The indicators of small project success

by

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Signatures have been redacted for privacy

To Dr. Gary R. Smith, Dr. R. Edward Minchin Jr., and my family.

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ABSTRACT

Much research has been conducted to establish project success factors/indicators for large project execution and delivery. Little research, however, has focused on success factors for small projects, and most does not examine the differences between success factors of large projects and those of small ones. Some factors for large projects are unnecessary and ineffective for small projects.

This study examines and provides small project execution factors that are related to obtaining success. In order to support the analysis needed in the research, an RT 161 (Small Project Execution) Database was designed with the organization-oriented technology, which involved will not only collect data from different projects over an organization, but it also will be incorporated into the database. The research methods involved examining and deciding which small project execution factors are related to obtaining success by literature research and factor examination, data collection and evaluation, and indicators identification. A total of 36 organizations including designers, owners and contractors are included in this database. Through classification research analysis, 14 indicators of small project success were determined. These are: (1) Construction Representative in Design Phase, (2) Bidding Process for Equipment Supply, (3) Documentation with Equipment, (4) Site Visit, (5) Maintenance Work for Small Projects, (6) Team Building, (7) Cross Training, (8) Permanent Work Force for Small Projects, (9) Mix Staffing, (10) Standard Process for Small Projects, (11) Contract Type Selection, (12) Site Safety Plan and Supervision, (13) Pre-hire Testing, and (14) Automated Project Control. The limitations and needed future study of those factors are also investigated.

CHAPTER 1

GENERAL INTRODUCTION

The primary goal for each party of the project team is to make the project successful, no matter how large or small. Achieving this success depends on many factors, such as resource availability, cost, cash flow, weather conditions, and uncertain surroundings, as well as project management and organization.

Much research has been conducted in order to establish project success factors/indicators, and although researchers have, indeed, established them for project management, most of their work did not distinguish between success factors of large projects and those for small ones. Small project execution often results in less than optimal project cost, quality, and schedules when executed using standard project delivery systems. This is due to the difficulty of reducing large project delivery processes for small projects. Some of the factors for large projects are unnecessary and ineffective for small projects. Do project success factors apply to both large and small projects? If so, do the project success factors from large projects apply to small projects without modification? Can any dramatic distinctions between large and small projects be expected? If so, do these factors have the same effectiveness if they are applicable to both large and small projects? This study will answer these questions by identifying the differences between success indicators of small and large projects.

Purpose of This Study

The purpose of this research is to provide a reasonable approach to examining small project success. This will be accomplished by identifying project execution input that leads to successful projects and then by developing models to predict the success of a small project based on this input. Small projects in this study are defined as capital projects (note that maintenance projects are excluded in the definition of small capital projects) between \$100,000 and \$2,000,000 total installed cost (TIC). Project success is defined as projects that are no more than 5% over budget and no more than 7 days behind schedule. The objective of this study is to research and document the success factors best associated with the small project execution process. This will aid in future projects being successful in scheduling and budget. Included within the best success factors concepts will be the examination of technology applications to the small project environment. The researcher will use the data, which was collected from the small project execution practice, to develop a statistical analysis to correlate best success factors to results. The study identifies key indicators necessary for achieving small project success during each of these phases: Front-end Planning, Design, Procurement, Construction, Start-up and Operations, Project Processes and Controls, Organization, Contracting, Technology and Information Systems, People, and Safety, Health and Environment.

Thesis Organization

This thesis has five chapters. Chapter 1 provides the introduction and purpose of this study. Chapter 2 consists of the literature review on factors related to project success. Chapter 3 introduces RT 161 (Small Project Execution) Database and Technology for data collection and analysis. Chapter 4 presents a paper showing the results of objectives noted above. The main conclusion of this study is summarized in Chapter 5, along with suggested areas of further study.

CHAPTER 2

LITERATURE REVIEW

Introduction

Currently, many companies use project manuals that define time-tested procedures for large project execution and delivery. Large projects generally have the advantage of well-defined processes, with success factors that are easily identifiable. However, small projects, when executed using standard project delivery systems, result in less than optimal project cost, quality, and schedules. Large project delivery processes are not easily reconfigured for small projects and often fail to deliver the projects in an effective manner.

Previous work on both large and small projects was reviewed, revealing how much has been accomplished in the areas of measuring and indicating the success of a construction project, with budget, schedule, and quality being the major concerns for a construction project. This literature review focuses on identifying the measurements, factors, indicators, and models for both large and small project success. A project's success is subjective, depending on who is making the evaluation, which phase of the project is being evaluated, and what baseline values are being used to make the assessment. The purpose of a detailed review is to avoid duplication of effort and to make note of the gaps in practices already identified for small projects.

Project Success Measurement

A detailed review of work measuring project success clearly reveals that there are many interpretations. Among most researchers, though, there exists some agreement.

Murphy, Baker, and Fisher measured success by using six items: (1) overall project success, (2) parent organization satisfaction, (3) client organization satisfaction, (4) ultimate user satisfaction, (5) project team satisfaction, and (6) fulfillment of technical performance or mission. They pointed out that measuring success is a multi-dimensional concept with several measures that are both objective and subjective in nature [Murphy et al. 1974].

Might and Fischer clearly specified and employed six distinct measures of success applicable to three specific criteria, which were cost, time, and technical performance: (1) the subjective measure of the overall success as perceived by the respondent, (2) the measure of cost overrun/underrun as a percentage of the initial estimate, (3) the measure of the schedule overrun/underrun as a percentage of the initial estimate, (4) the subjective assessment of the technical success relative to the initial plan, (5) the subjective assessment of the technical success relative to other projects in the firm, and (6) the subjective assessment of the technical success measured in terms of the technical problem identification process (i.e., a successful project is one that requires little or no crisis management while still meeting cost and schedule goals). They also pointed out that technical performance was ranked first among success factors approximately 60% of the time and cost and schedule were distant second and third choices [Might and Fischer 1985].

Cleland pointed out that project success is dependent upon the management approach--planning, organization, evaluation, and control tied together through an appropriate project leadership. His paper, examining project success from the owner's viewpoint, stated that project success is meaningful only if the following are considered: the degree to which the project's technical performance objective was attained on time and within budget and the contribution that the project made to the strategic mission of the enterprise. Measuring the success of a project includes an ongoing assessment of how the project is perceived by parties (project team members, subcontractors, suppliers, government agencies, customers, and other relevant groups). One party's view of a project success may be different than that of another [Cleland 1986].

De Wit pointed out that measures of success took into account the objectives of all parties who had something at stake, including all management levels. A project is considered an overall success if it meets the technical performance specification and if there is a high level of satisfaction concerning the project outcome among key people in the parent organization, project team, and key users or clientele of the project. On the other hand, measuring success is a complex task. Rarely is a project considered a complete failure for all parties during all phases in the life cycle; rather, it might be a success for one party and a disaster for another. Success is also time dependent. For example, a project may be perceived a success one day and a failure the next. To think that one can objectively measure the success of a project is an illusion [De Wit 1986].

Tuman defines project success from the perspectives of different project participants, each who has his own criteria, and discusses the impact of each participant on success. Four main categories of participants in the paper are (1) the project champions (entrepreneurs, developers, investors, client, politicians, etc.), (2) project participants (project management, engineering, construction, vendors, suppliers, etc.), (3) community participants (community members, religious leaders, political groups, environmentalists, etc.), and (4) parasitic participants (information media, opportunists, activists, etc.).

The criteria for success from the viewpoint of the project champions is well defined--they want a good return on their investment, as well as services and products at minimum expenditure. They also want end results as envisioned at the project start, a rewarding experience, and an enhanced reputation. The criteria for success from the viewpoint of the project participants, those who contribute to the actual planning and execution of the project, is to satisfy everyone else and be recognized for their efforts. They would prefer the project to be completed on time and within budget, to meet all objectives, and to satisfy the goals and desires of other interested parties. Community participants, who will be directly or indirectly affected by the project, would like to see the community benefit by the project. At the same time, they hope to minimize the impact on the community and profit from project. For parasitic participants, who neither have a direct involvement in the project nor are directly affected by the project, their actual power to impact the success of a project directly is limited. They are seeking the opportunity for self-fulfillment, the opportunity to promote their own views, ideas, or philosophy, and the opportunity for profit or gain [Tuman 1986].

McCoy proposed a project success measurement technique defined as the Integrated Project Baseline (IPB) approach. This approach is established in the beginning of a project and maintained throughout the entire project in terms of cost, schedule, and technical performance. The IPB incorporates three criteria, which are operability, project cost, and completion on schedule. These criteria are (1) key health indicators of project success, (2) directly related to project results, (3) measurable, and (4) manageable. He concluded that the IPB provides an objective tool for measuring the success of projects and improves objectivity by specifically defining the criteria against which performance of the project will be evaluated [McCoy 1986].

Salapatas and Sawle state that utility projects shouldn't be considered a complete success unless the client, builder, and public perceive the project to be a success. They believe that there are three important differences between past and present measure of success: (1) increasing emphasis on the basic success criteria in terms of budget, schedule, and quality, (2) the utilities to be the primary evaluators of project success pushed by the onset of competition, and (3) using the internally performed management audit as a success measurement tool [Salapatas and Sawle 1986].

Struckenbruck points out that even though the evaluation of project success is often assumed to compare project accomplishments with its planned goals and objectives, measuring success might be quite complex due to the many different perspectives of the project. Therefore, simply comparing a project's accomplishments with its planned goals and objectives can be deceptive. Each project party has very different criteria for project success, depending on how they measure success, what they are evaluating, and when the evaluation takes place. Project managers must carefully keep in mind top management's wants and needs and try to incorporate them into their planning process [Struckenbruck 1986].

Ashley, Lurie, and Jaselskis investigated success from the project management's point of view. They found that success was defined as results much better than expected or normally observed in terms of cost, schedule, quality, safety, and participant satisfaction. The research also showed that there were six criteria used to measure construction project success: (1) budget performance, (2) schedule performance, (3) client satisfaction, (4) functionality, (5) contractor satisfaction, and (6) project manager/team satisfaction [Ashley, Lurie, and Jaselskis 1987].

Carroll presented the Construction Industry Institute's 8 elements of project success: (1) key leaders, (2) compatible objectives, (3) design basis, (4) project strategy, (5) roles and responsibilities, (6) information system, (7) qualified people, and (8) working relationships [Carroll 1989].

Sanvido states that success for a given project participant is defined as the degree to which project goals and expectations are met. These goals and expectations may include technical, financial, educational, social, and professional aspects; however, they may be different for many project participants [Sanvido 1992].

Naoum used a theoretical framework to assist in comparing project performance, concluding that to achieve project success, the parties need to match the various organizational forms to the client's characteristics, criteria, and priorities. He defined 10 factors to measure project performance: (1) pre-construction time, (2) construction time, (3) total time, (4) speed of construction, (5) unit cost of building, (6) time overrun, (7) cost overrun, (8) client's satisfaction with time, (9) client's satisfaction with cost, and (10) client's satisfaction with quality [Naoum 1994].

Kerzner developed a modified definition of project success. A successful project is one that is being completed (1) within the allocated time period, (2) within the budgeted cost, (3) with acceptance by the customer/user, (4) when the contractor can use the customer's name as a reference, (5) with minimum or mutually agreed upon scope changes, (6) without disturbing the main work flow of the organization, and (7) without changing the corporate culture. Kerzner also pointed out that project success is often measured by the actions of these three groups: the project manager and team, the parent organization, and the customer's organization [Kerzner 1998].

A review of the literature shows that different researchers use different measures. In general, though, these researchers came to many of the same conclusions concerning project success. This review, however, did not yield any construction-related articles that detailed specific measures for small project success.

Project Success Factors

Factors or indicators showing or making construction projects successful are described in many articles.

Murphy, Baker, and Fisher identify several determinants of project success. Their study was designed to include as many variables as possible that are important for project effectiveness. Several individual variables were identified as strongly correlating to project success. These are (1) project team sense of mission, (2) project team spirit, (3) project team goal commitment, (4) project team capability, (5) project manager's satisfaction with planning and control, and (5) unity between project manager and client contact [Murphy, Baker, and Fisher1974].

Morris conducted a comprehensive examination of factors that had significant impact on success or failure of major projects. In his analysis of project success, he defined and tested hypotheses related to project definition, technical, finances, environment, schedule, and management. The findings of his study suggest several external and internal factors that need managing if the project is to be successful. External factors relate to government/corporate changes, regulations, technical developments, and political environment. Internal factors deal with effective leadership, positive participant attitudes, "good" planning, and well defined work scope [Morris 1986].

Jolivet and Batignolles identified a list of 17 factors often found in successful construction projects: (1) a project director is nominated, (2) the project is subdivided, (3) the project organization is determined by the project director, (4) the objectives are established and made known, and (5) activity is in accordance with written procedures, (6) contract management, (7) program management, (8) cost management, (9) quality management, (10) administrative and financial management, (11) personnel management, (12) design management, (13) purchasing and subcontract management, (14) construction management, (15) shutdown procedures, (16) management of project "know-how," and (17) documentation [Jolivet and Batignolles 1986].

Ashley, Lurie, and Jaselskis conducted a pilot study that established the determinants of construction projects success. They found that the following areas are emphasized in successful projects: planning effort (construction and design), project manager goal commitment, project team motivation, project manager technical capabilities, scope and work definition, and control systems. The researchers found that successful projects finished under budget had better construction productivity, man-hour utilization, and safety performance [Ashley, Lurie, and Jaselskis 1987].

Pinto and Slevin determined critical success factors that are predictors of successful project management. Managers with extensive project experience were used to generate a list of success factors that they felt were crucial to successful project implementation. Ten factors were compiled: (1) project mission, (2) top management support, (3) project schedule/plan, (4) client consultation, (5) personnel issues, (6) technical tasks, (7) monitoring and feedback, (8) communication, (9) trouble-shooting, and (10) client acceptance [Pinto and Slevin 1992].

Sanvido et al. state that success on a project means that certain expectations for a given participant are met, whether for an owner, planner, engineer, contractor, or operator. The four most critical success factors derived from the Integrated Building Process Model are (1) a well-organized, cohesive facility team to manage, plan, design, construct, and operate the facility, (2) a series of contracts that allows and encourages the various specialists to behave as a team without conflicts of interest and differing goals, (3) experience in the management, planning, design, construction, and operations of similar facilities, and (4) timely, valuable optimization information from the owner, user, designer, contractor, and operator in the planning and design phases of the facility [Sanvido et al. 1992].

