the information search stage selected 6 vendors to be contacted. Vendors were divided into two grouping of Pre-packaged software, and WPMS. As called for by the planning stage three vendors in each category were analyzed. Once it was decided that these vendors had the possibility of meeting the RFP requirements initial contacts were made. RFP requirements were transmitted to them either via fax, e-mail, or mail.

During the process of obtaining RFP from vendors' number of difficulties were faced. Among the most prominent ones were the nature of vendor interest. Some major vendors did not show any interest in participating in the RFP process. It was understood that they were interested in participating with a "small organization". Some other significant vendors indicated that their systems were not totally applicable to an SMSCO. As a result of this and in order to end up with at least three major vendors in each category, project team was forced to repeat some of the past procedures that had led to the selection of vendors. This recursive nature of activity was observed between information search, planning and selection/short list elements. Ultimately two vendors one from each group was selected for detail evaluation.

Section 7.2.4.6 Evaluation

Evaluation was a critical and complicated process that was completed by the project team team. Critical factors that were considered by the team included the following: strategic match, stakeholders influence, system specific, organizational impact, life cycle approach, financial criteria.

Within this process vendors, the functionalities provided by ERP system, and technical issues were evaluated. Project team developed an scoring methodology that

was utilized to evaluate the short listed vendors. The methodology used was based on weighting score that were assigned to each task. As shown in ***Figure 30*** items that were previously identified in the RFP requirement list were further broken down to their core elements and individual score based on the team's understanding of their over all impact was assigned.

In addition to the overall score two item of references and warranty period were noted and compared.

It was anticipated that vendor evaluation would be carried out over several of the stages within the EAM processes. The recursive nature of the these activities also caused the team to re-contact vendors with request to resubmit in part or in full, their RFP responses according to the teams refined criteria.

As for the functional and technical evaluations, they were carried out, in part, during the selection process and then, more intensively, during the complete evaluation processes. The criteria and strategies that were established during the planning process were utilized to complete the evaluation process. The deliverables of this stage consisted of a vendor and functionalities/modules that should be utilized.

Company X

Evaluation Items		Max. Score	Vendor A	Vendor B	Comments
Functionalities	Controls	8			
	Admin.	8			
	Contract Management	6			
	Modularity	5			
	Collaboration	5			
Security	Data Reliability	9			
	Data Access	7			
	Data Control	6			
	Data Legality	5			
Cost	Implementation Cost	7			
	Initial Cost	6			
	Maintenance Cost	5			
	Training Cost	5			
Time	Technical Durability	7			
	Production	4			
	Training	4			
	Implementation	3			
Score Total		100			
References Checked					
Warranty Period					

Figure 30 Vendor Evaluation Form

Section 7.2.4.7 Choice

This stage was the natural culmination of the evaluation process. Once the deliverable of the evaluation process became clear it was forwarded to the entire ownership group. Project team decided to obtain the approval of the entire ownership group in order to strengthen the commitment of the organization to the entire program. In turn the complete ownership group took this opportunity to conduct an independent review of the finding of the project team and approved the implementation process.

Section 7.2.4.8 Implementation

Implementation, as the last stage of the EAM it represented the final series of activities that had to be carried out to successfully select and implement an ERP system.

The negotiation part of this stage consisted of the business and legal segment. As many issues as possible were addressed in the business negotiation between Company X and the selected vendor.

Section 7.3 Chapter Summary

This chapter presented the case study of Company X's application of EAM in investigating the possible adoption of an ERP system. Company X was a mid size general contacting firm operating in Mid Atlantic region of the United States of America.

Each element of EAM was utilized by Company X's project team in order to either adopt of reject an implementation of an ERP system. The existing operating systems of the Company X were evaluated to verify existence of potential operational system problems. The current ERP systems were divided into the following two categories;

WPMS, and Pre-packaged Software. Utilizing various sources information was gathered about six vendors, three in each category.

Within planning stage project team was finalized and utilized to develop strategies that were followed. Project team defined organization's goals and objectives along with its requirements. Element of self-regulation was utilized to define and prioritize the requirements of Company X for a future ERP system.

During processing of elements of selection and evaluation each vendor was reviewed and evaluated based on a system that was developed by the project team. Initially two vendors were selected from each category, and then one was identified to be the most compatible for Company X.

Project team recommended vendor A to the ownership group for final review and approval. Upon verification of project team's recommended findings the ownership group decided to accept the selection of vendor A and started the final negotiations to purchase and adopt the system.

CHAPTER 8 ERP ADOPTION MODEL (EAM) DISCUSSIONS

This chapter introduces a final version of the research model EAM. The proposed final version incorporates the findings of previously conducted questionnaires and the case study. In chapter three, EAM was introduced in its theoretical format. Subsequently two questionnaires were prepared and distributed so that thru analysis of their data, prohibitive/self-regulation criteria could be identified and analyzed. Theoretical version of EAM was then amended to reflect the impact of these criteria. In addition logic, practical application, and processes of EAM for SMSCO, were verified by the findings of a case study which was completed. Issues of importance to the final version of EAM are presented and discussed here in more detail.

Section 8.1 ERP Adoption Model (EAM)

Previously in this research four prohibitive/self-regulation criteria were identified and confirmed. These criteria that were discovered to act as prohibitive factors in utilization of ERP systems by SMSCO were introduced into EAM not only as prohibitive in nature, rather as prohibitive/self-regulation criteria. As shown in ***Figure 31*** the final version of EAM reflected the imbedded prohibitive/self-regulation criteria in self-regulation element.

The final version of EAM was utilized in the case study that was completed for company X. These criteria were adopted by the company X as part of processing their self-regulation element.

