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CASE STUDY ANALYSIS IN SUPPORT OF
FRONT END PLANNING IMPLEMENTATION

by

THE UNIVERSITY OF TEXAS AT AUSTIN

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Research Report 213-12

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FRONT END PLANNING IMPLEMENTATION

by

Kyle T. Irons
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The University of Texas at Austin

A Report to
Construction Industry Institute
The University of Texas at Austin

Under the Guidance of
CII Project Team 213
Support for Pre-Project Planning

CII Research Report 213-12
March 2006

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Printed in the United States of America.

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Executive Summary

Many research investigations have indicated that projects have a higher chance of success when thorough front end planning is performed. Previous research efforts have sought to determine a statistical link between front end planning and the performance metrics for both building and industrial projects. The authors of this research report intend to supplement prior research with case study analysis that provides situational insight that supports business decision making of business managers and project representatives. The research conducted in this study was performed in conjunction with CII Research Team 213 (RT 213), Support for Pre-Project Planning.

The data for this research report were gathered through a series of questionnaires and interviews with project representatives from 17 projects totaling \$1.5 billion. Case studies were written by the authors and reviewed project representatives for accuracy and anonymity. The lessons learned from the case studies were distilled and evaluated to uncover correlations between front end planning issues and project success. A matrix of issues was created, and along with pattern-matching techniques, project data were sorted. The conclusions were drawn using expert knowledge of the authors and research team.

The case study analyses identified several planning related issues that affect project success, including: defined front end planning process,

adequate scope definition, existing conditions definition, correct contracting strategy, alignment, teambuilding, participation of owner and contractors in the front end planning process, leadership, experience, and labor availability and skill. Anecdotal evidence is provided to support the proper implementation of these issues.

Chapter 1: Introduction

1.1 Front End Planning Overview

Front end planning has long been recognized as an important process that increases the likelihood of a successful project. Front end planning is defined as “the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project.” CII research indicates that well-performed front end planning can reduce costs by as much as 20 percent; lead to less project variability in terms of cost, schedule, and operating characteristics; and increase the chance of meeting a project’s environmental and social goals (CII 1995). Typical activities and products of front end planning include:

- Options analysis
- Life-cycle cost analysis
- Project execution plan
- Environmental analysis
- Space planning
- P&IDs and site layout
- Capacity
- Products/usage

- Procurement plan
- Architectural renderings
- Appropriation submittal package

Alignment has also been recognized as an important factor during successful front end planning. Alignment is defined as “the condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives” (CII 1997).

The term front end planning will be used throughout this research report. In past research efforts, this process has been called various names such as pre-project planning, front end loading (FEL), programming/schematic design, scope definition and many other terms. It was decided by the research team guiding this effort that front end planning most accurately describes the activities involved. The term “pre-project planning” was replaced because many felt the planning process included planning efforts performed during the project, not just before as this term implied.

Figure 2.1 shows where the front end planning process occurs in the life cycle of a project. The process generally encompasses three sub-phases: feasibility, concept, and detailed scope. In many organizations, these phases are checked at “phase gates” indicated by the number

diamonds on this diagram. Front end planning generally ends at Phase Gate Three with project approval unless the project is terminated at an earlier gate. Input into the front end planning process is in the form of business information.

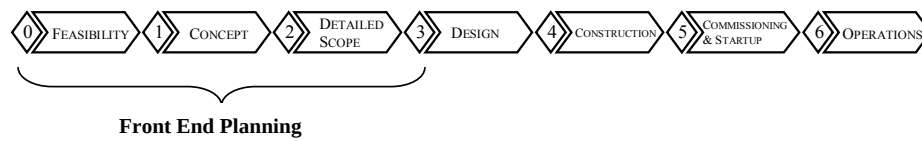


Figure 2.1: Project Life Cycle Diagram

CII has recognized front end planning (pre-project planning) and alignment as Best Practices and has developed several tools to aid in front end planning, including the Project Definition Rating Index (PDRI) for Industrial Projects, the Project Definition Rating Index (PDRI) for Buildings, and the Alignment During Pre-Project Planning Manual. Past CII research also suggests a direct relationship between project success and level of front end planning effort (CII 1995, Wang 2002, Ray 2005).

Other front end planning factors have also been recognized as having an affect on project success. Given that the design process begins during front end planning, expectations are that a higher percent design complete at the end of front end planning should also correlate to greater project success. Likewise, the degree of alignment during front end planning has been recognized as an important factor for successful front

end planning. Little past research has attempted to quantify the relationship between these factors and project success.

Further, while front end planning has been accepted within industry as an important factor in determining a project's success, little research has quantified the amount of money that organizations are spending on front end planning. Many barriers exist to the implementation of good front end planning. Schedule and budget limitations often pressure those in the industry to eliminate time and expenses to the project. Business stakeholders often look at front end planning as an optional process and may not see the value that good front end planning offers.