Chua, Kog, and Loh distinguished critical success factors for different project objectives relating to budget, schedule, and quality using the analytic hierarchy process. These researchers determined the relative importance of 67 success-related factors, which were grouped under four main topics: (1) project characteristics, (2) contractual arrangements, (3) project participants, and (4) interactive process. The top 10 overall ranking factors are: (1) plans and specifications, (2) constructability, (3) PM commitment and involvement, (4) realistic obligations/clear objectives, (5) PM competency, (6) contractual motivation or incentive, (7) site inspections, (8) construction control meetings, (9) formal communication, and (10) economic risks. It is important to note, however, that each set of critical success factors differs depending on the project objective. The top ten factors for budget performance are: (1) plans and specifications, (2) constructability, (3) economic risks, (4) realistic obligations or clear objectives, (5) PM competency, (6) funding, (7) budget update, (8) PM commitment and involvement, (9) contractual motivation or incentives, and (10) risk identification and allocation. The top ten factors for schedule performance are: (1) plans and specifications, (2) constructability, (3) PM commitment and involvement, (4) PM competency, (5) contractual motivation or incentives, (6) realistic obligations or clear objectives, (7) schedule update, (8) construction control meetings, (9) capability of contractor key person, and (10) pioneering status. The top ten factors for quality performance are: (1) plans and specifications, (2) constructability, (3) site inspections, (4) PM commitment and involvement, (5) realistic obligations or clear objectives, (6) PM competency, (7) construction control meetings, (8) formal communication (construction), (9) capability of contractor key person, and (10) contractual motivation or incentives and design control meetings [Chua, Kog, and Loh 2000].

Cheng, Li, and Love established a partnering framework to identify the critical success factors which can improve the productivity and performance of construction projects. These factors are: (1) effective communication, (2) conflict resolution, (3) adequate resources, (4) management support, (5) mutual trust, (6) long-term commitment, (7) coordination, and (8) creativity [Cheng, Li, and Love 2000].

A review of the literature yielded few construction-related articles that focused on success factors for small projects; that is, many of the papers did not differentiate between success factors for large projects and those of small ones.

Might and Fisher investigated whether project size is a factor affecting the utility of various project management systems by categorizing the projects into high-cost and low-cost groupings. They classified projects costing $2,000,000 or less as small projects. Regressions, which had the six criteria of success as the dependent variables and the project management control techniques as independent variables, were run separately for the large and small project data. Levels of statistical significance associated with the regression coefficients were presented. They concluded that the analysis did not yield dramatic distinctions between large and small projects that many observers would believe exist. However, it suggested that (1) there might be some differences between large and small projects with a control system, apparently having considerably more influence (both positive and negative) on success in large projects than is the case with smaller ones, and (2) the use of technical monitoring as a project management control system stands out from the rest in the uniformly strongly negative association between its use and project success overall success criteria and only large projects can afford such tight technical control [Might and Fisher 1985].

Conley developed a concept in partnering for small construction projects and states that the reduction in schedule growth and claims cost, along with the increase in value engineering savings, supports the use of partnering concepts in projects of all sizes. Since small construction projects do not always have sufficient funding to enable them to organize a formal partnering effort with paid facilitators, an informal partnering option is suggested. The use of informal partnering on small construction projects would be more appropriate for projects that have a duration of at least 6 months and for which schedule growth is a major concern of the owner [Conley 1999].

Dunston and Reed developed and implemented the Small Projects Team Initiative (SPIT). By following this initiative, (1) design cost is lower, (2) schedule growth is less, and (3) change order cost is lower [Dunston and Reed 2000].

Project Success Model

Few articles investigated and established a model to describe or predict the success of a project.

Murphy, Baker and Fisher developed a model for project success using regression techniques. A step-wise regression analysis showed that successful project outcomes are based on multiple factors. More important, the work shows that many important factors lie within the control of those managing the project. The seven determining factors on the perceived success of project factor are: (1) coordination and relations, (2) adequacy of project structure and control, (3) project uniqueness, importance and public exposure, (4) success criteria clarity and consensus, (5) competitive and budgetary pressure, (6) initial over-optimism and conceptual difficulty, and (7) internal capabilities build-up [Murphy, Baker, and Fisher 1974].

Tuman identifies the conditions for success, reviews some of the traits that distinguish a successful project team, and explains how a model can be developed and used to build a team with the appropriate success characteristics. The following creates a success model: (1) establishing project success goals, (2) identifying the success process, (3) success characteristics mapping, and (4) defining project team's modulus [Tuman 1986].

Pinto and Slevin investigated modeling techniques to identify important success factors depending on the project phase. These researchers determined that the critical factors are not of equal importance over the life of the project. In other words, different sets of these factors become more critical to project success at different phases in the project life cycle. A step-wise regression analysis was used to identify key factors for each phase of the project life cycle. These are: (1) conceptual, (2) planning, (3) execution, and (4) termination [Pinto and Slevin 1988].

Jaselskis developed a predictive discrete choice model used for achieving outstanding project performance, such as better scheduling performance and better budget performance, by 4 success categories: project manager (PM education level, PM technical experience, PM subordinates), project team (team turnover), planning (constructability), and controls (budget updates, control meetings during construction, controls meeting during design, and control system cost) [Jaselskis 1988].

Balachandra proposed a contextual framework to measure the success factors for the project, which consists of a contingency cube with three contextual dimensions [Balachandra 1997].

Griffith et al. designed and developed an index to measure the success of industrial project execution. The index is comprised of 4 variables: budget achievement, schedule achievement, design capacity, and plant utilization. The Success Index Equation yields results ranging from 1 (complete failure) to 5 (complete success). This equation may be used to compare success levels of a wide range of projects with different budgets, schedules, and products. Generally, an index value of 3 or higher indicates that the project either met or exceeded all 4 of the success variable goals [Griffith et al. 1999].

A review of the literature did not yield any construction-related articles using different models for large and small project success.

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CHAPTER 3

THE RT161 (SMALL PROJECT EXECUTION) DATABASE AND TECHNOLOGY

In order to support the research analysis needed for the Constuction Industry Institute (CII), an RT 161 (Small Project Execution) Database was designed. This chapter gives an overview of the RT 161 (Small Project Execution) Database and applied technologies.

Technologies of RT161 (Small Project Execution) Database

A literature review was performed in order to search for organization-oriented databases or systems that are currently available or under development. None, however, was found in the project execution area; therefore, an organization-oriented database is needed to integrate the collection of data and incorporate that data into the decision-making process.

The ultimate goal of the database is to collect and generate information on which to base the most critical factors. This will, in return, produce optimal choices concerning small project decisions. From this perspective, the organization-oriented technology involved will not only collect data from different projects over an organization, but it also will be incorporated into the database. The database categorizes the organization type and then transforms the original data into useful information to support success factor identification and execution decisions. Such a database uses database management and data processing concepts.

A wide range of database management technologies is available today, with software for implementing the required database and data processing capabilities available for any size of computer hardware. The relationship between technology and data requirements will be briefly discussed here. A diagram showing how information requirements are structured for the database will help to illustrate those technologies that would be appropriate at different levels in the small project execution process. Three distinct levels of data are required to support this process (Figure 1). Level I, the CII level, deals with project execution decisions, critical factor identification, and report generation; this level is supported by data generated from Level II. Level II, the organization level, is able to collect, generate and store data from and for Level III, the component level. The component level will then provide the detailed information about each of phases in small project execution.

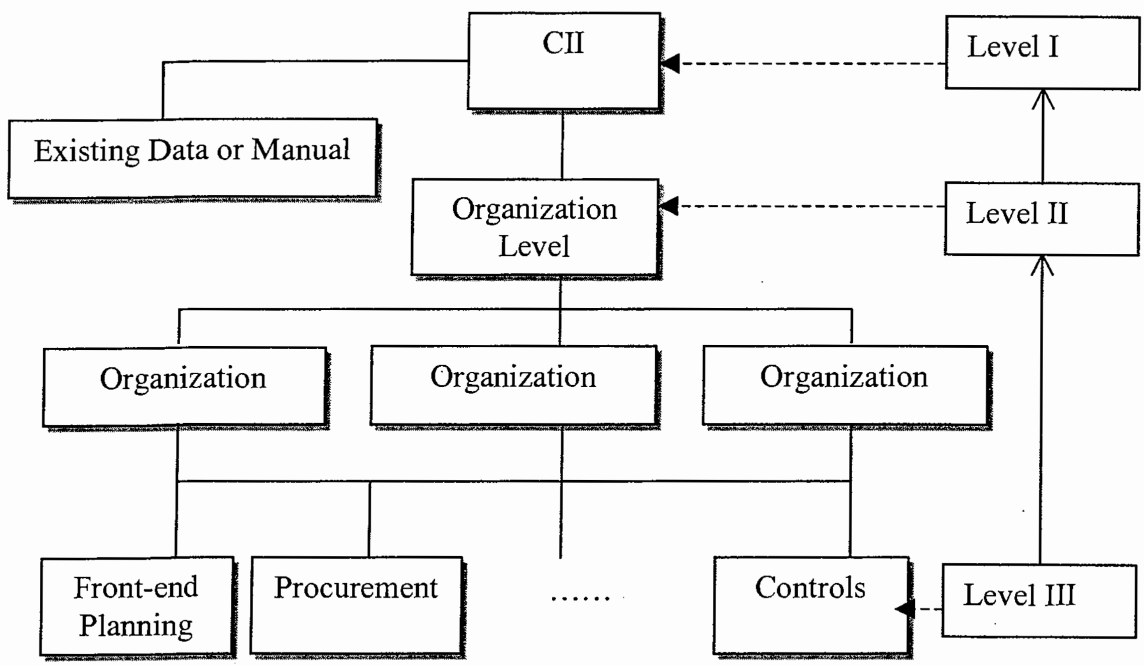

Figure 1. Data Levels

The decision, the data required to support these decisions, and the appropriate technologies to capture the needed data vary depending on the decision level. The approach to capturing, handling, and using the necessary data also varies with data level. It is necessary to identify data requirements and potential technologies for providing the data. The effort is ultimately centered on using technology for collecting data that describe execution of each phase for a small project.

Each of the three decision levels discussed above has distinct data needs that may be satisfied by new or existing technology. At the CII Level (Level I), an integrated database and database management system would support the CII needs. Such a system could potentially provide integration reports of numerical, categorical, and statement data and then be used for supporting the whole construction industry.

The organization level (Level II) deals with detailed data concerning organization type, history, size, project distribution, and small project contribution and information on trends. Data collection needs at this level are extensive and can be done by a survey; however, this part of the database may be expanded to document management systems for the organization. This expansion would enable a wider, more interactive use of the database. The information here could be used to categorize the data in Level III and group the analysis in Level I.

The component level (Level III) technology is needed to provide accurate, comprehensive data for each of the execution components within an organization. Technology at this level is component-specific, with the objective of measuring or monitoring a specific feature of interest within each phase of a project. This will be discussed in the next section.

Generally, the higher the decision level, the less detail needed to support the decision process. Also, the data needs at the various levels can often be satisfied by data collected at the lower level via the appropriate technology. Detailed data can be analyzed at the organization level and the CII level.

General Overview of RT161 (Small Project Execution) Database

To help with analyzing and identifying critical success factors for small projects, a Small Project Execution Database has been developed with Microsoft Access 97/2000. This database is for the systematic use of project execution practices to determine the differences between large and small projects and also identifies the critical success factors for small projects. The key to the small project execution database concept is the structured techniques, procedures, and processes necessary for effective and successful management of small projects. It provides data and tools to aid in decision making for small project management.

Figure 2 presents a schematic data flow of the system, which is modeled using an organization data flow diagram. The diagram illustrates data flow (arrows), data storage (cylinders), reports (multidocuments), system agents (rounded rectangles), and processes (rectangles). Five major processes identified in the diagram are: 1) Survey, 2) Interview, 3) Data Entry, 4) Data Storage, and 5) Analysis and Report Generation. The broken arrows between agents and processes illustrate the data categorized by certain agents.

Small Project Execution data is initially collected from a survey of organizations working on small projects. Before data is entered into the database, the principal researcher validates and modifies them by interviewing each of these organizations. The interview should focus on key information about small project execution, and confidentiality of proprietary information should be strictly controlled. Key information concerning execution includes factors or components that will be analyzed in the next chapter. If some information is missing, then the data forms will be completed by either calling the respondent or by checking the data's influence on the analysis model. When all information is present, the data will be entered into the database. When the researchers or CII or any other potential users need information about a specific category or general review of the small project execution, they can input their own criteria and then query the database. For example, to know how many contractors responded "same engineering risk on both large project and small project," the user just needs to select "Contractor," "Front-end Planning," and "Engineering Risk" in the query conditions, and then run a query to get the results. The most frequently used categories of reports are already listed in the menu. Users, however, can get reports from the menu without making their own queries.

The information extracted by queries can be analyzed either within the Small Project Execution Database or by transferring the data to the statistical analysis tools, such as SAS, if a more complex analysis or model building is required. By doing this, the report on critical factors or guidelines of succesful small project execution will be reached. This paper focuses on the critical success factors of small project success in terms of project budget and project schedule. Only a segment of the data in the database will be used.

Structure and Elements of RT161 (Small Project Execution) Database

To operate the database effectively and efficiently, a structured menu for RT 161 (Small Project Execution) database was created. This menu defines the procedure of building and operating the database.