Having to consider the prohibitive/self-regulation criteria in self-regulation element forced the organization to deal with issues that became critical in their decision making process. In fact it was anticipated that this would occur, and that is why it was

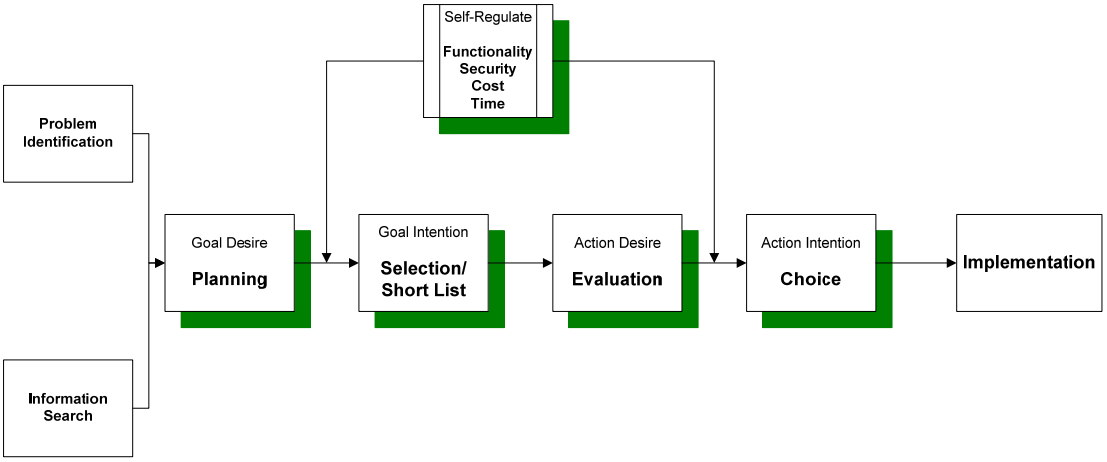

Figure 31 ERP Adoption Model (EAM)

incorporated into EAM at rather early stage. With utilization of this concept the organization had an opportunity to conduct a self evaluation of their current procedures and operations. Completing this self evaluation process allowed the organization to compile a list of requirements that were both realistic and reflective of their organization.

Issue of reflectivity is a critical issue that must be considered by each organization. Within construction industry in general and SMSCO in particular uniqueness of the particular organization's operation is a known and accepted fact. Therefore in order for the organization to utilize any decision making model, that model must be able to address organization's uniqueness. In utilizing the decision making model the organization must be able to reflect on who they are. EAM allows for this reflectivity thru utilization of prohibitive/self-regulation criteria. As a result of having to deal with these criteria the SMSCO will have to establish goals and objective, review their current procedures, identify their current short comings, develop realistic requirements for the new system, prepare and provide adequate resources to implement the system.

Completion of the case study identified some critical issues with utilization of EAM that need to be discussed in further detail so that lessons learned can be identified and shared.

Section 8.2 Hierarchical Ranking of Criteria

Successful completion of the case study in general, and the observed impact of the self-regulation element of EAM in particular, provided strong evidence to support the validity of the hierarchical rankings of prohibitive/self-regulation criteria. Having to deal with prohibitive/self-regulation criteria, in the order that it was proposed, forced the organization to set realistic goals and objectives at a very early stage of the decision-making process.

In addition it was noticed that while the ranking of the criteria had to be maintained, their subcategories could be redefined in broader terms to include organization specific items. For example while one company defines payroll as a task to be included in Admin. section of Functionality criterion, another company can place it within Contract Management section of Functionality. This flexibility allows each SMSCO to tailor the process closer to their actual operation.

Section 8.3 Prohibitive/Self-regulation Criteria

As it was stated before, this research paid particular attention to the study of prohibitive/self-regulation criteria and their impact on utilization of EAM. In general the completed case study verified their significance, and impact on EAM. However, it must be noted that the case study also raised some new issues that need to be discussed and addressed.

When dealing with functionalities it became apparent that issue of modularity is a very significant one. Having the capability of adopting a limited version of an ERP system that could be subsequently added on is critical for SMSCO. Systems that are able to provide capabilities in a modular format will have substantial advantage to their counterparts that must be adopted as whole. SMSCO can justify and handle the adoption of new ERP systems on a modular basis a lot easier and quicker.

When dealing with security in the case study, access level by employees and other collaboration members, became an issue that had to be dealt with. SMSCO more so than their larger counter parts will have difficulty accepting access to their sensitive data. In order to overcome this problem it is recommended that project team utilize educational resources that any vendor would be able to provide in order to establish a comfort level for the ownership group.

Cost as a prohibitive/self-regulation criterion has a significant impact on the overall decision-making process as anticipated. In the case of company X within the element of self-regulation of EAM they had to deal with the issue of cost. Company X conducted a cost benefit analysis and utilized its findings to compute a budget item that included individual line items for different cost categories. In their case company X's project team established an understanding that budget numbers for the cost had to be met and would not be allowed to exceed.

Even though ranking for cost criterion, placed it third among all criteria, its impact must not be taken lightly. The allocation of cost and its assignment by the organization must be considered. SMSCO members must consider the associated cost items not only as a direct project expense, but rather as a capital expenditure that need

to be treated as an asset. Company X was able to justify the substantial expenditure required by treating it as an asset that was to be depreciated over a period of time.

When reviewing Time as prohibitive/self-regulation criterion it must be understood that technical durability is rightly an issue that must be reviewed. However, it is important for the organization to establish an understanding of their requirements and not be concern with every new "gadget". As long as the system is capable of addressing the needs of the organization it must be considered as an adequate.

Section 8.4 Vendor Participation

Vendor participation in the processes of EAM must not be taken for granted. Some vendors even though claim to have software that would be suitable for SMSCO are not interested in participating in the process since the size of potential account will not be large. Company X experienced this phenomenon when they attempted to obtain interested vendors to participate in their process. Lack of interest shown by vendors to company X's representative was not limited to a particular category, and should be anticipated by other SMSCO members.

In order to overcome these problem SMSCO members must plan to play a pro-active role when it comes to solicitation process. It must be understood that in order to find a vendor that is willing to work with the organization ample amount of resources in form of employee time must be provided.

Section 8.5 Process Re-engineering

It should be anticipated that each member of SMSCO will have a unique set of business processes that has been utilized with some degree of success in the past. Customizing the functionalities of a new system for an existing organization will

generate number of dilemmas. It is expected that each organization would like to minimize the changes in their business processes, however it should be understood that ERP system customization to fit existing operations can not be always completed successfully. After all ERP systems bring a whole new way of thinking to an existing operation that has been deemed change worthy. It is recommended that SMSCO members consider changing their existing processes to fit the ERP system rather than the other way around.

Timing of this change is also very critical. If both ERP implementation and business process changes were to be completed at the same time the organization will face number of difficult scenarios. It is recommended that SMSCO members must complete the process re-engineering of their operation prior to ERP system implementation. In addition it is suggested that for a period of time shortly after ERP system implementation a parallel set of operational procedures be carried out so that the confidence level of the organization in the new system is enhanced.

