



Construction Industry Institute®

Analysis Supporting Front End Planning for Renovation and Revamp Projects, Part 2

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ANALYSIS SUPPORTING FRONT END PLANNING FOR
RENOVATION AND REVAMP PROJECTS, PART 2

by

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The University of Alabama

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The University of Texas at Austin

Under the Guidance of
CII Research Team 242
Front End Planning for Renovation/Revamp Projects

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EXECUTIVE SUMMARY

Increasingly, manufacturing, commercial, and institutional owners are retrofitting or renovating their existing facilities. Whether it is an issue of making the facility more efficient with new production technology, meeting standards and safety requirements based on new environmental regulations, or maintaining historically significant buildings, these projects present unique risks. Front End Planning (FEP) is a critical process for uncovering unknowns in existing facilities, while developing adequate scope definition and a structured approach for the project execution process. Shutdown/Turnaround /Outage (STO) projects are a specific subset of renovation and revamp (R&R) projects in the industrial sector. Previous research using benchmarking and metric data analysis has supported FEP as a valuable practice for project success. The purpose of the research presented in this document is to supplement previous research efforts while focusing explicitly on R&R and STO projects. This research report was performed in conjunction with Construction Industry Institute (CII) Research Team 242 (RT 242), “Front End Planning for Renovation/Revamp Projects.”

The Benchmarking and Metrics (BM&M) database program at CII was used to stratify the data and then to analyze the differences between indices and metrics supporting front end planning when comparing R&R and greenfield projects. CII BM&M management staff provided a sample dataset of projects for the comparison used in this research effort. The database used for this analysis included 679 projects with a total installed cost of greater than \$23.5 billion. The document analyzed six indices supporting FEP and five project execution performance metrics using various statistical methods including standard deviations and ANOVA analysis. This analysis included the PPP Index, Alignment, Change Management Index, Constructability Index, Zero

Accident Techniques Index, and Quality Management Index. Also included is an examination of the critical performance metrics; project cost growth, project schedule growth, and change order costs. In contrast to the hypothesized results, the front end planning indices, practice usages, and performance metrics did not show results for R&R projects being worse than greenfield projects. In fact, no difference between the R&R projects and the greenfield projects were found in the reported results. All of the comparisons were checked for statistical appropriateness which showed that there was no statistical significance in the difference between any of the factors. The lone exception was the Zero Accident Technique Index which showed that greenfield projects had greater practice use. The authors speculate that the reason for this statistically significant increased value is based on the nature of R&R projects and project teams.

As part of the research effort, the authors and the RT 242 research team developed the STAR Tool to provide a means of assessing key planning attributes unique to STOs, resulting in an opportunity for earlier risk identification and mitigation. This research report details the development of the tool, prioritization and refinement using four research charrettes, and after the fact testing of the tool on completed and in-planning STOs. The charrettes included a total of 67 participants representing 39 separate organizations with combined project management experience of over 1,300 years and STOs representing nearly \$5.5 Billion in total installed construction cost.

CHAPTER 1: INTRODUCTION

In recent years, a high percentage of the annual construction-related capital spending by many organizations is on renovation and revamp (R&R) work rather than on new construction. Estimates by the U. S. Department of Commerce are in the hundreds of billions of dollars annually for nonresidential, R&R projects (U.S. Department of Commerce 2007). Consequently, a large volume of contractor work is in this arena as well. The Construction Industry Institute (CII) in conjunction with The University of Alabama formed the Front End Planning for Renovation/Revamp Projects Research Team, RT-242, in October of 2006 to analyze R&R projects in relation to front end planning effort and efficiency. These team members represent a broad range of the industry from process manufacturers to governmental agencies to building contractors. The experience level of the team members ranged from engineering project managers to a vice president of a multi-million dollar construction company. The research team was made up of twenty-two industry representatives, two academic researchers and two graduate students. A list of the research team is given in Appendix A.2.

While addressing renovation projects at a high level, CII research to date has not focused on R&R work directly. R&R projects present challenges that are unique compared to new construction, consequently requiring more comprehensive planning and execution. Such projects are wrought with the risks of unknown conditions, and are often, but not always, executed while a portion of the same facility must remain in

operation. Despite these facts, the front end planning process in most organizations is structured around new construction or greenfield projects rather than R&R projects.

The front end planning process is characterized by a formal process that guides an organization through various planning efforts with regular gate checks, using checklists to provide defined deliverables. The process should include such steps as defining a charter, developing objectives, scope definition, stakeholder identification, and alignment. Absent the right approach, R&R projects could result in serious disputes within the owner organization or between the owner, design professional and contractor.

1.1 Construction Industry Institute

The Construction Industry Institute is a consortium of more than 100 leading owner, engineering-contractor, and supplier firms from both the public and private arenas, who pool resources to study the engineering and construction industry (CII 2007a). CII's mission is to "add value for members by enhancing the business effectiveness and sustainability of the capital facility life cycle through CII research, related initiatives, and industry alliances" (CII 1999c). (A complete list of CII member organizations at the time of this study is provided in Appendix A.1.)

1.2 Front End Planning Overview

Front End Planning (FEP) 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 1994). FEP is arguably the single

most important process in the project lifecycle. Figure 1.1 shows the FEP process within the project life cycle (CII 1995).

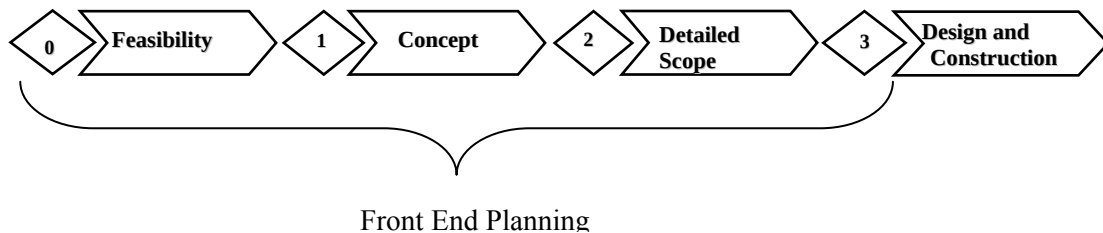


Figure 1.1 Front End Planning Process

The FEP process generally includes three sub-phases: feasibility, concept, and detail scope. The diamonds in the diagram represent key decision gates that must be addressed prior to moving on to following phases. Front end planning generally ends at phase gate three with project approval unless project is terminated at an earlier gate (CII 2006b).