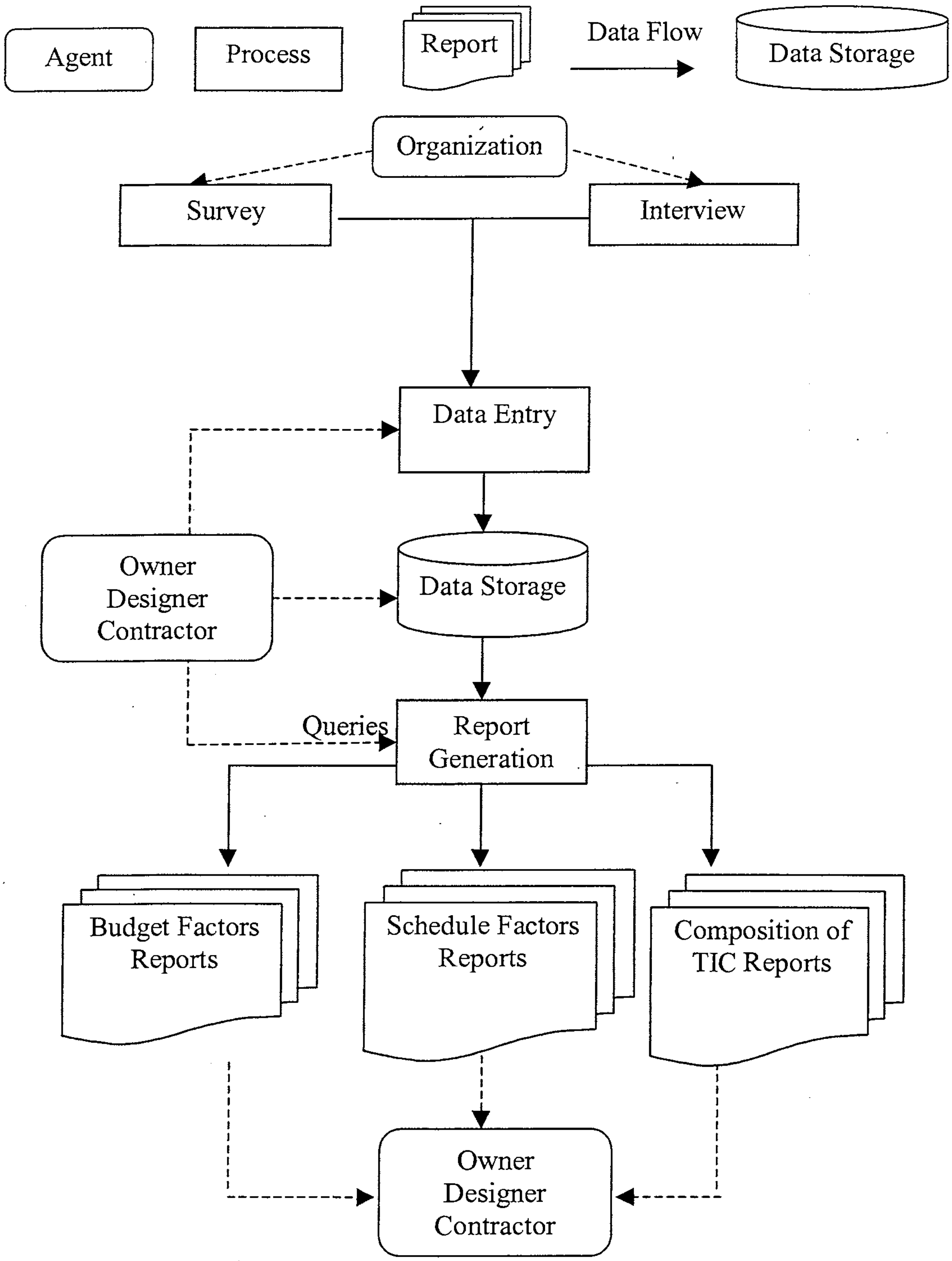

Figure 2. Data flow Diagram for RT161(Small Project Execution) Database

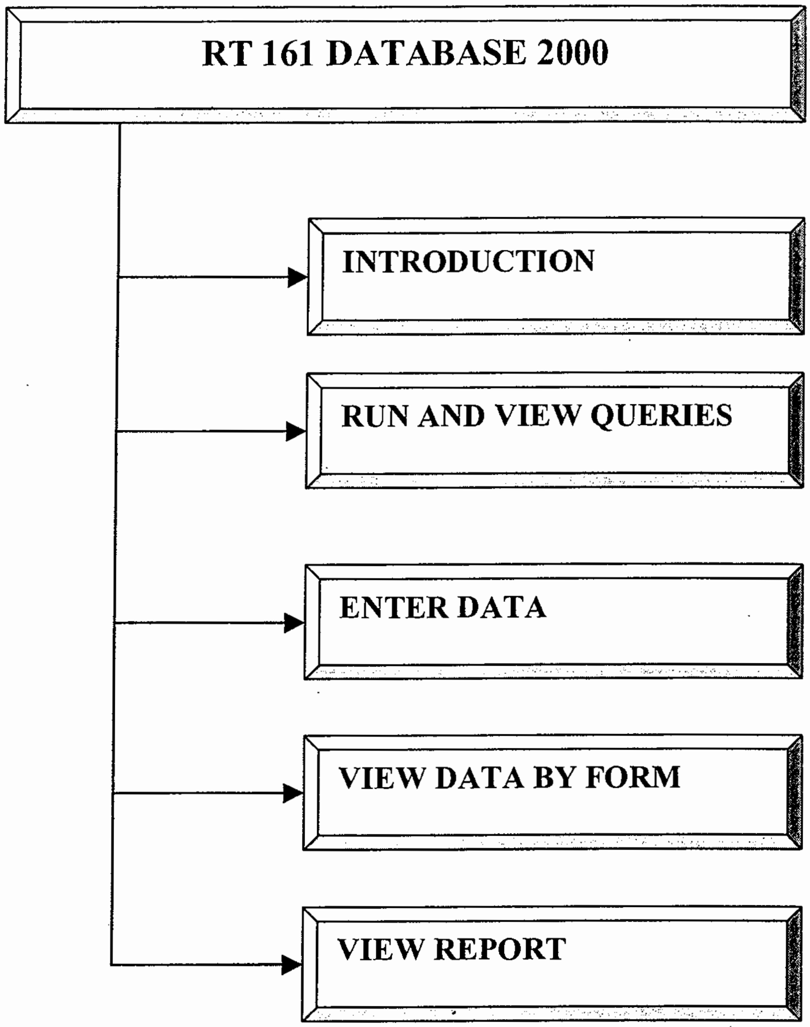

Figure 3. Structure of RT161 (Small Project Execution) Database

Figure 3 shows the structure of RT161 (Small Project Execution). The structure is fairly straightforward. The procedure includes the scope and methods to gather, store, manipulate, and retrieve small project execution data and information.

For the database to operate meaningfully, RT161 (Small Project Execution) Database components are divided into 3 top-level divisions and 19 components, as shown in Figure 4. The last database components vary with the purpose of data analysis. All of these components will be discussed in further detail in the next chapter. Four types of data were recorded, as shown in Figure 5. These are numerical, yes/no, multiple choice, and statement.

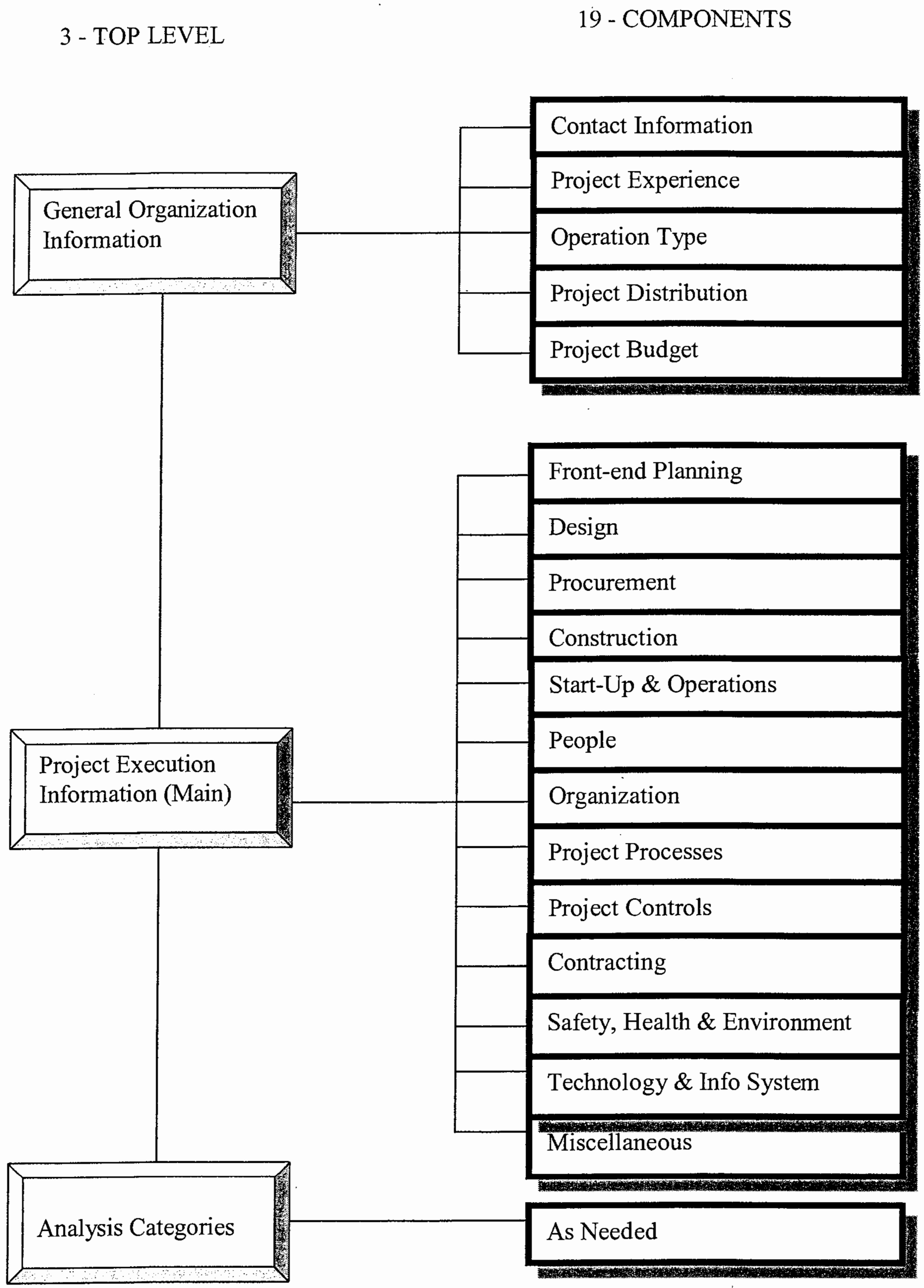

Figure 4. RT 161 Database Components

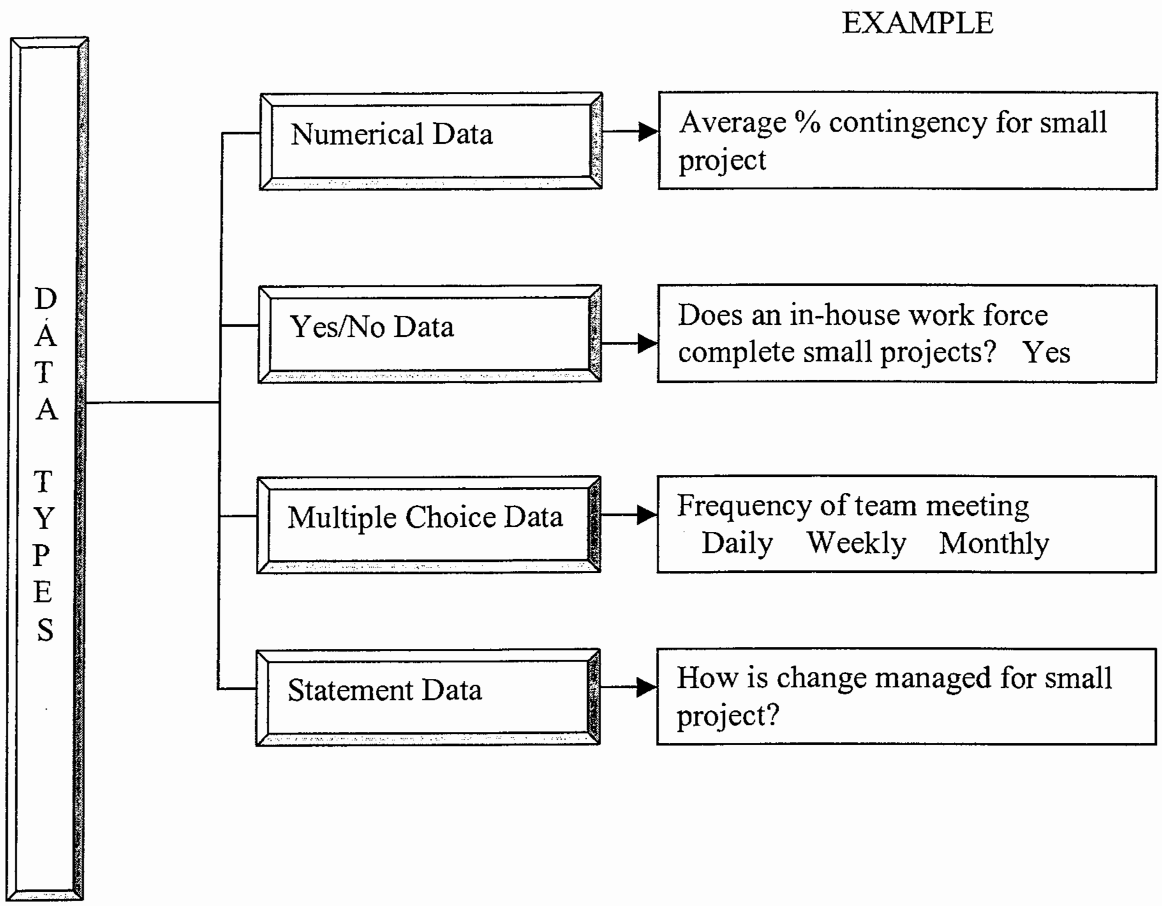

Figure 5. Data Types

CHAPTER 4

INDICATORS OF BUDGET AND SCHEDULE SUCCESS FOR SMALL PROJECTS

A paper to be submitted to Journal of Construction Engineering and Management

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Abstract

Much research has been conducted to establish project success factors/indicators for large project execution and delivery. Little research, however, has focused on success factors for small projects, and most does not examine the differences between success factors of large projects and those of small ones. Some factors for large projects are unnecessary and ineffective for small projects.

This research paper examines and provides small project execution factors that are related to obtaining success. The paper also identifies the indicators that are important, necessary, and sufficient for achieving small project success by providing literature reviews and evaluating data from a survey of 36 organizations. Through classification research analysis, 14 indicators of small project success were determined. These are: (1) Construction Representative in Design Phase, (2) Bidding Process for Equipment Supply, (3) Documentation with Equipment, (4) Site Visit, (5) Maintenance Work for Small Projects, (6) Team Building, (7) Cross Training, (8) Permanent Work Force for Small Projects, (9) Mix Staffing, (10) Standard Process for Small Projects, (11) Contract Type Selection, (12) Site Safety Plan and Supervision, (13) Pre-hire Testing, and (14) Automated Project Control.

Key Words: Small Projects, Success Indicators, Success Factors, Execution, Classification, Construction.

INTRODUCTION

Much research has been conducted to establish project success factors/indicators, and many companies currently use project manuals that define time-tested procedures for large project execution and delivery. Large projects generally have the advantage of well-defined processes and procedure manuals so that those success factors are excellent indicators of a successful large project; however, small project execution often results in less than optimal project cost, quality, and schedules when using standard project delivery systems. Some large project delivery processes are not easily scaled down for small projects and may fail to deliver the projects in an effective manner. In short, some factors for large project success are unnecessary and ineffective for small projects.

Making the project successful is the major goal for each member of the project team no matter how large or how small the project; however, many factors, such as resource availability and cost, cash flow, weather conditions, and uncertain surroundings, as well as project management and organization, make it challenging. Despite the high uncertainty and complex nature of the project, many researchers still have been attracted to investigating project success factors.

These researchers established a set of success factors/indicators for projects or project management; however, few of them have focused on success factors for small projects. That is, most of their work does not examine differences between success factors of large projects and those of small ones. Do the project success factors apply to both large and small projects? Do the project success factors from large projects apply to small ones without modification? Can any dramatic distinctions between large and small projects be expected?

Do these factors have the same effectiveness if they are applicable to both large and small projects?

This study will try to answer those questions by identifying the differences between success indicators of small projects and those of large ones. The purpose of this research is to provide a reasonable approach to examining small project success by identifying project execution input that leads to successful projects and then developing models to predict the success of a small project based on this input. Small projects in this study are defined as capital projects (note that maintenance projects are excluded in the definition of small capital projects) with Total Installed Cost (TIC) between $100,000 and $2,000,000. Project success in this study is defined as the projects that are no more than 5% over budget and no more than 7 days behind schedule.