Finally it must be pointed out that all of proposed changes ultimately deal with people. Therefore the process of change management must be people friendly. Attempts should be made to get the people of the organization to buy into the process. Some of the strategies to use would be as follows; introduce the change on an incremental basis, educate the staff as to the benefits of the proposed changes, show strong senior management commitment to changes, and provide adequate training time for the staff.

Section 8.6 Role of Suppliers and Sub-contractors

An issue that was not considered as strongly as it should have been in the case study was the impact that suppliers and sub-contractors potential utilization of the ERP

system would have on the success of the entire system. Members of SMSCO usually collaborate with suppliers and subcontractors that are either the same size or most often smaller than them. Therefore in order for ERP system to be successfully utilize as a collaborative tool the role to be played by this second tier users must be reviewed.

The second tier user's technical capabilities must be studied and correctly documented. Their familiarity and use of computer technology applications in their operation must be realistically verified. The level of required hardware and software for proper utilization of the system at the second tier level must be identified and its existence or lack of among the group should be checked out.

Without adequate infrastructure second tier user will not be able to either provide data in necessary format or access the information available. Attempts must be made to either encourage the existing second tier users to adopt proper infrastructure and technical know how or to find new suppliers and sub-contractors that can properly participate in a collaborative environment.

Section 8.7 Iterative Nature of EAM's Elements

Self-regulation element of EAM is designed and placed to have an iterative influence on the entire process. The thinking behind this fact was to allow the iterative nature of this element to address the issues that arise from self evaluation conducted by the organization. The nature of the iterative processes indicates activities/feedback/adjustment/input. It is anticipated that as a result of completing self-regulation element project team might have to re-visit the process starting with selection/short list element. However it should be pointed out the iterative nature of self –regulation element can impact at both end of the main decision core.

Section 8.8 Chapter Summary

This chapter presented the ERP Adoption Model (EAM) for SMSCO to successfully implement an ERP system within their organization. The proposed EAM consists of eight different elements.

Hierarchical ranking and the role of the prohibitive/self-regulation criteria in self-regulation element were verified and discussed. Each individual criterion was discussed and its potential impact on EAM was analyzed. Issues dealing with participation of vendors in the process were also highlighted and discussed to extend possible utilizing the findings of the case study completed for company X. Process of re-engineering the existing operational processes was reviewed and suggestion was made that SMSCO should prepare to adjust their process first before they implement an ERP system and initially plan to operate both systems in parallel for a period of time. Potential participation by suppliers and sub-contractors was discussed and suggestions were made in order to address issues. Finally the iterative nature of self-regulation element and its impact on EAM was reviewed.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

This chapter will review the significant findings, and summarizes the formulation utilized to answer research questions. Practical guidelines to be utilized by SMSCO in their decision making process for adoption of ERP systems will be presented. The level of achievement of the research objectives will be scrutinized, and research limitations and recommendations for future work will be made.

Section 9.1 Research Summary

This research set out not only to formulate the reason(s) why SMSCO fail to utilize ERP systems, but also to propose a decision-making model which could be utilized when they decide to adopt an ERP system.

This research was completed in five phases that consisted of problem formulation, prohibitive criteria confirmation, self-regulation analysis, ERP Adoption Model (EAM) Discussions, and guidelines & conclusions.

After identification of the problem to be resolved by this research was completed, comprehensive literature review was conducted in the area of ERP applications in all industrial sectors with special attention given to the construction industry. In particular, ERP applications utilized by SMSCO were scrutinized, and in order to obtain an in depth knowledge of this subject, on-site interviews relating to their ERP experiences were conducted with various owners of SMSCO.

Current understandings of technology adoption process, associated risks and benefits of ERP application were studied. Number of existing and prominent technology

adoption models were reviewed and based on their applicability to technology adoption in construction three of them was further scrutinized in detail.

After a careful review of existing technology models, a new ERP Adoption Model (EAM) was formulated and projected. This model adopted a new paradigm shift proposed by Bagozzi (2007) and incorporated it's a new decision making core.

In order to identify the prohibitive criteria leading to lack of utilization of ERP systems by SMSCO a questionnaire was designed, pilot-tested, and used as the primary instrument to survey the SMSCO sector and collect the necessary data. Based on the analysis of the results obtained from this questionnaire, number of critical prohibitive criteria that would affect adoption and implementation of ERP by SMSCO was identified. Alternative ERP systems that are currently available for utilization were categorized and investigated. It was decided that in order to confirm and complete the required analysis to gauge the impact of the prohibitive criteria and their potential role in self-regulation part of proposed decision-making model, a second questionnaire be designed and submitted to industry experts for completion. These experts were chosen because they had previous relevant experience with the implementation of ERP systems. The second questionnaire was distributed via SurveyMonkey, a web-based service.

The data obtained as a result of the second field questionnaire were analyzed to formulate a hierarchical ranking system for the prohibitive criteria and establish a thorough understanding of their role as self-regulating elements in the decision-making model. The relationships of the prohibitive criteria were analyzed. The results obtained for alternative ERP systems were compared so that the final

recommendations could address the applicability and adoptability of a system. Various statistical methods were utilized to complete this analysis.

In order to validate the research model a case study that dealt with a medium size general contracting firm's adoption of an ERP system was conducted. As a result of data analysis and the case study conducted, the previously mentioned ERP Adoption Model (EAM) was completed. Prohibitive criteria and their ranking were adopted by getting incorporated into the self-regulation element of research model. Each individual element was further analyzed and its sub parts were identified. Issues of importance to the final version of EAM were presented and discussed in detail.

Section 9.2 Research Results & Contributions

This research has delivered valid conclusions as the result of a case study and statistical analysis completed utilizing the data obtained through two separate field questionnaires. Contributions of this research consisted of the following major items:

1. Obtaining data as a result of two field questionnaire
2. Identification & confirmation of prohibitive criteria
3. Analysis of prohibitive criteria
4. ERP Adoption Model (EAM)
5. EAM Utilization case study

After a careful review of existing technology models, a new ERP Adoption Model (EAM) was formulated and projected. This model adopted a new paradigm shift proposed by Bagozzi (2007) and incorporated it's a new decision making core.

Two separate field questionnaires were successfully designed and distributed, which resulted in collection of valid responses. These data were then utilized to complete the required analysis.