Previous research from CII indicates that effective front end planning can reduce project cost as much as 20 percent (CII 1995). The following project elements can be heavily affected during the front end planning process:

- Alignment
- Leadership
- Experience
- Budget
- Schedule
- Scope Definition
- Site Conditions
- Modularization

Some owners view the FEP process as time taken at the beginning of a project that causes the completion date to be extended rather than a method of increasing project speed to delivery. Owner finance departments require accurate cash flow plans that are

“locked in” early in the process, which can be particularly problematic on these types of projects due to the inherent characteristics of R&R projects. The project team is sometimes expected to follow unrealistic budgets, putting pressure on expenditures, and sometimes, causing project scope to be used as contingency. In many cases, neither training nor experience in project delivery techniques can overcome these external project pressures, and the value of “getting the project right and then going fast” is lost. Project costs can still get out of control even with good FEP due to lack of scope control discipline.

The front end planning process has many different aliases, such as pre-project planning, front end loading, programming/schematic design, and scope definition. For this document, front end planning will be the term used throughout the Research Report.

1.3 Scope

This research study begins with the assumption that the FEP process is valid and valuable; however, its usage, particularly in regard to revamps and renovations, is not consistent. The research investigation focused solely on renovation and revamp, R&R projects. The term R&R was defined by the Research Team (RT) 242 as a project that is focused on an existing facility, which includes the act, process, or work of replacing, restoring, repairing, or improving this facility with capital funds or non-capital funds. It may include additional structures and systems to achieve a more functional, serviceable, or desirable condition, including improvement in:

- profitability
- reliability

- efficiency
- safety
- security
- environmental performance
- or compliance with regulatory requirements (Howard et al. 2008)

The preliminary research conducted as part of RT 242 evaluated front end planning usage and methods for R&R projects, as well as to assess its relationship to “project success.” Data were gathered through questionnaires and interviews for both quantitative and qualitative analysis of the front end planning process of R&R projects and its relationship to project success. The term “project success” was defined by the owner or contractor who submitted the project for case study analysis. The authors did not determine whether or not a case study project was successful, the submittal representative defined the project’s success. The scope was not limited to projects completed by the organizations represented by the members of the RT 242. R&R projects from previous case studies conducted by CII were also included in the analysis (Howard et al. 2008).

This research report describes the second phase of the research effort. Based on CII’s Benchmarking and Metrics database, 679 projects were analyzed for FEP usage and various other metrics. The dataset was stratified according to project type (greenfield vs. R&R), project value and respondent type (owner vs. contractor). Based on the various stratified datasets, FEP practice usage, performance metrics, and project decision making references were compared for all the respondents. Another major research topic covered the development and validation of a new and novel tool for the management of

Shutdowns/Turnarounds/Outages (STO). STOs are a subset of R&R projects in the industrial sector. These events typically occur when planned disruptions to normal use or operation of a manufacturing facility take place to facilitate maintenance, enhancements, or tie-ins. It is common to have several construction projects executed during an STO and the integration of the activities is often problematic.

1.4 Front End Planning for Renovation and Revamp Project Research Team

The terms renovation and revamp, R&R, which was defined in Section 1.2 of this Chapter, will be used throughout this document but an additional definition is needed for this research report.

1.4.1 Shutdown/Turnaround/Outage Projects

Shutdown/Turnaround/Outage “projects” are a subset of renovation and revamp projects. These projects are generally a combination of one or many smaller projects or discrete activities. Each STO is typically unique and can be small to very large in terms of construction costs, although almost always constrained to a relatively short schedule duration. STOs usually are typically focused in the industrial construction sector (although not always) and have specific time constraints for performance, and large business cost drivers for successful completion on a tight schedule. These cost drivers include such things as significant losses of production or sales opportunities resulting from any delays. For these projects, coordination of effort between multiple projects, each with their own unique issues, with facility maintenance and operations activities is

extremely important. Unforeseen conditions and work requirements often come up during the work (CII 2008a).

1.5 Objectives

This section presents the objectives for this document as well as the objectives for the entire team.

1.5.1 RT 242 Objectives

The research objectives identified by the entire RT 242 team are as follows:

1. Enhance or supplement the CII Best Practice entitled front end planning and focus on the obstacles to successfully performing revamp and renovation projects.
2. Identify preferred methods for optimizing front end planning for revamp and renovation and shutdown, turnaround and outage projects, including the use of new and existing technology for site investigations, human resources requirements, contracting approaches, and cost and schedule estimating methods.
3. Produce documents and tools to assist project teams in developing effective front end planning for R&R projects, including risk identification, assessment, and mitigation methods.

1.5.2 Research Objectives

Within the context of the RT 242 objectives, the specific objectives of the combined research conducted were:

1. To explore the extent of R&R projects within CII.
2. To identify unique risks and issues related to R&R projects.
3. To highlight and describe critical success factors and overarching issues that affect performance of R&R projects.
4. To analyze the Benchmarking and Metrics database in support of FEP for R&R projects.
5. To describe unique risks and issues related to STO projects.
6. To detail the development and approach of the STAR Tool for use on STO projects.

Objectives one through three can be found in RR 242-11. This research report provides a discussion of research objectives four through six.

1.6 Hypothesis

The overriding hypothesis of this research is that specific practices in the front end planning process will add value to the revamp or renovation of a capital project or a shutdown/turnaround/outage, and subsequently ensures business success; and that a project team (and an organization) must perform these practices effectively in order to have a more successful project venture.