This paper presents a classification method that helps to predict the probability of success for small projects and is applied during earlier phases based on certain input related to project front-end planning, design, procurement, construction, project controls, project team, project organization, safety, and technology.

RESEARCH PURPOSE AND OBJECTIVES

The purpose of this project was to research and document the best success factors associated with the small project execution process in order to make it successful in the areas of scheduling and budget. Included in this was the examination of technology applications to the small project environment. The researchers used the data, which was collected from small project execution practices, to develop a statistical analysis over many locations to correlate the best success factors to results.

The study is going to develop a guideline to help small projects and small project managers efficiently allocate their limited resources in such a way as to maximize the likelihood of achieving small project success while not using the complicated procedures that were designated for large projects. Previous research deals with project success as simply being identified for large or general projects but not specifically for small ones. The study identifies key indicators necessary for achieving small project success. The results derived can help project managers to efficiently execute their small projects by providing them with a probability of success based on certain key indicators as input to their projects.

The analysis primarily focuses on those actions and input that can help achieve small project success in project budget and project scheduling. It does not consider the success of other project objectives, such as quality, safety, clients' satisfaction, and market entry, although these are important. Measuring those factors needs more complete and complicated analysis and may be considered in future research.

Results from this research can help small project managers in owner, contractor, and designer organizations effectively and efficiently direct limited project resources and expenditures for each of the phases--Front-end Planning, Design, Procurement, Construction, Start-up and Operation, Project Processes and Controls, Organization, Contracting, Technology and Information Systems, People, and Safety, Health and Environment--in such a way as to meet prescribed budget and schedule goals.

METHODOLOGY

The hypothesis of this research is that there is an opportunity to improve the overall competitiveness of small project construction execution by researching and documenting successful small project execution processes related to project cost and schedule. The research methodology involves examining and deciding which small project execution factors are related to obtaining success, collecting data and evaluating the data on these factors, and identifying the indicators that are important, necessary, and sufficient for achieving small project success. There are three distinct phases to this research: literature research and factor examination, data collection and evaluation, and indicators identification. Each of those phases is briefly described below.

In the first phase, literature search and factors examination, previous work on both large and small projects was researched and reviewed at the detailed examination level. By doing this, industry experience and efforts were captured to help identify the factors for attaining both large and small project success. In this phase, a list of potential factors was summarized.

Based on the results of the first phase and availability of data from the Construction Industry Institute (CII) research Access Database, the second phase concentrated on data collection and evaluation; the characteristics of data gathered and basic statistical results were classified. This phase also investigated the important success factors for small construction, comparing them to those for general projects or large projects by the classification research method.

The final indicators of small project success, which are project independent, easy to input, necessary, and sufficient, are identified and then may serve as the base of developing a reasonable predictive model. The summary, recommendations, conclusions, and limitations of those indicators are made in the third phase.

LITERATURE SEARCH

Previous works on both large and small projects were reviewed at a detailed examination level. The literature review reveals how much has been accomplished in the area of measuring or indicating the success of a construction project. Since it is generally accepted that budget, schedule, and quality are the major concerns for a construction project, the literature review was particularly effective in identifying the success measures and critical factors and indicating the major concerns for both large and small projects. The measures and indicators or the factors of project success have a general accepted meaning although they sometimes depend on who is making the evaluation, which phase of the project is being evaluated, and what baseline values are being used to make the assessment. The purpose of the detailed review is to avoid duplication of effort and identify gaps in practices already identified for small projects.

Many researchers have been attracted to the investigation of project success factors or indicators, as is evidenced by the many articles on the topic. Murphy, Baker, and Fisher (1974) identify several determinants of project success. Morris (1986) conducted a comprehensive examination of all factors that had a potentially significant impact on the likely success or failure of major projects and suggested several "external" factors that need managing, as well as many "internal" ones, if the project is to be successful. Jolivet and Batignolles (1986) identified a list of 17 factors often found in successful construction projects that are not found in unsuccessful projects. Ashley, Lurie, and Jaselskis (1987) also conducted a pilot study that established the determinants of construction project success. Jaselskis (1988) established a set of predictive factors for achieving project success by developing a predictive discrete choice model. Pinto and Slevin (1992) determined critical success factors that are felt to be predictive of successful project management. Sanvido et al. (1992) established the four most critical success factors derived from the Integrated Building Process Model. Chua, Kog, and Loh (2000) distinguished between the critical success factors for different project objectives of budget, schedule, and quality using the analytic hierarchy process and established 10 critical factors for each of those objectives. Cheng, Li, and Love (2000) established a partnering framework to identify the critical success factors that can improve the productivity and performance of construction projects.

The important factors, investigated and established by those researchers, that influence the success of the project (not categorized by large or small projects) are summarized in Table 1. The top eight factors are Budget, Schedule, Technical performance, Client satisfaction, Effective communication, Teambuilding, Long-term commitment, and Adequate resources.

A review of the literature yielded few construction-related articles focusing solely on success factors for small project success; most did not differentiate between success factors of large projects and those of small ones. Only a few researchers discussed specific factors in their papers.

Might and Fischer (1985) concluded from their research that if project size is a factor affecting the utility of various project management systems, then by categorizing the projects into high- and low-cost groups and by assuring as much differentiation as possible, the smallest and the largest dollar value projects could be directly compared. The researchers classified the projects costing $2,000,000 or less as small projects. Regressions, which contained dependent variables, the six criteria of success, independent variables, project management control techniques, and levels of statistical significance associated with the regression coefficients, are presented. Might and Fischer concluded that the analysis did not yield the dramatic distinctions between large and small projects that many observers believe exist but did suggest: (1) that there might be, in fact, some differences between large and small projects with control systems, apparently having considerably more influence (both positive and negative) on project success in large projects than is the case with smaller projects and (2) that the use of technical monitoring as a project management control system stands out from the rest in the uniformly strongly negative association between its use and project success. Besides listing success criteria, Might and Fischer concluded that only large projects can afford such tight technical control.

Conley and Gregory (1999) developed a concept for partnering in small construction projects and stated that the reduction in schedule growth and claims cost along with the increase in value engineering savings supports the use of partnering concepts in projects of all sizes. In addition, since small construction projects do not always have sufficient funding to enable them to organize a formal partnering effort with paid facilitators an informal partnering option is suggested. The use of informal partnering on small construction projects would be more appropriate for projects that have a duration of at least 6 months and for which schedule growth is a major concern for the owner.

Dunston and Reed (2000) developed and implemented the Effectiveness of the Small Projects Team Initiative (SPTI) and stated that, by doing it, (1) design cost is lower, (2) schedule growth is less, and (3) change order cost is lower.

From these findings it is obvious that there is much need for investigating the success factors for small projects.

DATA COLLECTION

Data collection was a two-stage process. First, telephone contacts and surveys focusing on small project execution problems, issues, technology applications, and solutions were issued to cooperating company project managers. They were requested to complete the surveys and provide appropriate supporting documentation. Confidentiality of proprietary information was strictly controlled. Contributors to the survey process will also be requested as a follow-up resource contact for the project team. A fairly even balance among owner, design professional, and contractor responses was maintained. In addition to project execution processes, key criteria for successful projects was also being collected. The second phase--site visits--was needed to successfully conduct the research. Due to the proprietary nature of some project products, project applications or demonstration of technology applications may have been conducted at locations other than the principal project site. Vendor and related site visits may have been coordinated with a planned research team meeting.

Purpose of the Survey

The survey used in the research was designed to collect information about small project execution processes. Specifically, those points at which small project processes differ from large project processes were of interest. The desire was to identify "best practices" or at least those that are successful in any one company's process. The purpose of using part of the survey for this research was to request the information and practice of small projects related to cost and schedule from the owner, the constructor, and the engineer. Analysis of this information and data will result in reasonable comparisons of key success indicators for both large and small projects.

Survey Structure

The survey consists of three parts: (1) Contact Data, which collects general information from participants such as organization name, the company's primary function, years of experience, total capital budget, and the portion of that made up by small projects, (2) Project Distribution, which shows the number of small new-work projects and small retrofit projects, the numbers of large new-work projects and large retrofit projects, and the trend of the number of small projects, and (3) the Project Execution Questionnaire. The questionnaire is separated by each major execution phase, which is Front-end Planning, Design, Procurement, Construction, Start-up and Operations, Project Processes and Controls, Organization, Contracting, Technology and Information System, People, Safety, Health, and Environment, and Miscellaneous. Each of these sets of questions has four types of questions: yes/no, statement, multiple choice, and numerical.

The questionnaire in the survey is classified by phases so that the data of different factors can be collected for each phase of project execution. The data was collected from the project manager or company manager who performed the execution stages of the project. The questionnaires are non-leading and are structured so that the interviewee could answer with the maximum possible degree of freedom and objectivity. The detailed description of each question in the questionnaire is based on the literature search and is intended to aid in refining the replies and comparing the information obtained from different interviewees.

Interviewee Selection

To analyze the data meaningfully, the interviewer carefully selected those organizations that are doing small project execution nationwide and randomly interviewed 34 organizations. A fairly even balance was maintained between owner/designers and contractors and those organizations covering various primary industries. By doing this, the information and data would become reasonable samples of the whole population industry and allow the authors to do statistical analysis and make inferences from those data.

DATA ANALYSIS AND FACTOR IDENTIFICATION

Overall, 36 surveys make up the project database. An on-site or telephone interview was also conducted for most of these surveys. This paper will examine the survey data related to the factors shown in Table 2, which were divided into 12 phases of small project execution. These factors are: (1) Front-end Planning phase: Detailed Planning efforts, Logistics challenges, Risk management, Contingency, and Specialized Projects checklist, (2) Design phase: Construction representative and Frequency of scheduled project team meetings, (3) Procurement phase: Procurement Performer, Bidding Process for Equipment Supply, Documentation with Equipment, and Site Visits, (4) Construction phase: On-site Owner's Representative, Change Management, Productivity Measuring, and Frequency of Project Meeting, (5) Start-up and Operation Phase: Master plan, (6) People: Staffing Decision, Ratio of Supervision Work Hours to Labor Hours, Team Building, and Cross Training, (7) Organization phase: Separate Organizational Structure, Permanent Core Management Group, Permanent Work Force, and Mix Staffing, (8) Project process: Standard processes, (9) Project control: Change Control, Project Initial Time, Budget Under-/Overrun, and Schedule Ahead/Behind, (10) Contracting phase: Contract Type and Contract Alliance, (11) Safety: Safety Requirement, Site Safety/Emergency Plan, Site Safety Supervisor, Safety Incentive Plan, Toolbox Meeting and Pre-hire testing, and (12) Technology: Automated project control.

Project Data Characteristics

Specific characteristics related to the survey data are described below. General characteristics pertaining to the respondents and organization operating types are discussed along with both general and small project experience and total annual budget. Project distribution characteristics demonstrated the ratio of large projects to small projects and the ratio of new work to retrofit.

General characteristics of the survey data are summarized in Table 3. The database includes a total of 36 organizations, with about 30 percent owners, about 20 percent construction or design-build companies, and about 40 percent engineer/architecture firms. This balance is enough to show the data that is effective for the owner, constructor, and designer. Among those organizations, the average experience in small project construction was 14 years, with an average of 20 years of experience in general projects. The respondents in the survey are in a variety of positions. About one-third of respondents are project managers, one-third are engineering or construction managers, about 14 percent are project engineers, and 6 percent are administrators. Among those respondents, about 17 percent are team leaders or company presidents.

The average Annual Total Capital Budget of all respondents is $240.5 million, ranging from $6 million to $1.2 billion, which represents the budget for the company (32%), division (24%), and plant (36%). Among them, the average Annual Small Project Capital Budget is $39.13 million, ranging from $5 million to $120 million, which represents the budget for the company (27%), division (27%), and plant (38%). About 16 percent of the Annual Total Budget is Small Project Capital Budget.

Characteristics of distribution for the projects in the database are summarized in Table 4. Among those projects completed that year, about half are classified as New Work, and half are classified as Retrofit (Revamp). For those New Work projects, about four-fifths of the projects are small projects, and about one-fifth are large projects. For those Retrofit projects, about 90 percent of the projects are small projects, and about 10 percent are large projects. Among those projects active at any one time, about one-third of the projects are classified as New Work, and two-thirds of the projects are classified as Retrofit (Revamp). It is interesting to note, however, that for those New Work and Retrofit (Revamp) projects, small projects constitute about the same percentage as above.

The trends of percentages of small projects in these organizations are summarized in Table 5. This is the statistical result of the responses to the question, "Do your current projections suggest that small projects as a percent of total projects will increase, decrease, or remain about the same as the data reported for the upcoming year?" Among 36 respondents, 22 percent thought that small projects as a percentage of total projects for the upcoming year would increase, while 36 percent thought it would remain at the same level. Only 14 percent of the respondents thought that the percentage would decrease. It clearly shows the importance and benefits to the construction industry of identifying the best practice of small project execution.

Classification Analysis

Overall, 36 surveys make up the project database, and an on-site or telephone interview was also conducted for most of these surveys. A summary of the survey response shows that not all of the respondents completed every section of the survey. Actually, in the data collection phase, not all surveys were returned; however, the data in the database is still felt by researchers to be representative of small projects. In order to uncover the indicators (factors) of success or patterns of success in the data presented, a certain analysis method called classification was adopted to compare those data among categories. In any investigation based on observational data, the factors under study are classification factors, which pertain to the characteristic of the units under study and are not under the control of the investigator. We classify objects or events for two main reasons: (1) to reduce a large number of individuals to a smaller number of groups in order to facilitate description and illustration and (2) to define extraordinary cases about which general statements can be made. The important steps in classification research are construction of single or multiple categories and assigning observations to those categories in multidimensional situations. By doing it this way, one can expect to identify differences among those categories. Detailed analysis of our data using the classification method will be presented next.

The categories of organization types have already been defined in the survey as Owner, Engineer, and Contractor. In addition, before categories could be defined, the organizations focusing on large projects had to be segregated from those that focus on small ones. Two criteria were used to classify the data in the database. First, if an organization reported its total capital budget equal to or under $20,000,000, then it would be classified as focusing on small projects; otherwise, it would be classified as focusing on large projects.

Second, if an organization had a ratio of Small Project Capital Budget to Annual Total Capital Budget, equal to or above 20%, it would be classified as focusing on small projects as well. By the criteria above, 10 organizations were classified as focusing on small projects, and 23 organizations were classified as focusing on large projects. The three remaining organizations in the database could not be classified as any category due to incomplete responses.

The classification categories defined for this paper were Budget Performance, Schedule Performance, Successful Budget and Schedule Performance, and Non-successful Budget and Schedule Performance.