Prohibitive criteria were identified and confirmed to consist of the following: cost, time, functionalities, and security. In turn each of these subcategories was further subdivided into subcategories that were individually and collectively analyzed utilizing statistical methods.

Rankings were established for each of the criteria based on multiple paired *t* tests. All possible pairs of criteria were assessed for significant differences. Criteria that were not significantly different were placed in the same ranking level.

In the case of cost criteria for the ERP alternate, the following ranking was established:

1. Implementation
2. Initial
3. Maintenance and Training

In case of cost criteria for the WPMS alternate, no significant differences were found among the four cost criteria.

Results from the analysis conducted for time criteria for the ERP alternate, indicated the following ranking:

1. Technical Durability
2. Production & Training
3. Implementation

The only difference observed for the WPMS alternate was the fact that production as a prohibitive criteria dropped to the bottom level.

The functionality criteria ranking for ERP alternate was as follows:

1. Project Controls & Administration
2. Contract Management

3. Collaboration & Modularity

The ranking of the same criteria for the WPMS alternate was as follows:

1. Project Controls, Collaboration, and Contract Management
2. Administration & Modularity

The security criteria ranking for ERP alternate was as follows:

1. Reliability
2. Access, Control & Legality

In the case of WPMS alternate, no significant differences were found among the four security criteria.

Overall criteria rankings for both alternate were discovered to be the same. They were as follows:

1. Functionality & Security
2. Cost & Time

It was observed that all four cost criteria were significantly more important for the choice of ERP alternate than for the choice of WPMS alternate. Administration functionality was also significantly more important for the choice of ERP alternate than for the choice of WPMS alternate.

A case study to verify EAM in general and impact of prohibitive/self-regulation criteria was conducted. Ultimately EAM, incorporating the study's findings associated with prohibitive/self-regulation criteria was finalized and proposed to be utilized by SMSCO in order to increase the chances of successful implementation of ERP system.

Section 9.3 Practical Guidelines for Utilization of EAM

One of the objectives of this research was to develop practical guidelines for SMSCO to be utilized in conjunction with EAM. Utilizing the ranking that was developed for prohibitive/self-regulation criteria, guidelines for measuring impact of the said criteria were developed. As indicated by ***Figure 32***and ***Figure 33*** each of the criteria were further subdivided into their sub-components and in addition to ranking their relative impact score was computed and provided. Relative Impact score is an indicator of importance of the criteria and where the greatest returns could be anticipated. This score should be utilized by SMSCO in order to maximize the return on their investment.

In addition some general guidelines were developed to be utilized in conjunction with utilization of EAM. As indicated by ***Figure 34*** the following stages of EAM were selected to have guidelines developed for:

- Problem Identification
- Information Search
- Planning
- Selection/Short List
- Evaluation
- Self-regulation

These guidelines even though very general in nature are presented in order to provide a road map to be utilized by SMSCO members.

Guideline for Measuring Impact of Self-Regulation Criteria		
WPMS Alternative		
Self-regulation Criteria	**Ranking**	**Relative Impact Score**
Functionalities		
Control	1	22.1
Collaboration	2	21.9
Contract	3	20.1
Administration	4	18.1
Modularity	5	17.9
Security		
Data Reliability	1	26.7
Data Control	2	24.1
Data Access	3	24.9
Legality	4	23.3
Cost		
Implementation	1	26.8
Initial	2	24.7
Maintenance	3	24.5
Training	4	24
Time		
Durability	1	28.3
Training	2	25.9
Implementation	3	24.5
Productivity	4	21.3

Figure 32 Guideline for Measuring Impact of Self-regulation Criteria – WPMS Alternative

Guideline for Measuring Impact of Self-Regulation Criteria		
Pre-Packaged Software Alternative		
Self-regulation Criteria	**Ranking**	**Relative Impact Score**
Functionalities		
Control	1	22
Administration	2	21.3
Contract	3	20.5
Modularity	4	18.3
Collaboration	5	17.9
Security		
Data Reliability	1	26.9
Data Access	2	25.2
Data Control	3	24.1
Legality	4	23.8
Cost		
Implementation	1	28
Initial	2	25.7
Training	3	23.3
Maintenance	4	23
Time		
Durability	1	33.9
Productivity	2	25.6
Training	3	23.1
Implementation	4	17.4

Figure 33 Guideline for Measuring Impact of Self-regulation Criteria – Pre Packaged Software Alternative

Element Description	Action to be Taken
Problem Identification	Establish project Team
	Investigate Consultant Role
	Complete self assessment - Utilize form 1
	Report specific findings
Information Search	Identify Information Source – Internal & External
	Screen Information
	Generate Leads
Planning	Set Goals & Objectives
	Create an schedule
	Create a budget
	Create a selection criteria
	Prepare for BPR Changes
	Prepare RFP –Utilize form 2
	Visit Vendors
	Deliverables (RFP, Criteria List, Vendor List)
Selection/Short List	Selection Criteria
	Preliminary Evaluation of Vendors RFP
	Create Short List of Vendors
Evaluation	Detail Vendor's scoring - Utilize form 3
Self-regulation	Identify Criteria
	Rank Criteria
	Complete self application of criteria

Figure 34 EAM Utilization Guideline

Section 9.4 Limitation of the Research

Even though this research delivered valid findings, it had shortfalls that were generated as a result of limitations experienced. Addressing these limitations would enhance the accuracy of the results even further. The major limitations are as follows:

- The temporary nature of the construction industry and its resistance to adopting new ideas presented one of the main limitations of this research. Existing legacy systems that are in use have created committed end users who are not willing to entertain new systems. This same group was not interested in participating in this and other similar research. Confidentiality was another factor that created a shortcoming for this research in obtaining valid information.
- Familiarity of SMSCO community with concept of ERP was another major shortcoming of this research. It was discovered that in order to obtain answers from SMSCO participants in field questionnaire, ERP concept had to be explained in more elementary forms so that they were understood. The answers provided had to be interpreted so that they could be applied to the ERP related question.
- The number of the participants in the field questionnaire was another major issue for this research. The number of willing participants was fairly limited, mainly because of this group's lack of understanding and knowledge about ERP systems. On the first field questionnaire the majority of participants were from mid-Atlantic region of United States of America. It is possible that if there were additional participants from other geographical regions, the findings would have

been impacted. Overall if more people participated, the quality of statistical analysis that was conducted would have increased.