1.7 Overview of Document

The findings produced as a result of this research are organized into two segments. The first segment is documented by Howard et al. (2008), and includes findings from the first three RT 242 research objectives. This research report describes the results of RT 242 research objectives four through six. This First Chapter states the scope and objectives of the research. The Second Chapter is a background of past front end planning, benchmarking and metrics research, and a novel research method employed on this study. The Third Chapter contains the methodology utilized for the research including the analysis and execution performed. The Fourth Chapter shows the results of the stratification of the benchmarking and metrics dataset. Chapter Five provides a description of the indices and metrics supporting front end planning. The Sixth Chapter describes the development and prioritization of the Shutdown Turnaround Alignment Review (STAR) Tool. The Seventh Chapter details the performance testing of the STAR Tool via actual project assessments. Chapter Eight summarizes the research performed and provides recommendations for future research.

CHAPTER 2: BACKGROUND

Front end planning (FEP) has been recognized as an important part of the project life cycle. A detailed search for research on front end planning for renovation and revamp as well as shutdown/turnaround/outage projects was performed through the Internet. The results of the search did not provide much valuable information for the study. The search was refined to include just front end planning within the construction industry. Several of the items displayed from that search were from The Construction Industry Institute. Chapter 2 highlights previous research focused on front end planning, the research methods used herein, and how they have impacted the construction industry.

2.1 Pre-Project Planning– Initial Investigation

The Task Force 39 was established in 1991 by CII “to find the most effective methods of project definition and cost estimating for appropriation approval.” The task force using IDEF0, Structured Analysis and Design Techniques, outlined the front end planning process (Gibson et al. 1995). Front end planning was defined by the team 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 effort formed a four step process for front end planning: organize the front end planning process, identify project alternatives(s), develop a project definition package, and make decisions of whether or not a project should proceed (Gibson et al. 1995).

The research also recognized several key front end planning practices:

- develop corporate goals and guidelines
- produce a highly experienced, multi-disciplinary project team with excellent communication skills
- align project team through team building
- define project objectives with stakeholder agreement
- create a formal front end planning procedures
- authorize sufficient time and resources for front end planning
- recognize roles and responsibilities
- eliminate poor business decisions and unreliable data

2.2 Front End Planning Research – Follow Up

In 1994, the Front End Planning Research Team (RT 113) was formed by CII to create easy-to-use front end planning tools. These tools were to be used by owner and contractor organizations to improve business, operational, and project objectives (CII 1996). From the efforts of this team, two documents were produced, Project Definition Rating Index for Industrial Projects (PDRI) and Alignment During Pre-Project Planning (CII 1996, CII 1997, CII 2006b).

The *PDRI for Industrial Projects* is a weighted matrix with 70 scope definition elements. These elements are issues needing to be addressed in front end planning. The PDRI categorizes these elements into three main sections with 15 sub-categories. The main objective of the PDRI was to allow a project team to measure the completeness of a

project's scope definition. The maximum score of the PDRI is 1000 points, but the lower the score the better the project scope definition (Gibson and Dumont 1996).

The research investigation also looked closely at project team alignment during front end planning. Its results included identification of 10 key alignment factors, development of the Alignment Thermometer, and publication of the CII Implementation Resource 113-3, *Alignment During Pre-Project Planning: A Key to Project Success*, which lays out key processes associated with gaining and maintaining alignment (CII 2005; Griffith and Gibson 2001).

2.3 PDRI for Building Research

In 1997, CII funded a research team to develop an easy-to-use tool similar to the PDRI for Industrial Projects for building and institutional projects. The PDRI for Building Projects research team (RT155) developed the *PDRI for Buildings* then tested the tool on sample projects (Cho et al. 1999, CII 1999b). The *PDRI for Buildings* has 64 scope definition elements that are broken into three main sections. The analysis of these sample projects showed a significant difference in project control parameters such as cost, schedule, and change orders between low scoring PDRI projects (better defined scope) and projects with higher PDRI scores (Cho and Gibson 2001, CII 1999, CII 2006a).

2.4 Applying the PDRI in Project Risk Management

Analysis of projects using the PDRI has been limited; Wang (2002) explored the relationship between project performance and PDRI score. Information was gathered for

analyses from 140 capital projects representing approximately \$5 billion in total construction cost. The link between well-defined scope and enhanced project performance was then established (Wang 2002).

2.5 Federal Facilities Council Study

Technical Report #146, titled “Starting Smart: Key Practices for Developing Scopes of Work for Facility Projects,” was sponsored by the Federal Facilities Council Standing Committee on Organizational Performance and Management. The committee wanted to aid public organizations in defining scopes of work for Federal facilities. The report pointed out that a thorough front end planning process was the key to a well defined scope of work. The committee examined both new construction and major renovation projects interfacing with a dozen federal agencies. The report also identified key practices for effective scope development and acquisition strategy related to scope definition and gave a range of project delivery systems and contract methods (FFC 2003).

2.6 Benchmarking & Metrics at CII

In addition to information gathering through the use of research teams, the CII Board of Advisors established the Benchmarking and Metrics (BM&M) committee in 1993 which, in turn, designed the BM&M Database.

The CII Benchmarking and Metrics Program was established to provide industrial performance norms, quantify the use and value of best practices, and help focus CII research and implementation efforts. A committee of industrial representatives working with CII staff develops policy and oversees execution of the program. This committee

has defined critical performance and practice-use metrics and developed a strategic approach to CII's collection, analysis, and dissemination of industry data. The Benchmarking and Metrics Committee meets on a regular basis for continued development and improvement of the program (Ray et al. 2006).

Since the establishment of CII in 1983, its members and academia have collaborated to evaluate best practices to improve the cost effectiveness of capital facility project execution including pre-project planning and alignment among others. The mission of CII BM&M is to quantify this value and to provide assessment to participants (CII 2008c).