1.2 Scope

The purpose of this research report is to offer support to the case for good front end planning. This will be achieved through case study analysis of the front end planning process on projects submitted from both owner and contractor organizations. Case studies were used to provide a rich data evaluation of selected projects in order to support the understanding of details surrounding front end planning. With data gathered from a survey questionnaires and an interview, a wide range of front end planning issues will be analyzed to determine their affect on project success. Front end planning issues studied include: defined front

end planning process, scope definition including tools, existing conditions definition, contracting strategy, alignment, teambuilding, leadership, project team experience, labor and role of owner and contractors in front end planning.

The scope was not limited to projects completed by the organizations represented by the members of RT 213. Projects were obtained from both owners and contractors and represent a wide variety of sectors including pharmaceutical, petrochemical, institutional, remediation and industrial. Qualifications were established for projects to be nominated for case study analysis. Project pairs were selected that met the following criteria: (1) one successful project and one unsuccessful based on the organization's criteria; (2) the final cost of the projects exceeded \$1,500,000; (3) the project has ideally been completed and has been in operation for at least six months; (4) the project has ideally been completed in North America; and (5) the facility should be a building or industrial facility, new or renovation.

1.3 Support for Pre-Project Planning Research

The Support for Pre-Project Planning Research Team was formed in April of 2004 to address the current state of front end planning among CII member organizations. The committee recognized the importance of creating a strong, early link between the business or mission need, project

strategy, scope, cost, and schedule. Maintaining that link unbroken throughout the project life is vital to project success. A list of CII member organizations is included in Appendix A.1 and a list of RT 213 members is given in Appendix A.2. The team is made up of 20 industry representatives, one academic researcher and three graduate students. The research objectives of RT 213 are as follows:

- Understand the current status of front end planning in CII membership.
- Develop case studies showing the business implications of poor and good front end planning.
- Review and update current CII front end planning documentation as necessary.
- Develop a new front end planning overview document; produce documents to assist project teams in these issues, including risk mitigation methods.

1.4 Objectives

The objective of this research report is to complement the statistical analysis performed by RT 213 to help communicate the importance of front end planning to upper level management. Through a series of case studies, relevant front end planning practices will be examined for their potential benefits to project cost, schedule, safety,

change orders, alignment with business objectives, profit and relationship with the owner or client. The case studies are intended to provide managers with situations and a decision making environment they can relate to and bring realism to their understanding of the process.

1.5 Hypothesis

The overarching hypothesis of this research report is that better front end planning leads to better project performance. It is expected that if a project does not perform up to an organization's standards, then that is due in part to inadequate front end planning. Likewise, for projects that perform well, it is expected that front end planning efforts are successfully being executed and help to lead to the success of the project.

1.6 Overview of the Research Report

This research report is organized into five chapters. The first chapter details the scope and objectives of the research report along with some background on current front end planning research. The second chapter gives an overview of front end planning and some background on past research in this area.

The third chapter contains the methodology employed for the analysis performed as part of this research report. The fourth chapter includes a summary of the case studies and an analysis of the case study

results. The fifth chapter outlines the recommendations and conclusions of this research report.

Chapter 2: Background

The Construction Industry Institute (CII) has long recognized the importance of front end planning and supports the practice among its member organizations. This chapter gives research background on previous front end planning research efforts.

2.1 The Construction Industry Institute

The Construction Industry Institute is a research organization with a singular mission: improving the cost effectiveness of the capital facility delivery process and the competitiveness of its member organizations. In 1983, the CII founding members were convinced of the serious need for construction-related research. This need was clearly identified by The Business Roundtable Construction Industry Cost Effectiveness Project, a five-year study that produced over 200 recommendations for improving the industry. One recommendation was to establish a national research center for construction. The founding members then established the CII at The University of Texas at Austin, where today it is considered a premier national forum for construction management research (CII 1999c).

2.2 Pre-Project Planning Research

In 1991, CII initiated a research project “to find the most effective methods of project definition and cost estimating for appropriation approval” and chartered Task Force 39, Pre-Project Planning. That team mapped the front end planning process by using IDEF0, Structured Analysis and Design Techniques (Gibson et al. 1995). It defined front end planning as “the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project” (CII 1994). The research team grouped front end planning into four steps: organize for front end planning, select project alternative(s), develop a project definition package, and decide whether to proceed with the project (Gibson et al. 1995). The research noted the link between level of front end planning and cost and schedule predictability of the project (Hamilton 1994).