- The experts selected to complete the second field questionnaire all had extensive experience with ERP systems, and their implementation however it is anticipated that their individual opinions were biased toward the particular alternative ERP system that they were accustomed to working with. Ideally, experts should have similar experience working with both defined alternative ERP systems in order to be able to respond to the questions posed to them by this research.
- For the purpose of this research alternative ERP systems were defined to consist of the following two categories: ERP, and WPMS. These two main categories could be broken down to more specific sub categories and then analyzed to provide an enhanced understanding of this topic.
- The time required to study IT related technology in general, and ERP in particular, presents an issue since the advancement pace of science in this area is rather fast. New products and services are constantly being introduced that could significantly impact the market place. Due to the limited time available for this research and the nature of construction industry, it was not possible to accommodate some of market changes.
- This study defined number of prohibitive criteria that would impact implementation of an ERP system within an SMSCO environment.

There remains the possibility that other prohibitive factors exist that need to be considered and analyzed.

Section 9.5 Future Research

Although this research has made practical and theoretical contributions to SMSCO members, there remains a significant potential for future advancements in this topic. Some of the possible areas that could be further investigated in future are as follows:

- The proposed ERP Adoption Model (EAM) that was generated by this research needs to be studied in more detail. Additional case studies and empirical research should investigate the relationship between the various elements of the model. In addition the relationship between various elements and external factors that have an impact on them must be studied.
- The role of prohibitive/self-regulation criteria in evaluation of particular ERP system could be looked at in further detail. In addition evaluation as an element of EAM has such a high impact on the process of decision-making that it needs to be studied in more detail.
- Establishing SMSCO-wide ERP implementation standards would be another topic of interest that could be pursued. These standards could help members of SMSCO establish a clear understanding of minimum requirements of an ERP implementation program. The addition of existing standards would increase the ability of the ERP community to better address the needs and requirements of SMSCO client category.
- A study could be done as to how to best educate and familiarize the SMSCO community with the concept of ERP. As it stands, members

of the SMSCO community are rarely aware of ERP systems and their capabilities. They are not familiar with the many benefits that could be generated from the implementation of an ERP system. Efforts must be made to communicate the beneficial features of ERP systems to SMSCO's executives so that they become aware and plan to utilize ERP within their organizations.

Appendices

Appendix A: Prohibitive Factors Questionnaire

Last Name: First Name:

Positions/Title:

1 - Which one of the following best describes your company's category?

- ☐ General Contractor
- ☐ Subcontractor
- ☐ Supplier
- ☐ Owner
- ☐ A/E
- ☐ Other

2 - Which one of the following ranges best describes your company's size:

- ☐ Under $1,000,000.00 in annual billing
- ☐ Between $1,000,000.00 to $7,000,000.00
- ☐ Between $10,000,000.00 and $20,000,000.00
- ☐ Over $20,000,000.00

3 - How familiar are you with Internet?

- ☐ Very familiar
- ☐ Some what familiar
- ☐ Not familiar at all

4 - Do you have access to Internet at work?

- ☐ Yes
- ☐ No

5 - Are you familiar with Project Management Tools based on Web-Technology?

- ☐ Yes
- ☐ No

6 – What is your senior management's attitude towards Internet/ Web-Technology's use?

- ☐ Very enthusiastic
- ☐ Halfhearted commitment
- ☐ Sees no value at all

7 – Which one of the following Web – Tools have you used on your projects?

- ☐ e-mail
- ☐ Instant Messaging
- ☐ File & Data transfer
- ☐ Collaboration tools
- ☐ Document Management
- ☐ e - Video Conferencing
- ☐ None of the above

8 – Which one of the following areas has you used or would use Web-tools to improve?

- ☐ Planning
- ☐ Cost & Time Controls
- ☐ Design
- ☐ Procurement/Bidding
- ☐ Estimating
- ☐ e-commerce
- ☐ None of the above

9 – Which one of the following Web based Project management systems have you used?

- ☐ Project Management System Application Service provider (PM-APS)
- ☐ In house developed Project Management System
- ☐ Commercial Web-enabled software packages
- ☐ None of the above

10 - Which one of the following areas were or would benefit most from utilizing Web-technology:

- ☐ Project communication
- ☐ Project Controls
- ☐ Project Administration
- ☐ Project procurement
- ☐ None of the above

11 – If you used Web – tools to manage your project did it improve your bottom line?

- ☐ Yes
- ☐ No
- ☐ I have not used Web – Tools

12 – Which factor would explain your decision not to use Web – tools?

- ☐ Cost
- ☐ Training required
- ☐ Infrastructure (download time etc.)
- ☐ All of the above

13 – Would you be willing to adjust your existing procedures to accommodate Web Technology?

- ☐ Yes
- ☐ No

14 – How concerned are you with security of your information when using Web – tools?

- ☐ Very concerned
- ☐ Some what concerned
- ☐ Not concerned at all

15 – Which one of the following factors would cause you to use Web-tools to manage your projects?

- ☐ Project Owner's Requirement
- ☐ Market Competition/ Trends
- ☐ More User Friendly software programs/packages
- ☐ Better technical support

16- Which one of the following cost factors would increase your use of Web-tools to manage your projects?

- ☐ Lower initial cost
- ☐ Lower maintenance cost
- ☐ Lower training cost
- ☐ Cost is not a factor

17 – Which one of the following statements would you agree with most?

- ☐ Legal concerns prevent me from using Web-tools
- ☐ Internet security concerns prevent me from using Web-tools
- ☐ Reliability and ownership concerns about the information prevent me from using Web tools
- ☐ Project Web-tools are too complicated to set up and operate
- ☐ All of the above

18 - In your opinion does your lack of commitment to use of Web –tools caused you to loose any business?

- ☐ Yes
- ☐ No
- ☐ I use Web –tools and have profited from it

19 - Which one of the following statements do you agree with most?

- ☐ Project Web –tools would eliminate communication issues
- ☐ Project Web-tools will help make communication issues non critical
- ☐ Project Web –tools will eventually replace face-to-face meetings
- ☐ Project Web tools will formalize, coordinate and document all project communications

20 - How small of a project are you willing to use Project Web-tools for?