All industrial organizations require reliable BM&M data to assess project and organizational performance. The data is collected by trained industry representatives and screened by CII staff prior to analysis. Results of the analysis are reviewed by committee representatives prior to publication. Although the process is designed to protect the confidentiality of proprietary data, the mechanics of the program are open to participating groups to ensure it serves the interests of all participants (Ray et al. 2006).

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

In 2005, Ray et al., analyzed front end planning using completed project data from CII benchmarking and metrics database. The thesis presented research on several aspects of front end planning including front end planning cost related to total cost, and effect on good front end planning on performance metrics. Performance metrics such as cost growth, schedule growth, and change orders were analyzed with respect to PDRI

scores, the Pre-Project Planning Index, percent design complete, and Alignment Index (Ray et al. 2006).

The sample size for the front end planning phase cost related to total cost analysis included 395 owner projects, and 212 contractor projects that represented infrastructure, building, and light and heavy industrial sectors. The mean front end planning cost was 3.4 percent of the total cost for owners, and 4.3 percent of contractors for all projects greater than or equal to \$5 million. The research uncovered that contractors spend more than owners on front end planning as a percent of total cost for all small projects for every sector. Owners spend the most money as a percentage of total cost on large projects (greater than \$5 million dollars) in the infrastructure sector (Ray et al. 2006).

The research compared the PDRI scores of industrial and building projects to performance metrics. The 237 projects with PDRI scores above 200 at the end of the detailed design phase, 186 projects performed worse on average than the mean of the samples with PDRI scores below 200 (those projects with better scope definition). It was determined that the difference in cost growth factor and schedule performance for industrial projects was statistically significant when the PDRI was executed. All differences in the performance metrics for building projects were statistically significant when the PDRI was used (Ray et al. 2006).

The percent design complete analysis found that the median percent design complete sub-sample of 27 industrial and 21 building projects outperformed the sample below the median percent design complete, on average, for cost and schedule performance. The median percent design complete of the sub sample was determined to be 20 percent. This leads to the conclusion that if the percent design complete was greater

than 20 percent, the project costs would decrease by 5.6 percent versus the project estimate at end of front end planning (Ray et al. 2006).

The researchers also analyzed 676 projects, 609 industrial and 67 building projects, to determine if the CII Pre-Project Planning Index score has an effect on the performance metrics. The Pre-Project Planning Index score has a rating scale from zero to 10. The higher the index, the greater defined the project is considered. For industrial projects, the results of the analysis show that the difference in the cost, schedule, and change order performance were statistically significant. For the building projects, the analysis was inconclusive, indicating the necessity to collect further data within the building sector (Ray et al. 2006).

Data sub-samples of 70 projects were analyzed to compare the Alignment index scores with the project performance metrics. The alignment index was based on the alignment thermometer, which was developed in previous research efforts (CII 1997). The thermometer consists of ten questions with a score range between 0 and 10. It is considered that the higher the score, the better the team is aligned. The mean alignment index score for the sample set was determined to be 6.5 percent. On average, sample projects at the end of detailed scope development, which had an alignment score greater than the median, outperformed the projects with scores below the median on all three performance metrics (Ray et al. 2006).

Finally, the usage of the PDRI tool by the CII membership was analyzed. In summary, 61.7 percent of CII member organizations are using the PDRI to aid in their front end planning efforts (Ray et al. 2006).

2.8 STO CRITICAL ISSUES

Approaching an STO using only greenfield project management techniques will most likely not lead to success. For activities that must be executed during the STO, effective early planning will improve the STO performance in terms of both cost and schedule. CII shows that planning for STO activities often result in limited durations with schedules showing tight tolerances and minimal slack time (CII 1991). Previous research conducted and detailed in another CII publication indicates that the coordination between critical maintenance work and planned activities helps overall project effectiveness (CII 2001).

The following unique and critical success factors were identified by the research team, and as part of the case study analysis detailed in Howard et al. (2008), as requiring additional care during front end planning of an STO; each needs to be considered when planning an STO (CII 2008a).

- **Alignment:** During planning for most projects, there is one project to be executed during a specific period. In the case of an STO, there typically are many individual projects and maintenance activities to be executed in the same period. From a overarching management perspective there is no longer a single focus, however staff or contractors working on individual projects may not see the overall vision and may maintain their individual focus. The organizational hierarchy and goals of the STO need to be understood by the various project teams.
- **Safety Management:** The nature of STOs imposes unique safety challenges in particular regarding work near existing operations and in close proximity to

multiple projects and contractors. Such periods of intense activity, with possibly competing objectives, may compromise safety if not actively managed. Consideration needs to be given during the STO to an overall safety program, and an enhanced emergency response capability.

- **Contracting Strategies:** Multiple contractors working on an STO with different contracting strategies may drive individual behavior that is not aligned with the overall objectives and priorities of the STO. Interfaces between projects, contractors, and the facility need to be planned and managed.
- **Availability of Resources:** Since the STO is characterized by a relatively short period of intense activities, availability of the required craft trades, engineering staff, procurement personnel, specialized contractors, or pieces of equipment such as cranes may be in short supply. In these periods of high demand, productivity or quality can suffer, negatively impacting cost and/or schedule. Additionally, resources to provide site training or orientation prior to and during the STO may be taxed during these periods. In some cases, input from these training resources may be required in the front end planning stages of the STO.
- **Logistics:** Due to competing priorities between the individual projects and maintenance activities making up the STO, there is a need for detailed, integrated plans that correlates the various activities. Coordination of lifts, swing space requirements, and other logistical issues must be understood prior to the STO. Material movement and staging prior to and during the STO must be coordinated.
- **Space Allocation:** With intensive activity during the STO, available space will often become constrained for equipment staging, part staging, work areas, lay

down areas, as well as pedestrian and traffic flow, and so on. A common, space allocation process for the STO is required, integrating all projects.