Through this research, several key front end planning practices were identified: defining corporate goals and guidelines, assembling a multi-disciplinary project team practicing excellent teamwork and communication, team continuity through team building, setting project objectives that all parties can agree on, creating a formal planning process, authorizing adequate time and resources for pre-project planning, understanding roles and responsibilities and other factors such as poor business decisions and unreliable data.

2.3 Front End Planning Research

In 1994, CII formed the Front End Planning Research Team (RT 213) to develop easy-to-use front end planning tools for use by owner and contractor organizations to better achieve business, operational, and project objectives (CII 1996). This team produced two books, (PDRI) Project Definition Rating Index for Industrial Projects and Alignment During Pre-Project Planning (CII 1996, CII 1997).

The PDRI for Industrial Projects is a weighted matrix with 70 scope definition elements (issues that need to be addressed in front end planning) grouped into 15 categories and further grouped into three main sections. The PDRI allows a project team to measure the completeness of a project's scope definition and a project can score up to 1000 points, with a lower score being better (Gibson and Dumont 1996).

2.4 PDRI for Building Research

CII commissioned a study in 1997 to develop an easy-to-use tool similar to the PDRI for Industrial Projects to be used on building and institutional projects. PDRI for Building Projects Research Team (RT155), developed the PDRI for Buildings tool and validated the tool through testing on sample projects (Cho et al. 1999). Analysis showed a significant difference in cost, schedule, and change order performance

between projects with lower PDRI scores (more complete front end planning efforts) and projects with higher PDRI scores (CII 1999).

2.5 Applying the PDRI in Project Risk Management

In 2002, Yu-Ren Wang's dissertation explored the link between project performance and PDRI score. Up until then, limited analysis of projects using the PDRI had been conducted. Data from 140 capital projects representing approximately \$5 billion in total construction cost were used for the research analyses. The relationship between good scope definition and enhanced project performance was demonstrated by this research (Wang 2002).

2.6 Federal Facilities Council Study

The Federal Facilities Council Standing Committee on Organizational Performance and Management sponsored Technical Report #146, entitled "Starting Smart: Key Practices for Developing Scopes of Work for Facility Projects" to help public organizations define scopes of work for Federal facilities. Published in 2003, the report concluded that the key practice to developing an effective scope of work for design is to conduct a structured, consistent, and thorough front end planning process and fully develop a project scope of work. Its objectives also included identifying key practices for developing effective scopes of work for design involving

new construction or major renovation projects and identifying key practices for matching the scope of work with the acquisition strategy, given a range of project delivery systems and contract methods (FFC 2003).

2.7 Analysis of Front End Planning Results Using CII's Benchmarking and Metrics Database

In 2005, Mike Ray's thesis examined the effects of front end planning on various project performance metrics including cost growth, schedule growth and change orders using data from the CII benchmarking and metrics database. The performance metrics were analyzed with respect to PDRI scores, Pre-Project Planning Index, percent design complete and Alignment Index.

The project samples for both industrial and buildings projects with PDRI scores above 200 at Phase Gate Three performed worse on average than the average of the samples with PDRI scores below 200 (those projects with better scope definition). This study found that the difference in cost growth factor and schedule performance for industrial PDRI was statistically significant. The favorable difference for all performance metrics was found to be statistically significant for the building PDRI.

This study also looked at samples of projects with the CII Pre-Project Planning Index score at Phase Gate Three above and below the

median of the combined sample (a higher score meant a more well-defined project). For industrial projects, the results of the analysis show that the correlation between the performance metrics of the two samples was statistically significant for cost, schedule, and change order performance. For the building projects, the sample with Pre-Project Planning Index scores was inconclusive, indicating the need to better develop metrics in this area.

The percent design complete analysis found that the project sample above the median percent design complete outperformed the sample below the median percent design complete on average for cost and schedule performance. These results were found to be statistically significant for this sample for cost performance. This cutoff value was 20 percent design complete at authorization for design and construction.

The sample with Alignment scores at Phase Gate Three above the median outperformed those with scores below the median on average. These results were found to be statistically significant for cost performance.

This research effort also sought to determine the phase costs for infrastructure, building, light industrial and heavy industrial projects. Pre-project planning phase costs averaged 3.4 percent of total cost for owners and 4.3 percent for contractors for all large projects, those greater than or equal to \$5 million. The study found that contractors spent more than

owners on pre-project planning as a percent of total cost across the board for small projects on all project types considered. Both owners and contractors spent more on small projects, those less than \$5 million, than on larger projects as a percent of total cost except for owner infrastructure projects where the large project sample had a higher percent of total cost than the small project sample.

Finally, this research analyzed the usage of the PDRI products in CII member companies. Overall, 61.7 percent of CII member companies are using the PDRI to improve their front end planning effort.