- ☐ Under $100,000.00
- ☐ Under $500,000.00
- ☐ Under $1,000,000.00
- ☐ Under $5,000,000.00

Appendix B: Prohibitive Criteria Analysis Questionnaire

1. Introduction

The objective of the survey is to evaluate alternate Enterprise Systems that could be implemented for Small to Medium Size Construction Companies doing project based production. The evaluation criteria are presented and described in Tables 2 thru 5. You are asked to evaluate 2 alternative systems (described in table 1) for each criteria.

The questionnaire survey will take about 15 minutes to complete, and the results of the survey will be only used for the academic research.

2. Table 1. Alternative Systems Definition

ERP: Existing software packages that aim to integrate the main business functions across all departments within an organization such as SAP3, Oracle (integrated with People Soft & JD Edwards), IFS program.

Web-based Project Management System (WPMS), any electronic project - management system which is conducted through private network that uses Internet Protocols to transmit information.

1. Introductory Questions

1. Describe the industry you have been working for.

- ☐ IT
- ☐ Consulting
- ☐ Construction
- ☐ Other

2. How many years have you been working for the industry you selected in question 1?

- ☐ ~ 3
- ☐ 3 ~ 6
- ☐ 6 ~ 9
- ☐ 10 years or more

3. Does your company use ERP systems?

- ☐ Yes
- ☐ No

4. Have you worked for or been involved in ERP implementation project?

- ☐ Yes
- ☐ No

3. Table 2 - Description of Cost Criteria

Initial Cost: Cost to evaluate systems, complete planning, buy and install all hardware and other accessories necessary to activate the program.

Implementation Cost:Cost to implement the program and to include items such as software & licenses, procedural changes, evaluation, consulting, new hires, and related overhead costs.

Maintenance Cost: Cost to update and maintain the system once implemented and to include cost of upgrade purchases, staff time and associated administrative overheads.

Training Cost: Cost to set up and train necessary staff to utilize the system project wide.

5. 2-C1 Initial Cost

Please assign a score indicating the value of initial cost as a criterion for each alternate. Initial Cost is defined to be cost to evaluate systems, complete planning, buy and install all hardware and other accessories necessary to activate the program.

	Very High		High		Moderate		Low		Very Low
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

6. 2-C2 Implementation Cost

Please assign a score indicating value of Implementation Cost as a criterion for each alternate. Implementation cost is defined to be cost to implement the program and to includes items such as software & licenses, procedural changes, evaluation, consulting, new hires and related overhead costs.

	Very High		High		Moderate		Low		Very Low
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

7. 2-C3 Maintenance Cost

Please assign a score indicating the value of Maintenance Cost as a criterion for each alternate. Maintenance Cost is defined to be the cost to update and maintain the system once implemented and to include cost of upgrade purchases, staff time, and associated overheads.

	Very High		High		Moderate		Low		Very Low
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

8. 2-C4 Training Cost

Please assign a score indicating value of Training Cost as a criterion for each alternate. Training Cost is defined to be cost to set up and train necessary staff to utilize the system project wide.

	Very High		High		Moderate		Low		Very Low
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

4. Table 3. Descriptions of Time Sensitive Criteria

Production Time: Time savings that result from higher operating efficiency.

Implementation Time: Time that will take to evaluate, purchase, install and go live with the system company wide.

Training Time: Time required training project staff to learn how to utilize the system for the day to day operation of the project.

Technical Durability Time: Time that the current software will be useful before requiring major upgrade.

9. 3 -T1 Production Time

Please select a time span indicating duration of Production Time as a criterion for each alternate. Production Time is defined to be time savings that result from higher operating efficiency.

	Very Short		Short		Moderate		Long		Very Long
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

10. 3-T2 Implementation Time

Please select a time span indicating duration of Implementation Time for each alternate. Implementation Time is defined to be time that will take to evaluate, purchase, install, and go live with the system company wide.

	Very Long		Long		Moderate		Short		Very Short
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

11. 3-T3 Training Time

Please select a time span indicating duration of Training Time for each alternate. Training Time is defined to be time required to train the project staff to learn how to utilize the system for the day to day operation.

	Very Long		Long		Moderate		Short		Very Short
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

12. 3-T4 Technical Durability Time

Please select a time span indicating duration of Technical Durability Time for each alternate. Technical Durability Time is defined to be time that the current software will be useful before requiring major upgrade.

	Very Short		Short		Moderate		Long		Very Long
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

5. Table 4. Description of Functionality Criteria

Project Collaboration: Capabilities which enable team members to work jointly in reviewing and completing project tasks (both internal and external).

Modularity/Flexibility: Availability and ease of use of option to purchase and implement independent modules to complete different tasks.

Project Controls: Tasks associated with management of items such as schedule, budget, change orders, RFI, shop drawing, document management process.

Project Administration: To be all tasks that are directly or indirectly required for proper administration of the project such as payroll, human resources, and associated main office operations.

Project Contract Management: is defined to be all tasks necessary to manage contractual obligations, such as subcontract agreement, purchase orders, insurance requirements, and safety compliance.

13. 4-F1 Collaboration

Please select a category indicating the importance of Collaboration as a criterion for each alternate. Collaboration is defined to be capabilities which enable team members to work jointly in reviewing and completing project tasks (both internal and external).

	Negligible		Less Important		Important		More Important		Imperative
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

14. 4-F2 Modularity/Flexibility

Please select a category indicating the importance of Modularity/Flexibility as a criterion for each alternate. Modularity/Flexibility is defined to be availability and ease of use of options to purchase and implement independent modules to

complete different tasks.

	Negligible		Less Important		Important		More Important		Imperative
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

15. 4-F3 Project Controls

Please select a category indicating the importance of Project Controls as a criterion for each alternate. Project Controls are defined to be tasks associated items such as schedule, budget, change orders, RFI, shop drawings, document management process.

	Negligible		Less Important		Important		More Important		Imperative
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

16. 4-F4 Project Administration

Please select a category indicating the importance of Project Administration as a criterion for each alternate. Project Administration is defined to be all tasks that are directly or indirectly required for proper administration of the project such as payroll, human resources, and associated main office operations.

	Negligible		Less Important		Important		More Important		Imperative
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

17. 4- F5 Contract Management

Please select a category indicating the importance of Contract Management as a criterion for each alternate. Contract Management is defined to be all tasks necessary to manage contractual obligations, such as subcontract agreement, purchase orders, insurance requirements, and safety compliance.