Budget Performance Comparison

Categories were combined based on the response to question 62 in the survey to get the average budget under/overrun data (percent of projects completed in the past 12 months) separately for organizations focusing on large projects and small projects, as shown in Table 6. Although just a few organizations provided all the data needed for a complete comparison, some inferences still can be drawn from these data. First, organizations focusing on small projects have more overall variability in their small project budget performance (49% of projects are between 5% over and 5% under budget) than organizations focusing on large projects (72% of projects are between 5% over and 5% under budget). Second, the owner organizations focusing on small projects have more variability of budget from large projects to small projects (80% - 45% = 35% of projects 5% over and 5% under budget) than engineer organizations (70% - 60% = 10%) or constructor organizations (50% - 38% = 12%). Finally, organizations focusing on small projects have almost the same overall overrun performance on small project budgets (15%) as those focusing on large projects (14%); however, owners focusing on small projects have more overrun performance on small project budgets (24%) than those focusing on large projects (9%), while engineers and contractors focusing on small projects have less overrun performance on small project budgets than those focusing on large projects.

Schedule Performance Comparison

Similarly, categories of formatted question 63 in the survey were combined to get the average schedule ahead/behind data (percent of projects completed in the past 12 months) separately for organizations focusing on large projects and small projects, as shown in Table 7. More organizations provided the data to this question than to the budget question although the number of organizations responding was still low. Some conclusions, however, have still been drawn from these data. First, organizations focusing on small projects have less overall variability in their small project schedule performance (55% of projects are between seven days ahead and seven days behind schedule) than organizations focusing on large projects (31% of projects are between seven days ahead and seven days behind schedule). In other words, organizations focusing on small projects perform significantly better on schedules than organizations focusing on large projects. Second, the owner organizations focusing on small projects have more variability of schedule performance from large projects to small projects (60% - 15% = 45% of projects 7 days ahead of and behind schedule) than constructor organizations (68% - 63% = 5%) or engineer organizations (49% - 35% = 14%). Third, organizations focusing on small projects barely maintain 72% of their projects on or ahead of schedule compared to 54% for organizations focusing on large projects. Finally, owner and contractor organizations focusing on small projects perform almost the same number of their small projects on schedule (60% and 63%). However, engineering organizations focusing on small projects only have a 49% performance.

Indicators of Small Project Success

The way to figure out what factors make small projects successful is to decide which factors relate to successful performance in terms of budget and schedule by comparing Successful Performance and Non-successful Performance organizations. Those related factors would become success indicators when a small project is in the planning.

Indicators of Successful Budget Performance

A Successful Budget Performance organization here was defined as 80% of projects in such an organization completing not more than 5% over budget. In other words, the sum of responses to the last three columns of question 62 is not more than 20%. The rest of the organizations are classified as Non-successful Budget Performance organizations. The database provides information from the 18 of 36 surveys that responded to question 62 (project budget under/overrun on small projects completed in the past 12 months). Fourteen organizations were classified as Successful Budget Performance organizations, and four were Non-successful Budget Performance organizations.

By using the definition above to examine the factors, it is possible to find out what factors are success indicators. Table 8 and Table 9 summarize the analysis results. There are 20 indicators of successful budget performance on small projects. These are: (1) Specialized Project Checklist, (2) Construction Representative in Design Phase, (3) Bidding Process for

Equipment Supply, (4) Documentation with Equipment, (5) Site Visit, (6) On-site Owner's Representative, (7) Team Building, (8) Cross Training, (9) Permanent Core Management Group for Small Projects, (10) Permanent Work Force for Small Projects, (11) Mix Staffing, (12) Standard Process for Small Projects, (13) Contract Type Selection, (14) Contract Alliance, (15) Site Safety/Emergency Plan, (16) Site Safety Supervisor, (17) Safety Toolbox Meeting, (18) Pre-hire Testing, (19) Automated Project Control, and (20) Maintenance Work for Small Projects.

Indicators of Successful Schedule Performance

Similarly, a Successful Schedule Performance organization here was defined as one in which 80% of projects were completed less than seven days past the planned scheduled completion date. In other words, the sum of the responses to the last three columns of question 63 is not more than 20%. The remaining organizations are considered Non-successful Schedule Performance organizations. The database provides information from the nine of 36 surveys that responded to question 63 (project ahead/behind schedule on small projects completed in the past 12 months). Eight organizations were classified as Successful Budget Performance organizations, and one was a Non-successful Budget Performance organization.

By using the definition above to examine the factors, it is possible to find out what factors are success indicators. Tables 10 and 11 summarize the analysis results. There are 19 indicators of successful budget performance on small projects. These are: (1) Construction Representative in Design Phase, (2) Bidding Process for Equipment Supply, (3) Documentation with Equipment, (4) Site Visit, (5) Maintenance Work for Small Projects, (6) Team Building, (7) Cross Training, (8) Separate Organization Structure for Small Projects, (9) Permanent Work Force for Small Projects, (10) Mix Staffing, (11) Standard Process for Small Projects, (12) Process Training, (13) Contract Type Selection, (14) Contract Alliance, (15) Site Safety/Emergency Plan, (16) Site Safety Supervisor, (17) Safety Toolbox Meeting, (18) Pre-hire Testing, and (19) Automated Project Control.

Indicators of Small Project Success in Terms of Budget and Schedule

From the analysis above, most of the indicators for Successful Budget Performance can be applied to indicate Successful Schedule Performance on small projects. Those indicators are: (1) Construction Representative in Design Phase, (2) Bidding Process for Equipment Supply, (3) Documentation with Equipment, (4) Site Visit, (5) Maintenance Work for Small Projects, (6) Team Building, (7) Cross Training, (8) Permanent Work Force for Small Projects, (9) Mix Staffing, (10) Standard Process for Small Projects, (11) Contract Type Selection, (12) Site Safety Plan and Supervision, (13) Pre-hire Testing, and (14) Automated Project Control. We will examine some of these indicators in detail.

Instead of just examining the indicators above, the organizations that demonstrate the indicator in both cases must be identified. Table 12 shows the analysis of various combinations of Successful Budget and Schedule Performance Organizations. Eight of 19 organizations were successful in both budget and schedule performance, while one was not successful in either budget or schedule performance.

Specialized Checklists

A specialized project checklist is an indicator of small project budget performance. Nine out of 14 organizations with Successful Budget Performance indicated that checklists were used in Front-end Planning, while four Non-successful Budget Performance organizations did not use specialized checklists; however, it is inconclusive as to whether use of the checklists is an indicator of project schedule performance. The same analysis conducted for schedule performance revealed that only half of the eight organizations with successful schedule performance used checklists. The organization (just one here) with non-successful schedule performance, however, used a detailed checklist. Similarly, for those showing successful performance on both budget and schedule, only half of the eight organizations used checklists.

The literature review does not show that a project checklist is a factor in the success of large projects. The survey also does not include a question requesting the information for large projects; however, most large projects have a well-developed general checklist for the planning phase. The difference between the specified checklist for small projects and general checklist for large projects is that the former is often a condensed version of the information required for formal documents and it functions as a reminder list. While the general checklist for large projects is developed to make sure everything necessary is accomplished in the planning phase, the checklist for small projects is usually specified for engineering cost estimation and project initiation.

Construction Representative During Design

A construction representative involved in constructability review in the design phase contributes to both budget and schedule performance on small projects. Twelve out of 14 organizations with successful budget performance had a construction representative involved during the design phase, and two out of four of the non-successful budget performance organizations did not have a construction representative involved. Six out of eight organizations with successful schedule performance had a construction representative involved during the design phase. For those showing successful performance on budget and schedule, seven of eight organizations had a construction representative involved. None of those organizations with non-successful performance on either budget or schedule utilized a construction representative during design.

Large projects also use a construction representative in the design phase; however, the representative's tasks or responsibilities for small projects are different than those for large projects. On large projects, a very formal constructability process is put into place, and a specific person is put in charge of implementation. It is conducted on a more formal, sign-off manner. The representative usually conducts a series of formal meetings concerning the specifications, job packages, and contracts. On small projects, the representative is either a single constructability coordinator for multiple projects or it's just the project engineer's part-time job. The process is conducted on a more informal basis, and less interaction is needed. There are fewer meetings and the meetings are less formal. The representative usually just calls the designer and asks questions. The representative role is often to provide the coordination for the construction manager. Clearly, this particular indicator for small project success is different than it is for large projects.

Maintenance Work

A surprising result is that maintenance work on small projects is an indicator of project performance, and this is probably because it contributes to the purpose of maintaining a consistent work force for small projects. Eleven out of 14 organizations with successful budget performance were involved in maintenance work, while six out of eight organizations with successful schedule performance were doing maintenance work. Five of eight organizations with successful performance in both budget and schedule were doing maintenance work.

This indicator is unique on small projects. Large projects never use maintenance work to contribute to its success.

Project Team Building

From the literature reviews, project team building is a very important factor in project success. Questions 34 and 47 in the survey requested the information related to team building and core management group building. Survey question 61 requested information about the average time from initial project idea until funding approval and mechanical completion. Obviously, the data shows that small projects require less time for both funding approval and mechanical completion than larger projects.

Additionally, after detailed examination of budget and schedule performance considering the core small project management group, it was found that many more projects among that group are on schedule and within the budget, which indicates that the improvement has also been applied to the budget and schedule performance. Regular team building, however, only improved schedule performance instead of improving both schedule and budget.

Through the literature review and data analysis, team building was found to be a success factor for both large and small projects, but there is a difference between small and large project teams. Large project teams are organized by team building activities and disband once the project is completed, whereas small project teams usually stay together and work toward building long-term relationships due to the nature of continuous streams of small projects.

Standard Written Processes

By classification analysis, it can be seen that standard written processes have a positive impact on project budget performance. Eleven of 14 successful budget performance organizations and five of six successful schedule performance organizations had standard written processes. This would suggest that standard processes benefit project performance.

Although the literature review did not confirm that a standard process is a success factor for large projects, standard processes were always adopted for large projects, although they are different than those for small projects. Any procedures from large projects should be tailored for small project requirements before they are used for small projects.

Alliances

The contract type can partially impact project performance. Nine of 14 organizations with successful budget performance responded that they used owner-engineering alliances for small capital projects, and 11 of those 14 organizations reported using owner-constructor alliances contracts. At same time, six of eight organizations with successful schedule performance used contract alliances between the owner and constructor; however, only half of these organizations were using owner-engineering alliance contracts, which did not reveal any preference for owner-engineering alliances for those organizations with successful schedule performances.

The survey data also shows that the alliance contract is a factor contributing to the large project success. However, because procurement of engineering and construction expertise is the key for an owner to effectively organize the small projects, and the owner can downsize the engineering functions with a continuing alliance contract, alliance contracts for small projects will help maintain a long-term relationship and trust between the parties that will lead to future small project success.

Safety

Safety is also an important issue for small projects. Twelve of 14 successful budget performance organizations showed that site safety plans, site safety supervising, and pre-hire testing were involved in small projects. All of the eight successful schedule performance organizations also applied the site safety plan and the safety supervising for small projects. Two of the eight organizations applied the pre-hire testing as well. The results clearly show the positive relationship between these safety efforts and successful project performance.

The survey in this study did not collect a great deal of information about safety performance on large project success; however, the literature review shows that only one paper thought safety performance is a success factor for large projects even though it is usually assumed that safety is an important factor. Additionally, the data shows that the lost time accident rate (number of accidents causing a lost work day per 200,000 hours) and the OSHA recorded rate for small projects are both greater than those for large projects. It clearly proves that safety is a more important factor for small projects than for large projects.

Automation

Automated project controls for both scheduling and budget were used by almost all organizations involved in the research. Although this would indicate no difference between organizations with successful performance and those without successful performance, the results still reveal that the use of automated project control will benefit the small project. In detail, twelve of 14 successful budget performance organizations used automated scheduling and budget control for small projects. Six of eight and seven of eight successful schedule performance organizations used automated scheduling control and budget control, respectively, for small projects.

The data also shows that almost all of the organizations involved in the study used automated project controls for large project scheduling and budget control. The reason the researchers still treat automated project controls as an important factor for small project success is that people usually think small projects do not need to adopt much high technology. The analysis clearly shows that new technology benefits small projects while communications capabilities are improved.

CONCLUSIONS AND LIMITATIONS

Conclusion

From the literature review and classification analysis of gathered data, the indicators of small project success can be identified. These factors should be utilized during the planning phase for small projects, with a successful implementation of these factors indicating a successful small project.

A well-developed specialized project checklist is an important indicator of small project success, especially in terms of project budget, because it can make the initial planning process more effective and provide the basis for other phases of project management.

An active and responsible construction representative in the project design phase used for constructability review and modification purposes is the key to keeping the design constructible and is very important for the successful delivery of the small project. A well-defined bidding process, full documentation with equipment, and sufficient site visits in the procurement phase are all indicators of small project success because they simplify the procurement process for small projects by providing consistency of parts, equipment, materials, and training.

Excellent performance of maintenance work in the construction phase would indicate a small project has an opportunity to be successful. This is because a contractor performing maintenance work could keep a consistent work force, be familiar with the operation, maintain a steady workload, and reduce staff training costs with time.

Effective and efficient team-building and cross-training in the staffing process are key factors to small project management and important indicators of small project success because all other factors depend upon people, especially for small projects, due to fewer team members and short project duration.

Maintaining a core management group (work force) and good staff mixing in the project organization is a key element in managing the project successfully. In addition, standard written procedures for a small project would avoid any misunderstanding among participants and standardize the processes by providing guidelines. This, too, is an important indicator of small project success.

Correct contract type selection in the contracting phase is a dominant factor in making a small project successful. The application of owner-engineer and owner-contractor alliances contract establishes a long-term relationship between the parties, which, in turn, fosters trust. This is an indication of small project success.

A site safety plan, safety supervision, and a pre-hiring test in Safety, Health, and Environment would require people to keep the work environment safe and healthy. Performing these functions would contribute to small project success.

Automated project control is a key in applying Technology and Information Systems in the construction industry. The adoption of an automated project schedule and budget control would improve the speed of tracking and controlling the project.

Limitations

The initial database was scheduled with 59 surveys; however, only 36 responses (34 responses with an interview) are in the final database. Twenty-three surveys were not returned, and subsequent contacts did not result in the return of the requested data. In the database, the response rate falls to as low as 12 responses for some questions. The most likely reason was the difficulty of the respondents in obtaining the requested information. A few of them lacked the desire to disclose their business data. Another limitation of the data in the database is that some unusual values or responses exist, which became outliers and influenced the analysis results.