2.8 Summary

Previous research conducted by CII indicates a strong correlation between effective front end planning and improved project success measured by lower cost, schedule, and change order growth. It shows that well performed front end planning can reduce project costs by as much as 20%, lead to less project variability, and increase the chance of projects meeting social and environmental goals. The research also shows a direct correlation between the level of front end planning effort and project success (CII 1994). Many organizations have incorporated a front end planning process into their project life cycles. However, the resources allocated to front end planning vary significantly between organizations.

Several tools have been developed to assist project participants in front end planning, including CII publication on PDRI for Buildings, PDRI for Industrial Projects, and Alignment During Pre-Project Planning. Many organizations have developed proprietary tools to aid in the front end planning phase of the project life cycle.

It should be noted that little research work has examined case studies. This research report will use case studies to identify and illustrate key front end planning principles.

Chapter 3: Methodology

3.1 Overall CII Research Team 213 Methodology

This research report discusses one part of the research conducted by CII Research Team 213 (RT 213) in support of front end planning. Figure 3.1 highlights where the research outlined in this research report supports the goals of RT 213. Shaded areas indicate work done by others.

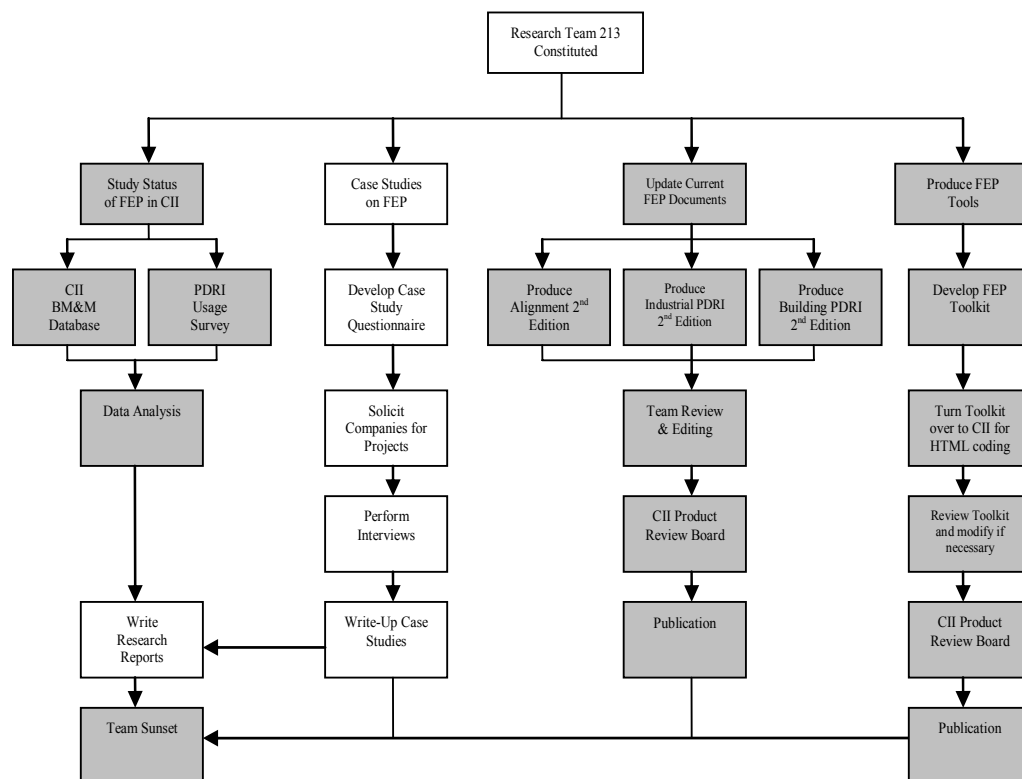


Figure 3.1: CII RT 213 Research Diagram

RT 213 is also performing other research and activities that are not detailed in this research report. For instance, RT 213 analyzed data gathered by the CII Benchmarking and Metrics Database on infrastructure, building, light industrial and heavy industrial projects (Ray 2005). These projects were also sorted by large and small projects. This data compared PDRI scores and performance metrics to the CII pre-project planning index, percent design complete and the Alignment Index. RT 213 also looked at current usage of the PDRI among CII members. The results of these analyses are published as CII Research Report 213-11.

In addition, RT 213 has updated all front end planning implementation resources and is developing an integrated, web-based toolkit for assisting front end planning efforts.

3.2 Research Report Methodology

An outline of the research methodology used in this portion of the study is shown in Figure 3.2. As discussed earlier, many of the research investigations have looked extensively at front end planning. Consequently, the authors began the research with a literature review of the current publications and resources on front end planning as described in Chapter 2.