	Negligible		Less Important		Important		More Important		Imperative
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

6. Table 5. Description of Security Criteria

Access: Means and methods provided for data protection from internal and external threats.

Control: accessibility and dependability of existing and historical project data.

Reliability: degree of accuracy and availability of data in a timely manner.

Legality: Issues dealing with accountability and responsibility of various personnel's interface with the system.

18. 5-S1 Access

Please select a category indicating your level of concern with of Access as a criterion for each alternate. Access is defined to be means and methods provided for data protection from internal and external threats.

	Extremely Concerned		Sufficiently Concerned		Concerned		Somewhat Concerned		Least Concerned
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

19. 5-S2 Control

Please select a category indicating your level of concern for Control as a criterion for each alternate. Control is defined to be accessibility and dependability of existing and historical project data.

	Extremely Concerned		Sufficiently Concerned		Concerned		Somewhat Concerned		Least Concerned
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

20. 5-S3 Reliability

Please select a category indicating your level of concern for Reliability for each alternate. Reliability is defined to be degree of accuracy and availability of data in a timely manner.

	Extremely Concerned		Sufficiently Concerned		Concerned		Somewhat concerned		Least Concerned
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

21. 5-S4 Legality

Please select a category indicating your level of concern for Legality as a criterion for each alternate. Legality is defined to be issues dealing with accountability and responsibility of various personnel's interface with the system.

	Extremely Concerned		Sufficiently Concerned		Concerned		Somewhat Concerned		Least Concerned
ERP	○	○	○	○	○	○	○	○	○
WPMS	○	○	○	○	○	○	○	○	○

7. Pair Wise Comparisons

Please evaluate each item by comparing it to others in the same category. Choose one of the terms "exactly", "about"', "at least", "at most" from the left drop down box and then select the number which you think is appropriate at the right drop down box in each pair wise comparison. For instance, if you think item A is at most 2 times more important than item B, and then choose "at most" & "2" respectively from left and right drop down boxes

8. Cost Criteria

22. Implementation Cost
Is more important than

		times
Infrastructure Cost by		
Maintenance Cost by		
Trainining Cost by		

23. Infrastructure Cost
Is more important than

		times
Maintenance Cost by		
Training Cost by		

24. Maintenance Cost
Is more important than

		times
Training Cost by		

9. Time Criteria

25. Production Time
Is more important than

		times
Implementation Time by		
Training Time by		
Technical Durability Time by		

26. Implementation Time
Is more important than

		times
Training Time by		
Technical Durability Time by		

27. Training Time
Is more important than

		times
Technical Durability Time by		

10. Functionalities Criteria

28. Project Collaboration
Is more important than

		times
Modularity by		
Project Controls by		
Project Administration by		
Project Contract Management by		

29. Modularity/Flexibility
Is more important than

		times
Project Controls by		
Project Administration by		
Project Contract Management by		

30. Project Controls
Is more important than

		times
Project Administration by		
Project Contract Management by		

31. Project Administration
Is more important than

		times
Project Contract Management by		

11. Security Criteria

32. Access
Is more important than

		times
Data Control by		
Reliability by		
Legal by		

33. Data Control
Is more important than

		times
Reliability by		
Legal by		

34. Reliability
Is more important than

		times
legal by		

12. Untitled Page

Thank you for taking the time to complete this evaluation.

Appendix C: SPSSS Outputs

CostInitialERP	CostInitialWPMS	CostImplemERI	CostImplemWPM
9.00	8.00	9.00	7.00
7.00	4.00	5.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	3.00	9.00	1.00
7.00	5.00	7.00	5.00
5.00	5.00	5.00	3.00
9.00	5.00	8.00	5.00
6.00	4.00	9.00	5.00
7.00	6.00	8.00	7.00
8.00	5.00	7.00	6.00
5.00	3.00	6.00	7.00
6.00	3.00	8.00	5.00
8.00	8.00	7.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
5.00	3.00	6.00	3.00
5.00	5.00	7.00	5.00
5.00	5.00	5.00	5.00
7.00	5.00	6.00	5.00
7.00	7.00	7.00	7.00
6.00	6.00	9.00	9.00
5.00	5.00	5.00	5.00
5.00	5.00	7.00	6.00
7.00	5.00	8.00	5.00

CostMaintERP	COstMaintWPM	CostTrainERP	CostTrainWPM
7.00	5.00	7.00	7.00
3.00	5.00	5.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	2.00	9.00	1.00
6.00	5.00	7.00	5.00
5.00	5.00	5.00	3.00
7.00	5.00	6.00	4.00
7.00	5.00	6.00	6.00
7.00	5.00	7.00	7.00
5.00	5.00	7.00	7.00
5.00	5.00	3.00	3.00
6.00	5.00	6.00	4.00
7.00	7.00	7.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
5.00	2.00	5.00	3.00
5.00	5.00	3.00	3.00
4.00	4.00	4.00	4.00
4.00	4.00	5.00	5.00
6.00	6.00	5.00	5.00
6.00	6.00	6.00	6.00
7.00	7.00	7.00	7.00
5.00	5.00	7.00	5.00
4.00	4.00	6.00	4.00

TimeProdER	TimeProdWPI	TimeImpERP	TimeImpWPI
7.00	7.00	1.00	5.00
5.00	6.00	7.00	3.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	1.00	9.00	2.00
5.00	5.00	5.00	7.00
5.00	5.00	5.00	5.00
4.00	4.00	1.00	5.00
4.00	2.00	1.00	5.00
4.00	3.00	1.00	6.00
4.00	4.00	3.00	4.00
5.00	3.00	4.00	6.00
3.00	6.00	2.00	7.00
4.00	4.00	4.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
7.00	5.00	4.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
5.00	5.00	6.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
5.00	5.00	1.00	1.00
3.00	3.00	3.00	3.00
5.00	5.00	3.00	5.00
8.00	5.00	3.00	7.00

TimeTrainERF	TimeTrainWPM	TimeDurabER	TimeDurabWPI
2.00	5.00	4.00	6.00
6.00	5.00	4.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	2.00	9.00	2.00
5.00	5.00	8.00	8.00
5.00	5.00	5.00	5.00
3.00	5.00	5.00	6.00
4.00	5.00	8.00	6.00
3.00	8.00	7.00	8.00
5.00	5.00	8.00	6.00
7.00	7.00	7.00	5.00
4.00	6.00	9.00	3.00
7.00	7.00	5.00	4.00
#NULL!	#NULL!	#NULL!	#NULL!
3.00	7.00	7.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
7.00	7.00	8.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
1.00	1.00	7.00	7.00
6.00	6.00	7.00	7.00
3.00	5.00	9.00	7.00
3.00	6.00	7.00	5.00