- **Fixed Resources:** Demands from various groups for the fixed resources of the facility can negatively impact the STO. Competition for the use of bridge cranes, service air, water, power, and so on can result in cost or schedule impact delays. Availability of these services can be affected by the work scope of the STO, as systems are taken out of service for maintenance or project tie-ins.
- **Control of Work Zone:** It is common to have multiple work zones controlled by multiple contractors during an STO. Consideration needs to be given to how these work zones will be controlled to ensure safety and efficiency, including pedestrian traffic, material movement, work space availability, and so on across these boundaries.
- **Lock Out/Tag Out Requirements:** STOs can be very complex, with diverse work in many locations on many different process systems. Some of these activities may not normally occur during online maintenance activities. This may increase the complexity of the lock out/tag out requirements. Periods of intense activity levels during an STO may strain the management of the lock-out/tag-out process. Older facilities may have degraded conditions that will render the most efficient or planned lock-out isolation points unavailable. The accessibility and condition of critical project lock-out/tag-out isolation points should be confirmed prior to the STO.
- **Unknown Site Condition:** Accurate knowledge of site conditions is critical to maintaining schedule and cost. Project interfaces to the existing facility may turn

out to be different than planned and project schedules may need to be adjusted with little notice. Accurate inventories of designated hazardous substances (asbestos, lead paint, etc.), accuracy of drawings and contractor knowledge of site operations, maintenance and safety procedures are some of the site conditions that may impact the STO.

- **Unplanned/discovery work:** Maintenance activities are usually also conducted during an STO. The possibility of unplanned/discovery work as a result of maintenance or project activities is great and can impact the overall scope of work to be conducted during the STO. Risk mitigations plans should be in place and procurement and contract strategies should be aligned to effectively anticipate and manage such situations.
- **Environmental Management:** Special precautions may be necessary to ensure the STO does not adversely affect the environment. Such items as noise, dust, and hazardous material control need to be managed. The scope of the STO needs to be understood to ensure that environmental control systems are not inadvertently taken out of service.
- **Permit Requirements:** Permits required by the local, regional or federal regulatory bodies required to construct, maintain, and operate the facility need to be obtained, in most cases, prior to the start of construction. Since several projects making up the STO may have specific permitting requirements, an integrated plan generally is required.

- **Security:** The intense nature of the STO may influence or tax site security arrangements. Additional resources may be required to manage movement of personnel, tools, and equipment in and out of the facility.
- **Traffic Control:** Consideration needs to be given to traffic control both entering and within the site, including material and equipment delivery, staging and conveyance as well as employee and contractor parking during these periods of intense activities.
- **Communication Strategy:** Effective communication strategies from the workforce to management levels are required prior to the STO. These include protocols for routine workforce communication, STO progress reporting, work group handoffs, and urgent item resolution (e.g., delays, unforeseen conditions, labor or material shortages, etc.).
- **Project Controls:** Reporting processes for controlling cost, schedule, and scope need to be flexible enough to supply the required information at the required time intervals for the overall STO and for individual projects as required.
- **Procurement Plan:** The fixed return to service date and the interdependencies imposed by projects and maintenance activities require a well-functioning procurement plan that is aligned with the integrated schedule, and be adaptable to unforeseen events. The procurement organization needs to be able to deal with urgent material requests and changes to contracts during the STO to effectively deal with discovery work. To the extent possible, potential material discovery risks (e.g., spare parts that are likely to be required) should be evaluated and actively managed prior to the STO.

- **Commissioning Plans:** The sequencing of the commissioning and start-up/return to service activities needs to be integrated and supported by a single plan (CII 2008a).

2.9 Front End Planning Toolkit

In 2006, CII's RT 213 developed a Front End Planning Toolkit for the purpose of allowing companies to have a “one stop shop” for front end planning tools. The purpose of this Front End Planning Toolkit is to define the functions involved in front end planning, and to provide a process that can be used in the front end planning of capital projects (CII 2006).

At the time this research team was formed, CII had four existing tools focusing on front end planning. These tools included: the *Pre-Project Planning Handbook*, the *Project Definition Rating Index, Industrial Projects*, *Alignment During Pre-Project Planning*, and the *Project Definition Rating Index, Building Projects* (CII 1995, CII 1996, CII 1997, CII 1999, CII 1999b, CII 2005, CII 2006a, CII 2006b, CII 2008d, CII 2008e). Each of these tools had been developed by CII research teams at different points in time. Even though they all were very effective tool, the team decided that it must update, or archive, each in order to provide a consistent message concerning the critical issues of front end planning.

The 2nd edition of *Alignment During Pre-Project Planning — A Key to Project Success* (initially published in 1997) was updated using materials from a recent CII project security study funded by the National Institute for Standards and Technology as well as the collective knowledge of the research team members. This new edition

clarified the methods for using the “alignment thermometer” tool, updated references, and shed new light on alignment and its relationship with security and sustainability issues (CII 1997, CII 2005, Griffith and Gibson 2001).

The 3rd editions of the *Project Definition Rating Index, Industrial Projects* (initially published in 1996 and revised in 2006) and *Project Definition Rating Index, Building Projects* (initially published in 1999 and revised in 2006) were updated to reflect knowledge gained from their usage over the past several years as well as specific issues related to renovation and revamp projects (CII 1996, CII 1999b, CII 2006a, CII 2006b, CII 2008d, CII 2008e). The team again drew upon materials from the CII / National Institute for Standards and Technology Security Study, and the collective knowledge of the research team members. The resulting updates significantly clarify the methods for using the Project Definition Rating Index, eliminated the “yes/no” options for some element definition levels (in the Industrial Projects version), discussed tool usage by both owner and contractor organizations, and referenced security and sustainability issues. These changes made these tools much easier to implement and addressed issues that were currently of major concern to planners (CII 2006).