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Table 1. Summary of Success Factors

AUTHORS / FACTORS	Ashely, Lurie, & Jaselskis	Carroll	Cheng, Li, and Love	Chua, Kog, & Loh	Cleland	Conley	DeWit	Jolivet and Batignolles	McCoy	Murphy, Baker, and Fisher	Might and Fischer	Morris	Naoum	Pinto and Slevin	Sanvido, etc.	Number Of Articles
Cost or Budget	X		X		X	X		X	X		X		X		X	9
Schedule/Planning	X		X		X	X			X		X	X	X	X		9
Technical Performance	X					X			X	X	X	X		X	X	8
Plan and Specs				X											X	2
Project Objective				X				X						X		3
Constructability				X												1
Client Satisfaction	X					X		X		X			X	X		6
Incentive				X												1
Site Inspection				X												1
Effective Communication			X	X				X					X	X		5
Adequate Resources			X					X					X	X		4
Personnel Management	X							X						X		3
Overall satisfaction										X	X					2
Project Team							X	X		X				X	X	5
Conflict resolution			X											X		2
Long Term Commitment			X	X	X								X	X		5
Partnering						X										1
Mutual trust			X													1
Safety Performance	X															1
No Disturbance to Primary Workflow							X	X								2

Table 1. (continued)

AUTHORS / **FACTORS**	Ashely, Lurie, & Jaselskis	Carroll	Cheng, Li, and Love	Chua, Kog, & Loh	Cleland	Conley	DeWit	Jolivet and Batignolles	McCoy	Murphy, Baker, and Fisher	Might and Fischer	Morris	Naoum	Pinto and Slevin	Sanvido, etc.	Number Of Articles
Educational or Social															X	1
Contribution to Mission of the Enterprise								X								1
Contract Management and Documentation								X								1
Leadership												X				1
Regulation / Environmental												X				1

Table 2. Factors and Related Survey Questions

Execution Phase	Factors	Question #	# of Responses
Front End Planning	Detailed Planning Efforts	1	
	Logistics Challenges	2	
	Risk Management	3	
	Contingency	4	14 of 31
	Specialized Project Checklist	5	20 of 34
Design	Construction Representative	6	24 of 32
	Frequency of Scheduled Project Team Meeting	8	
Procurement	Procurement Performer	10	
	Bidding Process for Equipment Supply	14	
	Documentation with Equipment	15	23 of 31
	Site Visits	17	1 of 31
Construction	On Site Owner's Representative	19	
	Change Management	21	
	Productivity Measuring	22	
	Frequency of Project Meeting	23	
Start-up & Operations	Master Plan	26	
People	Staffing Decision	30	
	Ratio of Supervision Work Hours to Labor Hours	32	
	Team Building	34	17 of 22
	Cross Training	40	20 of 27
Organization	Separate Organizational Structure	44	16 Of 29
	Permanent Core Management Group	47	17 of 29
	Permanent Workforce	49	21 of 36
	Mix Staffing	50	20 of 36
Project Process	Standard process	54	20 of 30
Project Controls	Change Control	59	
	Project Initial Time	61	
	Budget Under/Over Run	62	
	Schedule Ahead/Behind	63	
Contracting	Contract Type	65 & 66	
	Contract Alliance	69 & 70	
Safety Health & Environment	Safety Requirement	74	27 of 30
	Site Safety/Emergency Plan	75 & 76	27 Of 32
	Site Safety Supervisor	77	28 of 32
	Safety Incentive Plan	78	11 of 31
	Toolbox Meeting	79	28 of 31
	Pre-hire testing	80	29 of 32
Technology & Information Systems	Automated Project Control	83	

Table 3. Organization General Characteristics

DESCRIPTION	ORGANIZATION CHARACTERISTICS	
	NUMBER	PERCENTAGE
Respondent's Title	36	
Project Manager	13	35%
Engineering Manager/Supervisor	9	25%
Construction Manager	3	8%
Project Engineer	5	14%
Small Project Leader	1	3%
Administrator	2	6%
President	1	3%
Other	2	6%
Of those respondent, Team Leaders	6	17%
Organization Operating	36	
Owner Company	12	33%
Contractor Company	5	14%
Engineer/Designer Firm	14	39%
Design-Build	2	6%
Other	3	8%
Years of Project Experience (years)		
Mean	20	
Range	28	
Years of Small Project Experience (years)		
Mean	14	
Range	32	
Annual Total Capital Budget ($)		
Mean	240,500,000	
Range	6,000,000,000	
Representing the Budget for		
Company	8	32%
Division	6	24%
Plant	9	36%
Other	2	8%
Annual Small Project Capital Budget ($)		
Mean	37,620,000	
Range	120,000,000	
Representing the Budget for		
Company	7	27%
Division	7	27%
Plant	10	38%
Other	2	8%

Table 4. Project Distribution

NO. OF PROJECTS COMPLETED IN YEAR(1)	2370		
	No.	Ratio I [a]	Ratio II [b]
No. of New Work(2)	1150		49%
No. of Small New Project(3) - Total	944	82%	
- Average	73		
No. of Large New Project(4) - Total	206	18%	
- Average	11		
No. of Retrofit (Revamp)(5)	1220		51%
No. of Small Retrofit Project(6) - Total	1071	88%	
- Average	60		
No. of Large Retrofit Project(7) - Total	149	12%	
- Average	9		
NO. OF PROJECTS WORKED AT ANY ONE TIME (8)	1727		
	No.	Ratio I	Ratio II
No. of New Work(9)	547		32%
No. of Small New Project(10) - Total	435	80%	
- Average	31		
No. of Large New Project(11) - Total	112	20%	
- Average	8		
No. of Retrofit (Revamp)(12)	1180		68%
No. of Small Retrofit Project(13) - Total	1081	92%	
- Average	54		
No. of Large Retrofit Project(14) - Total	99	8%	
- Average	6		

[a] This ratio is of (3)/(2), (4)/(2), (6)/(5), and (7)/(5), respectively.
[b] This ratio is of (2)/(1), (5)/(1), (9)/(8), and (12)/(8), respectively.

Table 5. Small Project Percentage Suggestion*

Trends	Number Of Respondents	Percentage
Increase	8	22%
Decrease	5	14%
Remain the same	13	36%
No Response	10	28%

* Current projections suggest that the trend of small projects as a percent of total projects for the upcoming year.

Table 6. Average Budget Under/Over Run (percentage of small project completed in the last 12 months)

Organization Categories (# of respondents)	More than 5% Under Budget	Between 5% over and 5% under budget	More than 5% over budget
Focusing on Large Project (5of 10)	10	72	14
Owner (3)	11	80	9
Engineer (1)	20	70	10
Constructors (1)	15	50	35
Focusing on Small Project (11of 23)	37	49	15
Owner (4)	31	45	24
Engineer (4)	35	60	5
Constructor (3)	47	38	15

Table 7. Average Schedule Under/Over Run (percentage of small project completed in the last 12 months)

Organization Categories (# of respondents)	More than 7 days ahead of schedule	Between 7 days ahead and 7 days behind schedule	More than 7 days behind schedule
Focusing on Large Project (7 of 10)	23	31	46
Owner (3)	40	15	45
Engineer (3)	13	35	52
Constructors (1)	5	68	27
Focusing on Small Project (14 of 23)	17	55	28
Owner (4)	8	60	27
Engineer (7)	20	49	36
Constructor (3)	21	63	16

Table 8. Factors related to Successful Budget Performance (SBP)

FACTORS	**Indicator ?**	SBP ORGANIZATIONS (14)	RESPONSES YES	RESPONSES NO
Specialized Project Checklist	X	Overall (14)	9	5
		Owner (6)	3	3
		Engineer (5)	3	2
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	1
Construction Representative	X	Overall (14)	12	2
		Owner (6)	5	1
		Engineer (5)	4	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Bidding Process for Equipment Supply	X	Overall (13)	9	3
		Owner (6)	4	1
		Engineer (5)	3	2
		Constructor (1)	1	0
		Engineer & Constructor (1)	1	0
Documentation with Equipment	X	Overall (13)	9	4
		Owner (6)	5	1
		Engineer (5)	2	3
		Constructor (1)	1	0
		Engineer & Constructor (1)	1	0
Site Visits	X	Overall (12)	10	1
		Owner (4)	3	1
		Engineer (5)	5	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	0	0
Maintenance Work	X	Overall (14)	11	3
		Owner (6)	3	3
		Engineer (5)	5	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Team Building	X	Overall (13)	9	4
		Owner (6)	4	2
		Engineer (4)	4	0
		Constructor (2)	1	1
		Engineer & Constructor (1)	1	0
Cross Training	X	Overall (13)	10	3
		Owner (5)	3	2
		Engineer (5)	4	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0

Table 8. (continued)

FACTORS	**Indicator ?**	SBP ORGANIZATIONS (14)	RESPONSES	
			YES	NO
Permanent Core Management Group	X	Overall (13)	8	5
		Owner (6)	4	2
		Engineer (4)	2	2
		Constructor (2)	2	0
		Engineer & Constructor (1)	0	1
Permanent Workforce	X	Overall (11)	11	0
		Owner (4)	4	0
		Engineer (4)	4	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Mix Staffing	X	Overall (10)	10	3
		Owner (3)	3	0
		Engineer (4)	4	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Standard Process	X	Overall (14)	11	3
		Owner (6)	5	1
		Engineer (5)	3	2
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Process Training	X	Overall (13)	11	2
		Owner (6)	5	1
		Engineer (4)	3	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Contract Type (Reimbursable, Hard Dollar)	X	Overall (14, 14)	13, 10	1, 4
		Owner (6, 6)	5, 5	1, 1
		Engineer (5, 5)	5, 4	0, 1
		Constructor (2, 2)	2, 1	2, 1
		Engineer & Constructor (1, 1)	1, 0	0, 1
Contract Alliance (Owner-A/E, Owner-Contractor)	X	Overall (13, 14)	9, 11	4, 3
		Owner (6, 6)	4, 5	2, 1
		Engineer (5, 5)	3, 3	2, 2
		Constructor (1, 2)	1, 2	0, 0
		Engineer & Constructor (1, 1)	1, 1	0, 0
Site Safety/Emergency Plan	X	Overall (14)	12	2
		Owner (6)	5	1
		Engineer (5)	4	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0

Table 8. (continued)

FACTORS	Indicator ?	SBP ORGANIZATIONS (14)	RESPONSES YES	NO
Site Safety Supervisor	X	Overall (14)	13	1
		Owner (6)	6	0
		Engineer (5)	4	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Toolbox Meeting	X	Overall (14)	14	0
		Owner (6)	6	0
		Engineer (4)	4	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Pre-hire Testing	X	Overall (14)	12	2
		Owner (6)	4	2
		Engineer (5)	5	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Automated Project Control		Overall (14, 14, 14)	12, 12, 7	2, 2, 7
		Owner (6, 6, 6)	5, 5, 3	1, 1, 3
Project Scheduling	X	Engineer (5)	4, 4, 1	1, 1, 4
Project Budget	X	Constructor (2)	2, 2, 2	0, 0, 0
Project Productivity		Engineer & Constructor (1)	1, 1, 1	0, 0, 0

Table 9. Factors related to Successful Budget Performance (SBP)

FACTORS	Indicator ?	SBP ORGANIZATIONS (14)	RESPONSES		
On Site Owner's Representative	X		Full Time	Part Time	Not
		Overall (14)	10	2	1
		Owner (6)	3	3	1
		Engineer (5)	4	4	1
		Constructor (2)	2	2	0
		Engineer & Constructor (1)	1	1	0
Frequency of Project Meeting	X		Daily	Weekly	Monthly
		Overall (13)	0	9	1
		Owner (6)	0	3	1
		Engineer (4)	0	4	0
		Constructor (2)	0	2	0
		Engineer & Constructor (1)	0	0	0

Table 10. Factors related to Successful Schedule Performance (SSP)

FACTORS	Indicator ?	SBP ORGANIZATIONS (8)	RESPONSES YES	NO
Construction Representative	X	Overall (8)	6	2
		Owner (3)	2	1
		Engineer (2)	2	0
		Constructor (2)	1	1
		Engineer & Constructor (1)	1	0
Bidding Process for Equipment Supply	X	Overall (6)	4	2
		Owner (3)	2	1
		Engineer (2)	1	1
		Constructor (0)	0	0
		Engineer & Constructor (1)	1	0
Documentation with Equipment	X	Overall (7)	6	1
		Owner (3)	3	0
		Engineer (2)	1	1
		Constructor (1)	1	0
		Engineer & Constructor (1)	1	0
Site Visits	X	Overall (7)	4	2
		Owner (2)	1	1
		Engineer (2)	2	0
		Constructor (2)	1	1
		Engineer & Constructor (1)	0	0
Maintenance Work	X	Overall (8)	6	2
		Owner (3)	1	2
		Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Team Building	X	Overall (8)	5	3
		Owner (3)	1	2
		Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	0	1
Cross Training	X	Overall (8)	6	2
		Owner (3)	2	1
		Engineer (2)	1	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Separate Organization Structure	X	Overall (8)	5	3
		Owner (3)	2	1
		Engineer (2)	1	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	0	1

Table 10. (continued.)

FACTORS	Indicator ?	SBP ORGANIZATIONS (14)	RESPONSES	
			YES	NO
Permanent Workforce	X	Overall (7)	7	0
		Owner (4)	4	0
		Engineer (4)	4	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Mix Staffing	X	Overall (6)	6	0
		Owner (1)	1	0
		Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Standard Process	X	Overall (8)	5	3
		Owner (3)	2	1
		Engineer (2)	1	1
		Constructor (2)	1	1
		Engineer & Constructor (1)	1	0
Process Training	X	Overall (7)	6	1
		Owner (3)	2	1
		Engineer (1)	1	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Contract Type (Reimbursable, Hard Dollar)	X	Overall (8)	7	1
		Owner (3)	2	1
		Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Contract Alliance (Owner-Contractor)	X	Overall (8)	6	2
		Owner (3)	2	1
		Engineer (2)	1	1
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Site Safety/Emergency Plan	X	Overall (8)	8	0
		Owner (3)	3	0
		Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0

Table 10. (continued)

FACTORS	**Indicator ?**	SBP ORGANIZATIONS (14)	RESPONSES	
			YES	NO
Site Safety Supervisor		Overall (8)	8	0
		Owner (3)	3	0
	X	Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Toolbox Meeting		Overall (8)	8	0
		Owner (3)	3	0
	X	Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Pre-hire Testing		Overall (8)	6	2
		Owner (3)	1	2
	X	Engineer (2)	2	0
		Constructor (2)	2	0
		Engineer & Constructor (1)	1	0
Automated Project		Overall (8, 8, 8)	6, 7, 3	2, 1, 5
Control		Owner (3)	2, 2, 1	1, 1, 2
Project Scheduling	X	Engineer (2)	2, 2, 0	0, 0, 2
Project Budget	X	Constructor (2)	1, 2, 1	1, 0, 1
Project Productivity		Engineer & Constructor (1)	1, 1, 1	0, 0, 0

Table 11. Factors related to Successful Schedule Performance (SSP)

FACTORS	Indicator ?	SBP ORGANIZATIONS (14)	RESPONSES		
			Full Time	Part Time	Not
On Site Owner's Representative	X	Overall (8)	5	2	1
		Owner (3)	1	1	1
		Engineer (2)	1	1	0
		Constructor (2)	2	0	0
		Engineer & Constructor (1)	1	0	0
			Daily	Weekly	Monthly
Frequency of Project Meeting	X	Overall (8)	1	4	1
		Owner (3)	0	1	1
		Engineer (2)	0	2	0
		Constructor (2)	1	1	0
		Engineer & Constructor (1)	1	0	0

Table 12. Combinations of Budget and Schedule Performance

NUMBER OF ORGANIZATIONS		SCHEDULE PERFORMANCE		
		Successful	Non-Successful	N/A
BUDGET PERFORMANCE	Successful	8	1	6
	Non-Successful	1	0	3
	N/A	0	0	

CHAPTER 5

GENERAL CONCLUSION

Conclusion

By reviewing the literature and doing a classification analysis of the survey data, the results show that there is an opportunity to improve the overall success of the small project by researching and documenting successful factors of small project execution processes related to project cost and schedule. The factors related to small project success should be implemented during the planning phase, with a positive performance of these factors indicating a successful small project. During the analysis phase of this study, developing an effective database is the key to making the useful data available. The main indicators of small project success are as follows.