Next, the authors formed study sub-hypotheses to support the hypothesis that better front end planning leads to better performance. The

members of RT 213, representing both owner and contractor organizations, were polled to determine what issues are most important in determining if a project was “successful” or “unsuccessful.” The entire sample was used in this evaluation, primarily because of the similarity of issues, no matter the construction sector.

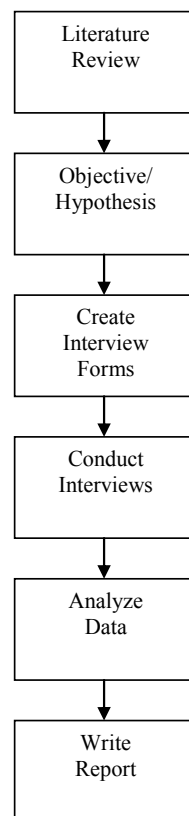


Figure 3.2: Research Methodology Diagram

RT 213 also helped define the characteristics of types of projects that would be considered as potential case study candidates. It was decided that the study would focus on pairs of projects from each participating organization that met the following criteria: one successful project and one that was unsuccessful based on the participating organization's criteria, the final cost of the projects exceeded \$1,500,000, the project had ideally been completed and in operation for at least six months, the project was ideally completed in North America, but acceptable nominations from projects completed worldwide would be considered, and the facility was a building or industrial facility, new or renovation.

In order to obtain accurate and detailed information from respondents, confidentiality of proprietary information was taken seriously. The case studies were written to disguise the identity of the participating organizations by withholding the name of the organization and project as well as distinguishable information. The case studies in this research report are named "O" for owner cases and "C" for contractor cases. The unsuccessful project is listed first in the pair, followed by the successful project. For example, the pair of projects for the second contractor organization is named C2.1 (unsuccessful) and C2.2 (successful).

The authors created a pre-interview questionnaire that sought general project information as well as the project representative's interpretations of project success. This questionnaire was vetted by the research team. The pre-interview questionnaire, which outlined key technical and performance information, was completed by the project representatives and returned to the authors who used this information to tailor a list of questions for the interview. See Appendices D.2 and D.3 for sample pre-interview questionnaire. The research team also provided input into this second structured interview guide.

From one to four representatives were interviewed for each of these projects. Typically, the authors were involved in each interview. After the interview, a case study was written by the authors and reviewed by the project representative(s) for accuracy and distinguishable information that might violate the confidentiality of the research process.

After the case studies were finalized, the data were sorted and organized. Pattern-matching, recognized as a dominant mode of analysis for case study research, was used to help analyze the case study data gathered. More specifically, the type of pattern-matching used for analysis in this research report is explanation-building. The goal of explanation-building is to "explain" a situation by finding a set of common links, which may often be difficult to precisely measure. This process is iterative by nature (Yin 1991).

Initial analysis uncovered issues that became apparent during the interview and from responses to the questionnaires on an individual project basis. A list of recurring issues was developed into a matrix matching planning issues to projects (see Appendix C.2 for this matrix). This matrix indicated both the presence and absence of particular front end planning issues on specific projects.

With the data sorted in this format, the authors were able to identify patterns such as the frequency of specific issues across several projects and the major issues on an individual project that contributed to project success or failure of the performance metrics. It was also found that certain planning issues often occur together or in groups with regularity. This implies a relationship between the two (or more) planning issues. The patterns discovered were compared to theoretical propositions that were discussed with between the authors.

As patterns in the data became apparent, data from all projects were reanalyzed by the authors. Cells in the matrix that were initially blank were able to be inferred with high confidence. The data were distilled from this matrix into three categories. The front end planning issues that frequently occurred were classified as either a critical success factor or an overarching lesson learned. Data not frequently occurring were discarded.

The distinction between critical success factors and overarching issues is that critical success factors are well-defined tasks that should be performed to increase the chance of project success. Overarching issues are lessons learned and are generally less tangible and sometimes out of the control of the project participants. Some issues identified early in this research effort were discarded at this point because they did not occur with enough frequency or did not have a tangible affect on the project outcome.

There are limitations to the data as a result of the collection methodology. First, the data cannot be generalized to the industry because the sample was a convenience sample. Nominations were limited to organizations that were members of CII and all but one pair of cases were nominated by members of CII Research Team 213. Also, the data collected were both quantitative and qualitative. Qualitative data is subjective in nature and can be difficult to properly compare in separate instances. Finally, the data collected likely do not take into account all the factors that can affect the success of a project; however, the collected data provide a rich source related to the sample.

Chapter 4: Case Study Results

This chapter will examine the results of the case study analysis starting with a characterization of the projects. Next, there is a summary of each case study project pair I summarized and then followed by a statistical analysis comparing project performance metrics of the successful and unsuccessful projects. Finally, the authors examine front end planning issues identified and overarching lessons learned from the case study analysis.