FunCollabERF	FunCollabWPM	FunModulER	FunModulWPM
5.00	5.00	7.00	4.00
5.00	5.00	6.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	7.00	9.00	3.00
4.00	7.00	5.00	5.00
7.00	7.00	3.00	5.00
5.00	7.00	5.00	7.00
8.00	3.00	7.00	3.00
7.00	9.00	6.00	8.00
7.00	7.00	9.00	5.00
3.00	4.00	3.00	5.00
7.00	7.00	5.00	7.00
7.00	9.00	5.00	5.00
#NULL!	#NULL!	#NULL!	#NULL!
5.00	7.00	7.00	3.00
#NULL!	#NULL!	#NULL!	#NULL!
7.00	6.00	7.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
6.00	6.00	8.00	8.00
7.00	7.00	7.00	7.00
7.00	9.00	8.00	8.00
7.00	9.00	8.00	4.00

FunControlERP	FunControlWPM	FunAdminER	FunAdminWPI	FunContractERP	FunContractWPM
7.00	5.00	7.00	5.00	7.00	5.00
5.00	5.00	5.00	5.00	4.00	5.00
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
9.00	3.00	9.00	2.00	9.00	3.00
9.00	9.00	9.00	3.00	9.00	5.00
9.00	3.00	5.00	5.00	5.00	5.00
5.00	5.00	5.00	5.00	5.00	8.00
5.00	5.00	6.00	3.00	5.00	3.00
9.00	9.00	9.00	9.00	9.00	9.00
9.00	9.00	9.00	3.00	8.00	8.00
8.00	6.00	6.00	4.00	5.00	4.00
7.00	7.00	7.00	7.00	7.00	7.00
7.00	9.00	7.00	9.00	7.00	9.00
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
7.00	4.00	7.00	7.00	7.00	3.00
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
9.00	9.00	9.00	9.00	9.00	9.00
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
9.00	9.00	9.00	9.00	8.00	8.00
9.00	9.00	7.00	7.00	8.00	8.00
9.00	9.00	9.00	5.00	9.00	7.00
7.00	7.00	9.00	3.00	8.00	5.00

SecAccessER	SecAccessWPI	SecControlERP	SecControlWPM
7.00	9.00	3.00	8.00
5.00	4.00	5.00	5.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	5.00	8.00	5.00
7.00	7.00	7.00	8.00
5.00	5.00	5.00	5.00
7.00	9.00	7.00	7.00
7.00	2.00	7.00	2.00
7.00	9.00	7.00	7.00
9.00	5.00	8.00	8.00
2.00	5.00	2.00	6.00
1.00	6.00	1.00	5.00
5.00	5.00	6.00	6.00
#NULL!	#NULL!	#NULL!	#NULL!
7.00	7.00	7.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
9.00	9.00	9.00	9.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	9.00	9.00	9.00
5.00	5.00	5.00	5.00
7.00	7.00	7.00	7.00
9.00	5.00	9.00	5.00

SecReliabERF	SecReliabWPM	SecLegalERF	SecLegalWPM
5.00	6.00	3.00	7.00
3.00	3.00	2.00	2.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
8.00	5.00	9.00	1.00
9.00	9.00	7.00	7.00
5.00	5.00	5.00	5.00
9.00	8.00	9.00	9.00
9.00	5.00	7.00	2.00
7.00	7.00	8.00	9.00
9.00	9.00	9.00	7.00
5.00	5.00	4.00	6.00
1.00	3.00	1.00	6.00
8.00	9.00	7.00	7.00
#NULL!	#NULL!	#NULL!	#NULL!
7.00	7.00	2.00	2.00
#NULL!	#NULL!	#NULL!	#NULL!
8.00	8.00	8.00	8.00
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
9.00	8.00	8.00	8.00
7.00	7.00	8.00	8.00
7.00	7.00	7.00	7.00
9.00	7.00	7.00	5.00

CostScore	TimeScore	FunScore	SecScore
7.00	3.50	6.60	4.50
4.00	5.50	5.00	3.75
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
8.00	9.00	9.00	8.50
5.75	5.75	7.20	7.50
4.00	5.00	5.80	5.00
6.50	3.25	5.00	8.00
6.00	4.25	6.20	7.50
6.25	3.75	8.00	7.25
5.25	5.00	8.40	8.75
3.75	5.75	5.00	3.25
5.50	4.50	6.60	1.00
6.25	5.00	6.60	6.50
#NULL!	#NULL!	#NULL!	#NULL!
4.25	5.25	6.60	5.75
4.00	#NULL!	#NULL!	#NULL!
3.50	6.00	8.20	8.50
4.50	#NULL!	#NULL!	#NULL!
5.25	#NULL!	#NULL!	#NULL!
6.25	3.50	8.00	8.75
5.00	4.75	7.60	6.25
5.00	5.00	8.40	7.00
5.25	5.25	7.80	8.50

CostScoreWPM	TimeScoreWPM	FunScoreWPM	SecScoreWPMS
6.75	5.75	4.80	8.00
5.25	5.00	5.20	3.50
#NULL!	#NULL!	#NULL!	#NULL!
#NULL!	#NULL!	#NULL!	#NULL!
1.75	1.75	3.60	4.00
6.00	6.25	5.80	7.75
4.00	5.00	5.00	5.00
4.75	5.00	6.40	8.25
5.00	4.50	3.40	2.75
6.25	5.75	8.80	8.00
5.75	4.75	6.40	7.25
4.50	5.25	4.60	5.50
4.25	5.50	7.00	5.00
7.25	5.25	8.20	6.75
#NULL!	#NULL!	#NULL!	#NULL!
2.75	6.50	4.80	5.75
4.50	#NULL!	#NULL!	#NULL!
4.50	6.00	7.80	8.50
4.75	#NULL!	#NULL!	#NULL!
6.25	#NULL!	#NULL!	#NULL!
7.25	3.50	8.00	8.75
6.00	4.75	7.80	6.25
5.25	5.50	7.60	7.00
4.50	6.75	5.60	5.50

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