1. A well-developed and professional specialized project checklist in the front-end planning phase. It can improve and make the front-end planning process more effective and provide the basis for other phases of project management.
2. An active and responsible construction representative in the project design phase. It can make design more constructible and provide great advantages to small projects due to both the construction representative's experience and the short duration of the project.
3. A well-defined bidding process, full documentation with equipment, and sufficient site visits in the procurement phase.

4. Excellent performance of maintenance work in the construction phase. A contractor performing maintenance work could consistent work force, be familiar with the operation, maintain a steady work load, and reduce staff training cost with time.
5. Effective and efficient team building and cross training in the staffing process.
6. Maintaining a core management group (work force) and good staff mixing in the project organization.
7. Standard written procedures in the processes for a small project. It would avoid misunderstanding among participants and standardize the process by providing guidelines.
8. Correct contract type selection in the contracting phase. An alliances contract would establish a long-term relationship among the parties.
9. Site safety plan, safety supervision, and pre-hiring test in Safety, Health, and Environment.
10. Automated project control. The adoption of an automated project schedule and budget control would improve the speed of tracking and controlling the project.

Further Study

Future studies need to focus on establishing a multiple regression model that helps to predict the probability of success for small projects and then applies it during earlier phases based on certain input related to the project front-end planning, design, procurement, construction, project controls, project team, project organization, safety, and technology. For those yes or no responses, categorical statistical analysis needs to be conducted. Model checking and modification also need to be performed from a statistical viewpoint.

APPENDIX A. LIST OF SURVEY TOPICS

Front-end Planning

Detailed planning efforts

Logistics challenges

Deliverables from the planning process

Risk management handling

- Engineering
- Construction
- Procurement
- Performance
- Regulatory requirements
- Health/Safety
- Economic
- Contractual
- Environment
- Political/Public

Contingency

Specialized project checklists/expedited review process

Design

Construction representative

Role of the construction representative

Deliverables from design process

Frequency of scheduled project team meeting

- Daily
- Weekly
- Monthly

Productivity measurement

Procurement

Procurement performer

- Owner
- Engineer
- Constructor

Expediting performer

- Owner
- Engineer
- Constructor

Procurement paper

- Owner
- Engineer
- Constructor

Equipment vendor selection process

Bidding process for equipment supply

Equipment supply specifications
- Functional specifications
- Detailed specifications
- Design/build concepts

Deliverables with equipment
- Spares
- Training
- Documentation

Site visits, factory acceptance tests, or restrictive payment schedules for equipment
Team members for the review of the equipment vendors bids, contracts, or negotiations

Construction
On-site owner's representative
In-house work force
- Union
- Merit
- Non-union

Change management
Productivity measurement
Frequency of scheduled project team meetings
- Daily
- Weekly
- Monthly

Production down time
Maintenance work and work force

Start-Up and Operation
Master plan for commissioning
Commissioning documents
Documents archive
Project closeout procedures

People
Staffing decision/personnel selection
Ratio of staff to TIC
Ratio of supervision work hour to labor hour
Project team integration
Team building process
Special qualification for team leadership
Incentive structure
Career path
Personality profile/standardized testing
Skill database
Cross training/benefit envision
Estimated annual corporate turnover

System of incentives or rewards

Organization
Organizational structure
Organization
    Matrix
    Special project team
Permanent core management
Separate office facilities/staff
Permanent work force/continuity
Mix experience

Project Process
Authorize funding
Deliverables for funding stages
Management review committee for funding
Individual projects/program of work
Written standard process
Training
Modification of procedure
Out-source project management
Activated retired personnel

Project Controls
Change control handle
Special project control
Average time from initial project idea until funding approval
Average time from initial project idea until mechanical completion
Budget over/under
Schedule variance
Average cost of engineering, procurement, management and administrator labor as a percent of TIC
Average cost of construction labor as a percent of TIC
Average cost of equipment and material as a percent of TIC

Contracting
Reimbursable contracts
Hard dollar contracts
Engineering design
    In-house design
    External design
Contract for construction management
Owner-engineering contract alliance
Owner-constructor contract alliance
Alliance partner vs. traditional contracting practices

Vendor alliance
Single prime contractor vs. multiple prime contractors

Safety, Health, and Environment
Safety and health requirements
Written site-specific safety plan
Written site-specific emergency plan
Site safety supervisor
Written safety incentive program for hourly craft workers
Toolbox safety meeting
Pre-hire substance abuse testing
Personal randomly screened for alcohol and drugs
Lost time accident rate
OSHA recordable rate

Technology and Information Systems
Automated controls for scheduling
Automated controls for budget control
Productivity tracking
Most effective new tools or technology
Automation in engineering workflow process
Forms of automation
- Package software (Prolog, Expedition)
- Project web page
- E-mail
- Intra-net established for small projects team

Other internal or customized technology for the planning, design, or management
New technologies benefit

Miscellaneous
Specific measures of success
Metrics to track success
CII best practices recommendations
Lessons learned file
Process gone wrong
Process gone well
Improved practices

APPENDIX B QUESTIONNAIRE OF RT 161 SMALL PROJEECT EXECUTION

INTRODUCTION

This survey is designed to collect information about small project execution processes. Specifically those points where small project processes differ from large project processes are of interest. The desire is to identify 'best practices' or at least those that are successful in any one company's process. The results of the research will be published as a separate source document, but the primary findings will be incorporated into a manual that is a toolkit for small project practices.

SMALL PROJECTS have been defined for this research as capital projects (note that maintenance projects are excluded in the definition of small capital projects) between $100,000 and $2,000,000 Total Installed Cost (TIC). Some questions necessarily cover a time period of your small project operations. Please respond for the current 12 month fiscal period activities.

CONTACT DATA

Respondent's Name:	Title:
Mailing Address:	E-mail:
	Telephone:
	Fax:
Years of Project Experience	Years Small Project Experience

Organization Name: Operating Primarily as: Owner ☐ Engineer ☐ Constructor ☐	Primary Industry
Annual **Total Capital** Budget: $ ____________ representing the budget for the: (Check One) Company ☐ Division ☐ Plant ☐	Annual **Small Project Capital Project** Budget ($)____________ (Check One) Company ☐ Division ☐ Plant ☐

PROJECT DISTRIBUTION

Number of Projects Completed in Year				No. of Projects Worked at any one time			
No. New Work		No. Retrofit (Revamp)		No. New Work		No. Retrofit (Revamp)	
No. Small	No. Large	No. Small	No. Large	No. Small	No. Large	No. Small	No. Large
Do your current projections suggest that small projects as a percent of total projects will increase, decrease, or remain about the same as the data reported for the upcoming year?							

FRONT END PLANNING

1.Due to the short duration of most small projects how would you compare detailed planning efforts with those conducted for large projects? Please describe the decision process or capital projects approval process for small projects, particularly where it is different from large projects approval process. Less☐ Same☐ More☐

2. a. Describe the logistics challenges that are different for small projects vs. large projects planning in your work environment.

b. What are the 'deliverables' from the planning process and how are they different from large projects?

3. How is risk management handled differently for small projects when compared to large projects?

Consider the following risk classifications. Is the risk that each represents the same or different for small capital projects compared to large projects?

Risk Category	**Same**	**Different**	**Briefly describe key factors for the difference.**
Engineering	☐	☐	
Construction	☐	☐	
Procurement	☐	☐	
Performance	☐	☐	
Regulatory Requirements	☐	☐	
Health/Safety	☐	☐	
Economic	☐	☐	
Contractual	☐	☐	
Environment	☐	☐	
Political/public	☐	☐	
Other (describe)	☐	☐	

4. In project planning, a contingency is often included in budget and time estimates. Is there any difference in contingency for small projects? Yes☐ No☐

If yes provide a brief description of the differences you perceive in contingency for small projects.

What is your average % contingency for small projects? ____ % Large Projects? _____ %

	Yes	No
5. a. Are specialized project checklists or expedited review processes used for small projects?	☐	☐
b. Would you be willing to provide a copy of your checklists/processes for our use in this research and subsequent publication?	☐	☐

DESIGN			
6. a. Is a construction representative involved during the design of the project?	Yes ☐	No ☐	
b. If 6a is yes, how is the role of the construction representative different (responsibilities or tasks) from large project constructability efforts.			
7.What are the deliverables for a small project from the design process?			
8. What is the frequency of scheduled project team meetings during the design phase?	Daily ☐	Weekly ☐	Monthly ☐
9. What productivity measurements are tracked for small project design?			

PROCUREMENT			
10. Who performs procurement?	Owner ☐	Engineer ☐	Constructor ☐
11. Who typically performs expediting?	Owner ☐	Engineer ☐	Constructor ☐
12. Whose paper is used for procurement?	Owner ☐	Engineer ☐	Constructor ☐
13. How is the equipment vendor selection process different for small projects compared to large projects?			
14. Do you use a bidding process for equipment supply? If yes. check the most common use of small project equipment supply specification. ☐ functional specifications, ☐ detailed specifications ☐ or design/build concepts			
15. Are small project deliverables such as spares, training, and documentation included/ordered with equipment?	Yes☐	No☐	
Is this different from large project requirements?	Yes☐	No☐	
16. For small projects, what are the key deliverables in equipment contracts to insure functional, timely, and lowest cost equipment?			
17. Do equipment vendors' delivery schedules for small projects require site visits, factory acceptance tests, or restrictive payment schedules? If yes, How is this different from large project requirements?			
18. For small projects, which project team members are included in the review of the equipment vendor bids, contracts, or negotiations? What would change if this were a 'large project'?			

CONSTRUCTION			
19. During execution of the work, is there an owner's representative on-site?	Full time ☐	Part-time ☐	Not on site ☐
20. a. Does an in-house workforce complete small capital projects?	Yes☐		No☐
b. What type of workforce is typical for small projects?	Union ☐	Merit ☐	Nonunion ☐
c. The workforce for large capital projects is typically	Union ☐	Merit ☐	Nonunion ☐
21. How is change managed for small projects?			
22. What productivity measurements do you track for small projects?			
23. What is the frequency of scheduled project team meetings during construction?	Daily ☐	Weekly ☐	Monthly ☐
	☐ Other (Describe)		
24. How is production down-time planned for small projects? How is this different than preparations for large projects?			
25. a. Do the contractors for small capital projects also perform maintenance work at the same location or plant site? b. Do they maintain separate workforces for small capital projects and maintenance work c. Do they track project and maintenance work separately?			

START-UP & OPERATIONS
26. Who prepares the master plan for commissioning small projects? How is this different from large projects?
27. Who prepares and executes small project commissioning documents? How is this different from large projects?
28. Who owns the documents? How is this different from large projects? Where are they archived? How is this different from large projects?
29. Describe how small project closeout procedures are different from large projects.

PEOPLE		
30. Please describe how are staffing decisions made for small projects from design through construction for your organization. (How are personnel selected for working on small projects?)		
31. What is your ratio of project staff to project TIC (# staff personnel / $1,000,000)	small projects	large projects
32. Please provide an estimate of the ratio of supervision work hours to labor hours. (Supervision MH/ Craft MH)	small projects	Large projects
33. What steps are taken to integrate small project teams? What percent of small projects have formal team building planned? %		
34. a. Is the team-building process different for small project teams? Yes ☐ No ☐ b. If yes, please provide some comparisons or differences between large and small project team building. c. In your opinion, is team building as important for small projects as it is for large projects?		
35. Do you have specific qualification criteria for small project team leadership?		
36. Do you maintain a separate incentive structure for personnel on small projects? A copy of the incentive scheme or a description is desired.		
37. Do small project personnel have a career path with opportunities similar to other project managers?		
38. Do you use personality profile or other standardized testing for identifying characteristics needed for small project management? How are these traits different from those used for selecting large project managers?		
39. Do you maintain a 'skills' database for all personnel to make staffing decisions? Is this the same database used for large and small projects? If no, what is different for small projects?		
40. Has cross training been used to cover possible expertise gaps in small projects staffing assignments?		
41.Where would you envision the most benefit would be gained from cross training?		
42. What is your estimated annual corporate turnover rate for small project personnel? % How different is this from your organization's personnel turnover rate?		
43. Is the system of incentives or rewards offered to small project personnel different than those offered to personnel assigned to large projects?		

ORGANIZATION				
44. Do you have a separate organizational structure for small and large projects?			Yes ☐ No ☐	
45. How long have you had the current organizational structure for small projects?	< 1 yr. ☐	1-5 yr. ☐	5-10 yr. ☐	>10 yr. ☐
46. Describe the organization used for small projects (ie: is it matrix, special project teams, etc)				
47. Do you maintain a permanent 'core management group' for small projects? Yes ☐ No ☐ Do they have their own physical location?				
48. Question for Contractors Only Do you maintain separate office facilities for small projects personnel? Is a separate small project staff maintained for these offices?			Yes ☐ No ☐ Yes ☐ No ☐	
49. Do you have a permanent workforce that participates in small projects? Yes ☐ No ☐ How is continuity maintained from project to project?				
50. Do you try to mix experienced personnel with 'youth' on small project teams?			Yes ☐ No ☐	

PROJECT PROCESSES	
51. At which process stages do you authorize funding for small projects? What deliverables are available for each funding stage? At which process stages do you authorize funding for large projects? What deliverables are available for each funding stage?	
52. Is there a management review committee for project funding?	Yes ☐ No ☐
53. Do you manage small projects as individual projects or as a program of work?	
54. Do you have written standard process for small projects?	Yes ☐ No ☐
55. Do you provide training to support the process requirements	Yes ☐ No ☐
56. If you use a single set of procedures for all projects, are they modified for small projects? What are the major modifications that must be accomplished?	Yes ☐ No ☐
57. Do you ever out-source project management of small projects? Under what circumstances?	Yes ☐ No ☐
58. Have you 'activated' retired personnel for managing small projects?	Yes ☐ No ☐

PROJECT CONTROLS	
59. How do you handle small project change control?	
60. Do you use any special project control systems for small projects? Please briefly describe the system.	Yes ☐ No ☐

61. For projects completed in the last twelve months, the average time from initial project idea for the project until:

	Small Projects		Large Projects	
a. Funding Approval	____days	+/- ____days	____days	+/- ____ days
b. Mechanical Completion	____days	+/- ____days	____days	+/- _____days

62. For the small projects completed in the last twelve months, what percent of them were above or below the original funding budget? Do you track the sources of the budget over/under runs when they occur?