The *Pre-Project Planning Handbook* (published in 1995) was reviewed by the research team. Although much of it was still valid, the team decided that its message needed to be updated both in terms of content and format. The FEP Toolkit draws heavily on materials from the *Pre-Project Planning Handbook*, which was archived by this effort. The objective of the Toolkit was to encourage the use of FEP knowledge, and promote consistency and excellence in planning to improve capital project effectiveness. By using the toolkit format, documents, templates, and tools, the organization can adapt the Toolkit

for internal use. The toolkit was developed in HTML language, and can be easily adapted to an organization's intranet or extranet site (CII 2006). The Front End Planning Toolkit has been updated to Version 2.0 by RT 242 to include the latest updates of the front end planning tools as well as to reflect changes resulting from updates related to the planning and execution of renovation and revamp projects (CII 2008)

2.10 Research Charrettes

A planning charrette is a tool used by designers and facility planners to elicit ideas and leverage industry experience in an intense and targeted workshop format. Based upon the French word for “cart,” “charrette” became part of the architectural vocabulary in the early 1900's at the Ecole des Beaux-Arts in Paris (Healey 1991). Currently, planning charrettes are being utilized for a variety of activities including facility programs, master plans, strategic operational plans, primary architectural designs, and more (Carter and Burgess 2002; Gibson and Gebken 2003; Lindsey et al. 2003; Lennertz and Lutzenhiser 2006). Organizations as diverse as the Federal Highway Administration, the U.S. Department of Energy, the U.S. Green Building Council, the U.S. Army Corps of Engineers, and the American Institute of Architects espouse the benefits of these workshops in the planning environment. The value of these sessions is found in gathering the key stakeholders in a short, intense work session, gaining input and making decisions that will lead to better project planning, alignment toward project goals, and ultimately better outcomes (Gibson and Whittington 2008).

A research charrette is a derivative of the planning charrette. It is a unique marriage of the planning charrette with social data collection methods to elicit ideas and

leverage industry experience in an intense and targeted workshop format. Its major advantages are the synergy gained by having a group of industry experts interacting in a structured manner, the ability to use multiple data collection strategies, and the fact that when the workshop is over, the data have been collected and are available for analysis. It also has a secondary benefit of helping to get “buy-in” from industry participants to use or rely on the results of the charrette and to solicit follow-on involvement for validation or testing of any methods, findings, or “best practices tools” developed (Gibson and Whittington 2008).

Research workshops (or charrettes) in construction or project research are not new. As an example, the National Research Council regularly convenes groups of experts and uses their collective knowledge and experience to determine findings and recommendations about specific issues. Research charrettes have been used to test software (Clayton et al. 1998). The term “charrette’s” genesis was in teaching architecture and it is still used in that regard today (Walker and Seymour 2008).

The typical research charrette would combine several types of data collection methods into a four to six hour session to focus on a single thread of the investigation. The charrette is managed by the researcher or research team, and is very organized in its focus. At the end of the workshop, all data necessary to complete a research investigation phase has been collected.

Research charrettes are typically very effective in exploratory studies. Combining the different methods used in the charrette with other data collection strategies outside of the charrette (perhaps specific case studies, structured interviews, statistical database

analysis, etc.) provides a ready method to accomplish the triangulation needed to conduct one of these studies (Gibson and Whittington 2008).

The research charrette uses the nonprobabilistic sampling method. Participants in the charrette (some of which may have travelled long distances to attend) are generally invited based on past contacts with the researcher, recommendations from the research sponsor or oversight team, or are actively involved in an organization such as a department of transportation or a research consortium or trade group and respond to an advertisement. Generally, the charrette will have certain parameters that are applied to screen the participants based on qualifications related to the study. For instance, the number of years experience that a person has been in industry, the types of projects that he or she has been involved with, educational background and so on which allow the researcher to focus in the proper area of assessment for the study. Several charrettes may need to be conducted at different geographic areas to improve participation. This dispersion will typically allow a more robust response set, but geographic differences cannot be inferred based on the locations (Gibson and Whittington 2008).

2.11 Summary

Previous research conducted by CII indicates a strong correlation between effective front end planning and improved project success measured by overall project cost, project schedule, and change order growth. The research shows that well performed front end planning can reduce project costs by as much as 20 percent, 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).

Ever since the effort began in 1991, many CII organizations have incorporated a front end planning process into their project life cycles. The FEP Toolkit makes the front end planning process implementation easier incorporating all front end planning tools into a user friendly application.

It should be noted that little research has been performed on front end planning specifically for R&R projects and almost nothing on STO projects. The research performed for this document will aide in discovering differences, if any, between R&R and greenfield projects related to FEP and other metrics. This research report will also describe the creation and testing of a novel tool for the planning the coordinating STO projects.

CHAPTER 3: METHODOLOGY

Chapter Three will discuss the methodology used to gather information for both qualitative and quantitative analysis. The entire outline of the methodology for the CII Research Team 242 will be illustrated, as well, a detailed breakdown of the research presented for this document.

3.1 Overall CII Research Team 242 Methodology

This research report details the research effort initiated by CII Research Team 242: Front End Planning for Renovation/Revamp Projects. Figure 3.1 outlines the extent of the research undertaking with the shaded steps performed by others.

Several other research endeavors and tool development efforts were conducted by the team. A phase I survey of CII membership was conducted in order to determine attitudes and perceptions toward R&R usage. Case studies of previously conducted projects were undertaken to identify critical success factors and overarching issues (Howard et al. 2008). The third editions of the Industrial and Building Project Definition Rating Index (PDRI) were updated to include unique aspects of R&R projects for scope definition (CII 2008d, CII 2008e).