4.1 Project Characteristics

This section will outline the project characteristics for the projects that were nominated and selected for case study analysis.

4.1.1 Owner or Contractor

Table 4.1 summarizes the project characteristics of projects studied in the case study analysis by those nominated by contractors, owners and total.

Table 4.1: Summary of Project Participation

	# of Projects	Total Cost (million)
Contractor	7	824.7
Owner	10	683.1
Total	17	\$1507.8

A total of 17 projects are included in this analysis. Of these projects, seven were nominated by contractors and 10 were nominated by owners. The results of the case study analysis represent a total of just over \$1.5 billion. Case studies written for projects submitted by contractors had a total cost of \$824.7 million while those written for owners totaled \$683.1 million.

4.1.2 Industrial or Building

A breakdown of industrial projects studied by sector is summarized in Table 4.2.

Table 4.2: Summary of Industrial Projects by Sector

Sector	Type	# of Projects	Total Cost (MM)
Industrial	Petrochemical	4	407
	Power	2	230.6
	Production (e.g. consumer products)	6	340
	Groundwater Remediation	1	4
Total		13	\$981.6

A total of 13 industrial projects were included in the case study sample, and total approximately \$981.6 million. Six of the projects were from the production sector, totaling \$340 million. Projects from the petrochemical sector were the largest by cost with \$407 million from four projects. Two power projects totaled \$230.6 million and one remediation

project totaled \$4 million. Table 4.3 summarizes the building projects by sector.

Table 4.3: Summary of Building Projects by Sector

Sector	Type	# of Projects	Total Cost (MM)
Building	Institutional	4	\$532.1

All of the building projects were from the institutional sector. In total, these four projects cost \$532.1 million at completion. A summary of the costs of all projects can be shown in Table 4.4 along with the assigned project number.

Table 4.4: Summary of Cost of All Projects

Project	Description	Cost (Million)
C1.1	Building material production	\$ 138.0
C1.2	Building material production	\$ 99.0
C2.1	Petrochemical	\$ 161.5
C2.2	Petrochemical	\$ 170.0
C3.1	Power plant	\$ 164.6
C3.2	Power plant	\$ 66.0
C4.1	Industrial- petrochemical	\$ 25.5
	<i>Subtotal of Contractor Projects</i>	\$ 824.6
O1.1	Consumer products production	\$ 21.1
O1.2	Consumer products production	\$ 25.7
O2.1	Consumer products production	\$ 31.0
O2.2	Consumer products production	\$ 19.2
O3.1	Institutional	\$ 215.0
O3.2	Institutional	\$ 219.0
O4.1	Remediation	\$ 4.0
O4.2	Petrochemical	\$ 50.0
O5.1	Institutional	\$ 50.0
O5.2	Institutional	\$ 48.1
	<i>Subtotal of Owner Projects</i>	\$ 683.1
	Total	\$ 1,507.7

4.2 Case Study Summaries

Seventeen case studies were written, seven for contractor nominated projects and 10 for owner nominated projects. The following section provides a brief summary of the case study pairs including general information on project type and major issues identified. Detailed case study write-ups are given in Appendix B.

4.2.1 Contractor

C1.1 and C1.2

This pair of projects is from a contractor that has recently instituted a front end planning process. The projects are both building material production facilities and represent a before (C1.1) and an after (C1.2) view highlighting the difference results from using the structured planning process. The contractor was not aggressively involved with the planning of project C1.1 and did not thoroughly question the planning results that it was given. On project C1.2, the contractor was much more aggressive in the planning effort and the structured process helped ensure the well-aligned project with a more complete scope definition.

C2.1 and C2.2

This pair of petrochemical facility revamp projects highlights the value of working with an owner who is not only involved in planning, but also understands what it takes to successfully plan a project. In project C2.1, the owner severely underestimated the total project cost and the contractor deemed the fundamental construction concept selected by the owner to be inferior to other alternatives. The owner in project C2.2 oriented the project in a successful direction and was deeply involved in the planning throughout.

The value of teams that have previous experience working together is also discussed in this pair of case studies. The more successful project demonstrates the success resulting from a setting a thorough planning process and following this process throughout the project.

C3.1 and C3.2

The contractor organization that built this pair of power plant facilities has a well-defined planning process. However, project C3.1 was planned more by “instinct” rather than using the process available. A representative from this project stated the project would have benefited from using a structured front end planning process and an outside facilitator. Project C3.2 followed the structured process which helped manage uncertainties and project complexities. This project encountered a force majeure event during construction and was able to proceed with minimal interruption due to preparations from extensive front end planning.

C4.1

This industrial facility retrofit project demonstrates the importance of selecting a contracting strategy that reflects the risks associated with a project. This contractor did not thoroughly define the existing conditions of this revamp project, which led to delays and decreased productivity.