More than 25% under budget	15% to 25% under budget	5 to 15% under budget	Between 5% over and 5% under budget	5% to 15% over budget	15% to 25% over budget	More than 25% over budget
_____%	_____%	_____%	_____%	_____%	_____%	_____%

63. For the small project completed in the last twelve months, what percent were mechanically complete ahead or behind the original funding approval schedule? Do you track the sources of the schedule variances when they occur?

More than 90 days ahead of schedule	30 to 90 days ahead of schedule	7 to 30 days ahead of schedule	Between 7 days ahead and 7 days behind schedule	7 to 30 days behind schedule	30 to 90 days behind schedule	More than 90 days behind schedule
_____%	_____%	_____%	_____%	_____%	_____%	_____%

64. For projects completed in the last twelve months, the average cost as a % of TIC. Please provide a brief description or explanation if the large and small project % is widely different.				
	Small Projects		Large Projects	
a. Engineering, procurement, management and administration labor (home office costs)	____%	+/- ____%	____%	+/- ____%
b. Construction labor is:	____%	+/- ____%	____%	+/- ____%
c. Equipment and Material Cost	____%	+/- ____%	____%	+/- ____%

CONTRACTING	
65. When do you use reimbursable contracts for small projects?	
66.When do you use hard dollar contracts for small projects?	
67. For engineering design on small projects do you use: a) in-house ☐ or b) external design ☐? What influences the choice?	
68. Do you contract for construction management services on small projects?	Yes ☐ No ☐
69. Do you have owner-engineering contract Alliances for: a. large capital projects?	Yes ☐ No ☐
b. small capital projects?	Yes ☐ No ☐
70. Do you have owner-constructor contract Alliances for: a. large capital projects?	Yes ☐ No ☐
b. small capital projects?	Yes ☐ No ☐
71. When do you elect to use an Alliance partner vs. traditional contracting practices for small projects?	
72. Do you use vendor alliances for small projects?	Yes ☐ No ☐
73. Do you use a single prime contractor or multiple-prime contractors for small capital projects? Which is the preferred approach and why?	Yes ☐ No ☐

SAFETY, HEALTH & ENVIRONMENT	
74. In your experience, are safety and health requirements relaxed on small projects?	Yes ☐ No ☐
75. Do projects have written site-specific safety plans?	Yes ☐ No ☐
76. Do projects have written site-specific emergency plans?	Yes ☐ No ☐
77. Do small projects use a site safety supervisor?	Yes ☐ No ☐

78.Do you use a written safety incentive program for hourly craft workers on small projects?	Yes ☐ No ☐	
79. Are toolbox safety meetings required on small projects?	Yes ☐ No ☐	
80. Is pre-hire substance abuse testing required?	Yes ☐ No ☐	
81. Are small project personnel randomly screened for alcohol and drugs?	Yes ☐ No ☐	
82. What was the OSHA safety records for projects last year?	Small Projects	Large Projects
a. The lost time accident rate (no. of accidents causing a lost work day per 200,000 hrs)		
b. The OSHA recordable rate (no. recordable accidents per 200,000 hrs)		

TECHNOLOGY & INFORMATION SYSTEMS		
83. In general do you use automated project controls for	Large Projects	Small Projects
a. Project Scheduling	Yes ☐ No ☐	Yes ☐ No ☐
b. Project Budget Control	Yes ☐ No ☐	Yes ☐ No ☐
c. Project Productivity Tracking	Yes ☐ No ☐	Yes ☐ No ☐
84. What new tools or technologies have you found to be ***most effective*** for small projects? Please provide product names where appropriate. Are these the same tools used for large projects?		
85. Do you use automation in engineering work flow processes?	Yes ☐ No ☐	
86. For **communications** on small projects, what forms of automation are used? ☐Package Software (Prolog, Expedition) ☐Project web-page ☐E-mail ☐ Intra-net established for small projects team. Others (please describe)		
87. Is there other internal or customized technology being developed specifically for the planning, design or management of small projects?		
88. What new technologies have benefited small projects the most?		

MISCELLANEOUS	
89. What are specific measures of success for small projects/program? What is your current performance data for these measures?	
90. What metrics are measured and maintained to track small project success?	
91. Do you track CII Best Practices recommendations for project success? Which ones and how do you measure?	Yes ☐ No ☐
92. Do you submit your small project data to the CII benchmarking database?	Yes ☐ No ☐
93. Do you maintain a lessons learned file for small projects?	Yes ☐ No ☐
94. Based on recently completed small projects, what has gone wrong from a project process viewpoint?	
95. Based on recently completed small projects, what has gone well from a project process viewpoint?	
96. If you were to benchmark yourself against a highly successful small project execution organization, who would you choose? Why (what is special or world class about their operations?)	
97. What practices have you improved in the last five (5) years for your small projects processes.	

APPENDIX C. SUMMARY OF SURVEY DATA

Front-end Planning

Detailed planning efforts - The majority of respondents felt that small capital projects have less detailed planning effort than large projects by a 3:1 margin (n=33).

Logistics challenges - The response supported that less detailed planning is conducted for a small project. The key logistics challenges provided for small projects are (1) shortened planning time and reduced planning, (2) information and communication, (3) less formal process, (4) flexible project teams, and (5) resource sharing.

Risk management – There is no real overall difference for small and large projects; however, different responses exist in each of the individual risk classifications in terms of the same or different risk rate for large and small projects, as shown in Table 1. Among those factors, only Health, Safety, and Environment categories were thought nearly to have the same risk rate for large and small projects.

Table 1. Risk Rate Responses (small vs. large projects)

RISK CATEGORY	SAME	DIFFERENT	% OF DIFFERENT
Engineering	9	11	52%
Construction	13	7	35%
Procurement	11	10	48%
Performance	11	8	42%
Regulatory Requirements	16	9	36%
Health/Safety	18	1	5%
Economic	9	12	57%
Contractual	12	6	33%
Environment	17	3	15%
Political/public	9	10	53%

Contingency - Fourteen of 31 respondents answered that there was a difference between the large projects and small projects considering a contingency in budget or time estimate. To reduce planning and engineering time or budget requires higher contingency allocations. Contingency allocations for small projects were generally higher than those for large projects.

Specialized project checklists or expedited review processes – The response that 20 of 34 respondents have or use specialized checklists shows that specialized project checklists or expedited review processes are widely used for small projects. These checklists covered small project definition, initiation, cost estimating, and delivery system.

Design

Construction representative – Twenty-four of 32 respondents said that some forms of constructability review were used by construction representatives during the design of the project. Eight respondents said that a construction representative or his/her input is not involved in the design phase. This result shows that a construction representative is widely used during the small project design process.

Frequency of scheduled project team meetings – The survey results (19 of 30 answered weekly) clearly show that design meetings tend to occur on a weekly basis, with others reporting meetings as needed. Small capital projects often require less or a lower level effort for design.

Procurement

Procurement performer – The survey data indicated that procurement responsibility would depend on project requirements, and the engineers dominate procurement, although owners, engineers, and contractors all have procurement specialists.

Bidding process for equipment supply - More than half of the respondents indicated that procurement practices on small projects were the same or very similar to large project procurement practices. Preferred vendors, supplier alliances, and compatibility with existing systems were indicated as practices somewhat unlike large projects; however, discounts were typically less for small project procurement than for larger projects. For small projects, detailed specification is predominant. Functional specifications were listed with detailed specifications in almost half of the cases. The design-build specification was the least selected type of specification.

Documentation with equipment – Twenty-three of 31 respondents thought that documentation was a key 'deliverable' compared to spares and training.

Site visits, factor acceptance tests, or restrictive payment schedules - Only one respondent suggested that on-site inspections were important to the equipment delivery process; however, most would perform site visits for large projects.

Construction

On-site owner's representative – The survey data clearly show that all small projects employed either a full-time or part-time representative.

Change management – The responses supported that change management is a prevalent element and factor in the fast track environment of small capital projects because effective management techniques are important to budget control. However, no unique or specialized processes were identified, and most respondents indicated that they used the same procedures for all projects.

Productivity measuring – Most of respondents said they have productivity measurements; however, those were very diverse among them. Table 2 shows categories of productivity measurements collected by the survey. It clearly shows that cost and schedule remain the more popular measurement techniques for productivity on projects and were tracked by all organizations.

Frequency of project meetings – Most respondents would like a weekly meeting as the predominant project meeting for small projects because they believe that it is the most

Table 2. Categories of Productivity Measurements

Productivity Measurements	Number of Responses
Milestones achieved (schedule)	5
Cost of quality and re-work costs	4
Work hour expended vs. budgeted	4
Total cost	4
Unit rates (productivity)	3
Unit rates (total cost)	2
Progress payment review process	2
Customer satisfaction	2
% time spent constructing (work sampling)	1
Safety	1
Engineering and home office expense %	1
Installed quantities	1
Earned value	1

effective way to exchange information and to update the project progress. However, some kinds of supplements and emergency meetings were also held as needed due to the short duration of the small projects.

Start-up and Operations

Master plan – The survey data indicated that there is a much less formal master plan for small projects than for large projects, and the informality, in some cases, reduced the level of effective documentation. This is because stand-alone teams are often created to ensure proper commissioning and start-up for large projects while not for small projects except existing commission documents are mainly prepared and owned by the owner's team (Table 3 gave the detailed responses for commission document preparation).

Table 3. Commission Documents Preparing Parties

Parties	Number of responses
Owner	15
Owner's Engineer	4
Designer	4
Contractor	1
Commission Group	1

People

Staffing decisions – Different kinds of respondents returned different responses for this factor. The owner respondents said, if considering replacement of personnel, they would be interested in an engineering alliance or contractor personnel as a potential representative because of the requirement of experience in the same or similar process. Knowledge and availability are also for the designers' staffing decision-making; however, they often rely on a pool of available qualified engineers instead of expertise on-site because of the generally short duration of small projects. The quick-response capability is also required for small projects. According to the responses, a matrix formulation for site design services was fairly common.

Ratio of supervision work hours to labor hours – This factor is a very important indicator of difficulty of management in small projects; however, unfortunately, we received a small number of responses here although the rough idea is clear, which suggests more difficulty exists or more supervision is needed on small projects.

Team building – The responses indicated that most respondents (17 of 22) have team building activities, which is as important for small projects as that for large projects. The data also showed that small project teams tend to stay together due to small projects being nearly a continuous stream. However, few respondents (4 of 19) have specific qualification criteria for small project team leadership.

Cross training – Twenty of 27 responses provided evidence that the cross training has been used in small project staffing. Cross training increased overall ownership, improved communication capability, increased flexibility in staffing, and reduced the number of specialists.

Organization

Separate organizational structure – More than half of the respondents (16 of 29) had a separate organization for small projects. This clearly shows that small projects require special organization, which should be independent from large projects. Matrix organization is the main form for small projects.

Permanent 'core management group' - Seventeen of 29 respondents supported maintaining a core management group for small projects.

Permanent work force – Twenty-one of 36 respondents maintained a permanent work force that participates in small projects by integrating maintenance work as well as larger capital projects, maintaining a steady work load from the owner organization, and employing local people who are more interested in staying at the project site.

Mix staffing – Twenty of 36 respondents mixed or attempted to mix experienced personnel with 'youth' on small projects. This meets the general consensus and is a part of the training program.

Project Processes

Standard process - About two-thirds (20 of 30) of the respondents used standard written work processes and related training requirements for small projects. For those using a single set of procedures for all projects, nearly all of the processes were modified in some form to accommodate small projects. In our survey, 15 of 26 respondents modified processes for their small projects, which include evaluation of project checklists and similar elements.

Project Controls

Change control – The data show that almost the same change control system was used for small projects as for large projects. This is unlike what many had anticipated.

Project initial time – The responses show that the most frequent time for project funding approval is about 90 days, with a general range of 60 to 180 days, while the time to mechanical completion was similar, ranging from 180 to 360 days.

Budget under-/overrun – In the database, 24 organizations responded that they had more than 75% of their small projects completed within a 5% overrun budget, while only 7 respondents reported a cost overrun more than 5% over budget. Among those at or less than 5% overrun organizations, nine owners responded 75%, 5 contractors responded 80%, and 10 engineers responded 88% of their projects completed in this way.

Schedule ahead/behind – In the database, five of eight owners, four of nine engineers, and three of four contractors reported 10% or more of their projects' scheduled completion time were greater than seven days late.

Contracting

Contract type – The survey requested the information on reimbursable vs. hard dollar contracts. The results show that 27 of 29 respondents used a reimbursable contract for small projects because of poor scope definition, while 21 of 27 respondents used a hard dollar contract because of tight budgets.

Contract alliance – The detailed summary of responses to this question is shown in Table 4. The engineering alliance contracts were arranged by seven of 11 owners for large projects and nine of 12 owners for small projects. Eight of 11 engineers used design alliance contracts for large projects, and nine of 11 engineers did for small projects. Seven of 11 owners used owner-contractor alliance contracts for large projects and nine of 11 for small projects. Two of three contractors used alliance contracts for both large and small projects. The reasons they used alliance contracts were to take advantage of services and expertise and because it was more cost effective. The survey also showed that the most favored method of contracting is with single prime contractors rather than multiple prime contractors.

Table 4. Contract Alliance Distributions

Contract Alliance	Number of Respondents					
	Owner		Engineer		Contractor	
	Large	Small	Large	Small	Large	Small
Engineering Alliance	7 of 11	9 of 12				
Design Alliance			8 of 11	9 of 11		
Owner-Contractor Alliance	7 of 11	9 of 11			2 of 3	2 of 3

Safety, Health, and Environment

Safety requirement – The survey reported that 27 of 30 respondents do not feel that safety requirements are relaxed for small projects.

Site safety/emergency plan – Twenty of 32 respondents had a site-specific safety and emergency plan.

Site safety supervisor – Twenty-eight of 32 respondents said they were using a full-time or part-time site safety supervisor.

Safety incentive plan – There are 11 of 31 responses indicating that safety incentive plans were in place for hourly craft workers.

Toolbox meeting – Twenty-eight of 31 respondents held a toolbox safety meeting.

Pre-hire testing – Twenty-nine of 32 respondents employed a pre-hire substance abuse testing.

Technology and Information Systems

Automated project control – Detailed automated project control responses are shown in Table 5, which were categorized into three major areas: project scheduling, budget control, and productivity. The software was popularly used for both large and small projects in terms of project scheduling and budget control; however, fewer projects were using software to track the productivity for small projects than for large ones. The other new tools or technologies most effective for small projects are integrated software, digital cameras, cell phones and radios, web sites and e-mail, bar coding, etc. According to the survey, e-mail, digital photographs, and cellular telephones are primarily the new technologies that benefit small projects because these improve or add to communications capabilities.

Table 5. Automated Project Control Tracking

Automated Tracking	Large Projects		Small Projects	
	Yes	No	Yes	No
Project Scheduling	27	0	23	6
Budget Control	27	0	23	3
Productivity	20	4	12	15