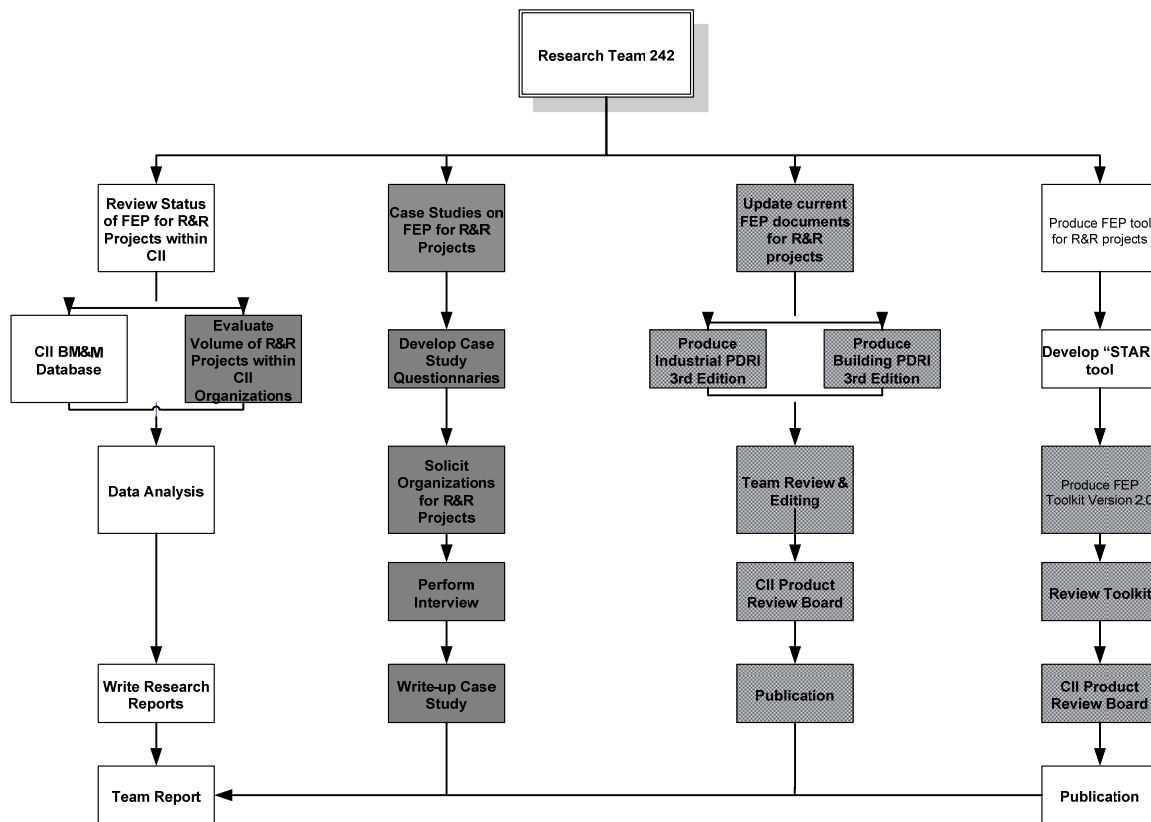


Figure 3.1: CII RT 242 Research Diagram

The research team has also been charged with informing organizations of the newest technology to aide in the front end planning process. Twenty-four technologies have been demonstrated and analyzed, including high definition laser surveying, ground penetration radar, ultrasonic testing, and risk analysis software among others. Each individual technology was listed on a project condition investigation (PCI) card which were then divided into project conditions with a matrix as well as a “transit map” which will lead the organization to several options for tools to assist in front end planning. The third edition PDRIs have been incorporated into the version 2.0 of the front end planning toolkit along with the new STAR tool and the 24 PCI cards (CII 2008, CII 2008b).

3.2 Report Methodology

The report methodology diagram for this document, which is illustrated in Figure 3.2, focuses on analysis of CII benchmarking and metrics data and the development and testing of a new management tool for planning STO projects.

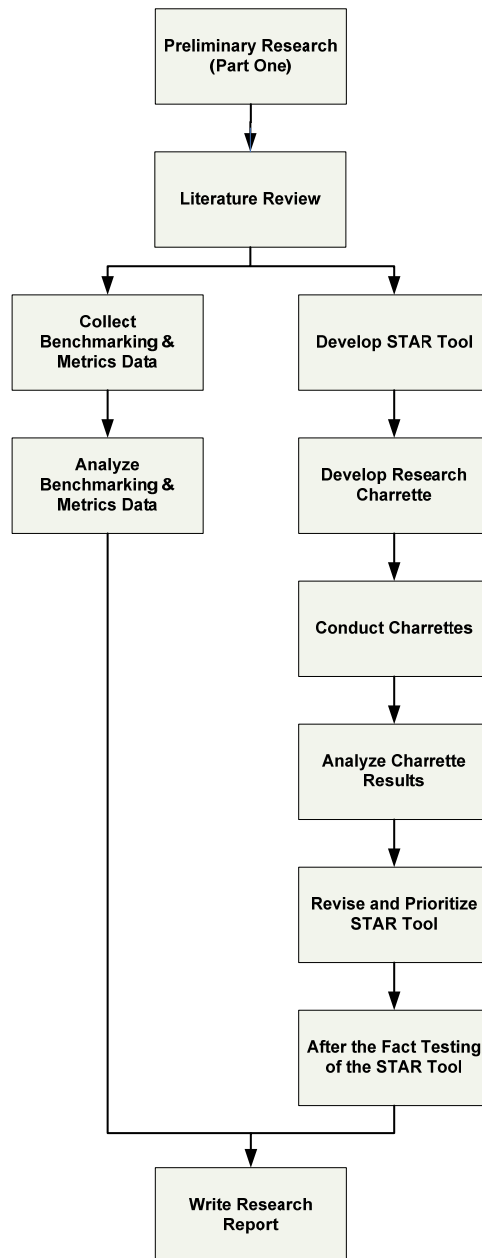


Figure 3.2: Report Methodology Diagram

3.2.1 Background

In order to understand the importance of front end planning in respect to all project as well as R&R, a review was conducted and presented in Chapter Two. A large amount of work has focused on front end planning of capital projects generically. During the background review, it was concluded that there was little information on front end planning related to R&R projects and almost nothing documented on the planning and coordinating of STO projects. CII provided a listing of projects in the Benchmarking & Metrics database to compare R&R projects versus greenfield projects to determine front end planning and practice usage.