The owner also was financially exposed when a critical turnaround period was extended. The project suffered from labor shortages and a lack of appropriate stakeholder involvement in project planning. Unfortunately, only one project was available from this respondent.

4.2.2 Owner

O1.1 and O1.2

This pair of consumer products production facility projects were completed concurrently on the same building site. Project O1.2 demonstrates the value of proper stakeholder identification and scope development. Given the requisite time to plan activities, the project team was able to successfully start a project in a manner that differed from the original plan.

Both projects suffered from a lack of available project controls information. A third party chosen to perform such crucial work should be heavily scrutinized before selection. Project O1.1 also suffered from a lack of subcontractor control. A project representative stated that this issue could have been mitigated with a different contracting strategy.

O2.1 and O2.2

This pair of consumer products production facility case studies highlights the need to perform essential front end planning prior to project authorization. Project O2.1 did not include design activities and

consequently required an exorbitant amount of effort to keep the project on-track. Using lessons learned from this project, project O2.2 integrated the design team into the planning process. This pair of projects also demonstrates the need for buy-in from upper management.

O3.1 and O3.2

This pair of institutional case studies emphasizes the importance of leadership and the benefits from a unifying voice that guides a project to a successful completion. A lack of leadership set project O3.1 on a course towards failure. The need for thorough stakeholder identification to garner the support and opinions of project participants is also discussed in this project. Project O3.2 performed extensive stakeholder identification which proved one key to project success.

O4.1 and O4.2

This pair of projects illustrates the difference in results when the front end planning process is followed and when it is not. Project O4.1, a groundwater remediation project, demonstrates the need for the owner to be actively involved in the front end planning process. The owner delegated planning to a consultant who was not familiar with the owner's work processes and did not work with the consultant during this process.

Both projects used the PDRI with mixed results. A representative from project O4.1 commented that a facilitator would have helped the project team question its assumptions, which would have benefited the project. The PDRI uncovered deficiencies in project scope on project O4.2, a petrochemical facility expansion project. With this information, the project team was able to adjust the project scope accordingly to comply with budget restrictions.

O5.1 and O5.2

Getting project stakeholders educated on the construction process is essential to the success of a project. Project O5.1 suffered from uneducated stakeholders who had differing opinions on the appropriate path of the project. The project manager for project O5.2 spent a large amount of time and effort educating the stakeholders to prevent this from happening. Both of these institutional building projects suffered from the selection of a poor A/E firm.

4.3 Summary of Project Performance

Project nominations for case study analysis were requested from CII member organizations in pairs; the nominees subjectively supplied one “successful” and one “unsuccessful” project. Of the 17 total case studies written, eight were successful and nine were unsuccessful projects.

Table 4.5 shows the average results of cost, schedule and change order performance metrics versus the estimate for design and construction at the end of front end planning.

Table 4.5: Performance Metrics Means for “Successful” and “Unsuccessful” Projects

	Cost Growth	Schedule Growth	Change Orders
Successful	-2% (N=6)	-2% (ahead) (N=5)	5% (N=7)
Unsuccessful	11% (N=6)	30% (behind) (N=9)	9% (N=7)

The results of Table 4.5 indicate that the successful projects substantially outperformed the unsuccessful project in the performance metrics listed for this small sample. Note that performance information was not provided on all projects by the project representatives. In some cases, numeric values were assigned from non-numeric data. For example, if a project was reported finished “on time,” then a zero percent schedule growth was assigned. If a project was reported as “high” schedule growth, however, no value was assigned because of the large uncertainty involved.

Projects that were seen by the organizations as “successful” finished on average two percent below budget, while projects seen as “unsuccessful” finished 11 percent over budget on average. The schedule change results were even more varied between the two groups as projects

that were “successful” finished an average of two percent ahead of schedule while “unsuccessful” projects were 30 percent behind schedule. Change orders for “successful” projects averaged five percent while “unsuccessful” projects averaged nine percent change orders.

Statistical analysis was performed to determine if there is statistical significance between the means of the performance metrics of the “successful” and “unsuccessful” groups. In the subsequent case study analysis, this significance will lend credibility to statements correlating good front end planning to successful projects and poor front end planning to unsuccessful projects. The authors’ hypothesis is that the projects that were submitted as successful would have a better performance metrics than the projects submitted as unsuccessful.

The means of the performance metrics listed in Table 4.4 were analyzed with Microsoft® Office Excel 2003 using a single factor ANOVA. The results were analyzed for statistical significance at the 90 percent level, or a P value ≤ 0.1 .

Several assumptions were made about the sample being tested. The first is that the data are normally distributed. The second assumption is that the two groups are independent. The third assumption is that the samples are homogenous and have equal variances.