3.2.2 Benchmarking & Metrics Analysis

After the initial phase of the research effort explored the differences between greenfield and R&R projects qualitatively, the authors and the research team needed to compare the project types quantitatively. Based on a selection of projects from within the CII Benchmarking and Metrics database, the dataset was stratified according to project type, project sponsor characteristics, and construction dollar size. The sample set was also analyzed for differing contract strategies. Next various front end planning indices and best practices metrics as well as performance metrics were compared including statistical treatments for standard deviation and ANOVA analysis of variance.

The ANOVA analysis of variance evaluated the indices to determine if the sub-sample differences were statistically significant. The confidence interval of the data needs to be less than, or equal to 90 percent; the p-value less than or equal to 0.10, or the F critical value cannot equal the F value. Three assumptions were made about the sample

being tested. The first assumption was that the data had a normal distribution. The second assumption was that the two groups are independent. The third assumption was that the samples are homogenous and have equal variances. The entire analysis is presented in Chapters Four and Five.

3.2.3 STAR Tool Development and Testing

As previously discussed, Shutdown/Turnaround/Outage (STO) “projects” are a subset of renovation and revamp projects. These projects are generally a combination of one or many smaller projects or discrete activities. Each STO is typically unique and can be small to very large in terms of construction costs, although almost always constrained to a relatively short schedule duration. STOs usually are typically focused in the industrial construction sector (although not always) and have specific time constraints for performance, and large business cost drivers for successful completion on a tight schedule. These cost drivers include such things as significant losses of production or sales opportunities resulting from any delays. For these projects, coordination of effort between multiple projects, each with their own unique issues, with facility maintenance and operations activities is extremely important. Unforeseen conditions and work requirements often come up during the work.

As noted in the background literature review, few references deal with this critical industrial process. This fact and subsequent discussions with the research sponsor lead to the direction of this exploratory research effort to develop the STO management tool.

Based on the STO critical issues as identified and described in Chapter Two, the STAR Tool was initially developed by a sub-team of ten CII research team members who

specialize in the planning and implementation of STOs. Nine summary categories and 94 elements were refined for a joint assessment of the multiple projects that will eventually converge during the STO. The complete, final version of the STAR Tool is available in Appendix B.

Once the initial tool was drafted, a series of four external workshops or charettes were held to prioritize the tool as well as provide input and suggestions for refinement. The structured workshops allowed interaction between industry professionals while also improving the STO planning tool and were modelled after previous workshops conducted by CII. These suggestions included a detailed vetting of the individual elements within the STAR Tool as well as assessment of tool appearance, ease of use, and overall usefulness. The workshops included a total of 67 participants representing 39 separate organizations with combined project management experience of over 1,300 years. Appendix C provides a list of the companies providing participants for the workshops.

Each of the respondents was asked to indicate the relative importance (priority) of each of the nine categories to the planning process for STO projects. The respondents used recent or existing STO projects as a basis for the prioritizations and these totaled approximately \$5.5 billion in total installed costs. Complete details on the development of the Tool is available in Chapter Six.

After the STAR Tool was prioritized and completed, participants at the workshops were solicited to perform additional testing of the Tool on either an in-planning STO or a recently completed STO. Copies of the validation questionnaire can be found in Appendix J. The industry professionals were asked to return completed questionnaires, copies of the filled out STAR Tool and accompanying documentation to

the authors. Overall four STOs provided performance testing data. Based on these responses the STAR Tool provided excellent assistance to the planning and coordination of the STO process. However, because of the small number of projects and limited industrial sectors actually providing data during this “beta-testing” phase of the STAR Tool, additional Tool testing is needed from CII. Chapter Seven includes a description of the STAR Tool testing procedures.

CHAPTER 4: STRATIFICATION OF DATASET

Chapter 4 discusses the stratification of the dataset from the benchmarking and metrics (BM&M) database. This database contains records from respondents within the Construction Industry Institute membership. The complete BM&M database contains greater than 1600 projects representing a total installed cost of over \$76 billion; it should be noted that sample projects are self-nominated and are not random. Sample projects used in this analysis came from different sectors of the construction industry including building, heavy industrial, light industrial, and infrastructure projects as developed by the Construction Industry Institute's benchmarking and metrics program. CII BM&M management staff provided a sample dataset of projects for comparison of R&R and greenfield projects to be used in this research effort. During 2002 CII changed the criteria for calculating several of the indices and thus limited the available projects that could be included in the dataset under review. The database used for this analysis included 679 projects with a total installed cost of greater than \$23.5 billion. However, not all of the projects were included in all the analysis because of missing or incomplete information. The analysis of the project records involved in this research effort was conducted using the Microsoft Excel® program.

4.1 Hypothesis

The authors hypothesize that R&R projects are typically more numerous than greenfield projects but they are also typically much smaller in terms of construction costs and project durations. As such the specific contract strategy chosen for each project classification will vary accordingly.

4.2 Characteristics of Projects

The two project characteristics compared as part of this research report are greenfield and R&R. CII defines a greenfield project as a project that is constructed on a site that has not been built upon in the past. The project may be located adjacent to other facilities (CII 2008). Aliases for greenfield projects include grassroots and new construction among others. The aliases for R&R projects as defined by RT 242 include:

- Retrofit
- Reconstruction
- Outage/Shutdown/Turnaround
- Maintenance project (does not include routine maintenance actions)
- Modernization
- Improvement project
- Repair project (does not include routine maintenance actions)
- Alteration
- Brownfield
- Rehabilitation
- De-bottlenecking
- Refurbishment
- Modification
- Upgrade
- Makeover
- Rebuild
- Overhaul
- Replacement