The first performance metric analyzed is cost growth. The results listed in Table 4.6 show a single factor ANOVA on the mean cost growth between the successful and unsuccessful groups.

Table 4.6: Single Factor ANOVA of Mean Cost Growth for Successful and Unsuccessful Groups

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
Successful	6	-0.108	-0.018	0.001836		
Unsuccessful	7	0.748	0.106857	0.008202		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.050365	1	0.050365	9.487479	0.010468	4.844336
Within Groups	0.058395	11	0.005309			
Total	0.10876	12				

The results of Table 4.6 show a p-value = 0.01. This confirms that the difference cost data means is statistically significant to the 90 percent level.

Table 4.7 shows the results from a single factor ANOVA on the mean schedule growth between the two groups.

Table 4.7: Single Factor ANOVA of Mean Schedule Growth for Successful and Unsuccessful Groups

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
successful	5	-0.1	-0.02	0.002		
unsuccessful	8	2.632	0.329	0.152575		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.3747723	1	0.374772	3.831223	0.076158	4.844336
Within Groups	1.076026	11	0.097821			
Total	1.4507983	12				

The results show that the difference in mean schedule growth for the successful and unsuccessful groups is significant at the 90 percent level, with a p-value = 0.08.

Table 4.8 shows the results of a single factor ANOVA on the mean change order performance as a percent to total project cost between the successful and unsuccessful groups.

Table 4.8: Single Factor ANOVA of Mean Change Orders for Successful and Unsuccessful Groups

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
successful	7	0.375	0.053571	0.001371		
unsuccessful	7	0.661	0.094429	0.003395		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.005843	1	0.005843	2.452163	0.14334	4.747225
Within Groups	0.028591	12	0.002383			
Total	0.034434	13				

With a p-value = 0.14, the results in Table 4.8 show that there is a not a 90 percent confidence statistical significance between the mean change orders for the successful and unsuccessful groups, although there are differences.

In summary, these results show that the sub-samples were significantly different. The cost and schedule metrics differences were statistically significant to the 90 percent level, while the change order metrics were not.

4.4 Case Study Analysis

Based on information gathered in the questionnaires and from the case study interviews, the authors created a list of issues that affected project success. The list was distilled and the issues were classified into

three categories: critical success factors, overarching lessons learned and the less frequently occurring issues that were discarded. The authors use the term “critical success factor” to identify issues on a project where a specific front end planning process or technique was critical in either the success or failure of the project and/or planning effort. Issues that became critical success factors were generally known industry practices with previous research from organizations such as CII. The questionnaires and interviews were designed to determine if these issues were critical to the success or failure of the sample projects.

Overarching lessons learned are characterized by issues that are not specific front end planning processes. The overarching lessons learned are more general and often are not controllable by the project manager.

There is an element of subjectivity in determining whether an issue was pivotal to the project outcome. The authors used information gathered from the project specific questionnaire and the project interview as well as patterns recognized from looking at all projects.

Through the case study research, there were several recurring problem topics were identified. Interestingly, recurring problems were not isolated to a particular project or industry type and were not iterated from only contractors or owners. Rather, in most cases these problems appear to be absolute rules that cross boundaries of industry and project types as well as point of view.

4.4.1 Critical Success Factors Identified

The following is a list of front end planning issues that were deemed as critical success factors:

- Defined front end planning process
- Scope definition, including tools
- Existing conditions definition
- Contracting strategy
- Alignment and stakeholder identification
- Teambuilding

The authors worked to filter numerous inputs and outputs of each project to determine what the effects were for the planning issues listed above. The case study research not only revealed the benefits of successfully performing front end planning, but also the problems that arose from failing to appropriately address planning issues.

The following sections highlight critical success factors. These are not given in order of importance.

Defined Front End Planning Process

A defined front end planning process is characterized by a structured process that guides an organization through various planning efforts with checklists and regular gate checks providing defined deliverables. The process should facilitate front end planning techniques such as defining a charter, partnering, scope definition, stakeholder identification and alignment.

Of the 17 projects, nine projects had a well-defined front end planning process while eight did not. Five of the nine well-defined processes were on successful projects. In the absence of a well-defined process, sample projects were unsuccessful five of eight times. Two of the unsuccessful projects that had a defined process failed principally because the process was not followed by the project team. See Appendix C.2 for a matrix that summarizes which projects were determined to have a well-defined and poorly defined planning process.

As reported by the respondents, not having a defined planning process typically caused problems related to significant issues that were overlooked or not performed in a thorough or timely manner. Some of the problems attributed to a lack of a structured planning process were poor alignment, poorly defined scope and drawings that were not fully conceptualized prior to construction. Projects with a well-defined front