

ASSESSMENT OF PROJECT CONTROLS FOR
SHUTDOWNS/TURNAROUNDS/OUTAGES

by

PRATHEEKSHA PREMRAJ

STEPHANIE C. VEREEN, COMMITTEE CHAIR
W. EDWARD BACK
GARY MOYNIHAN
ERIC MARKS
MARCUS PERRY

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ABSTRACT

Shutdown/Turnaround/Outages (STOs) are unique construction projects required to meet demands such as maintenance needs, increased market demand, and changes in technology. Shutdown, Turnarounds, and Outages projects (STOs) are maintenance projects subject to compressed schedules, and hence require a time efficient cost control system with robust monitoring, reporting, and mitigating to ensure the success of the project.

The purpose of this research was to address the significant lack of literature about project controls for STOs by identifying current project control tools used by industry practitioners. Relevant data was collected using the Delphi methodology. The Delphi process, an approach particularly effective in exploring areas of research where there is little or no information available, was applied to the collected data to allow for anonymity, interactivity, and feedback in the survey process.

The data collection process involved three rounds of surveys: (1) Survey Round 1 was conducted using questionnaire, (2) Survey Round 2 through conducting semi-structured interviews, and (3) Survey Round 3 using questionnaire. The questionnaires used in Survey round 1 and Survey round 2 had two parts – Part A and Part B. Part A was designed to collect demographic data and Part B had three main sections. The first section was to prove that STOs vary significantly from traditional construction projects; the second section to obtain information on current practices, and section three to analyze barriers to implementation of optimum project controls.

The research contributes to the body of knowledge through addressing the significant lack in literature on STOs and project controls for STOs. Additionally, the paper informs less experienced professionals about information required for effective planning and risk management processes by providing a list of risk factors. The research results will be fundamental to improving project controls processes for STOs and may also benefit traditional projects and provide significant information on the cost and schedule controls for STOs.

DEDICATION

This dissertation is dedicated to the memory of my father who never got to see this day, Pooja Mucherla without whom this would not have been possible, and my family.

LIST OF ABBREVIATIONS AND SYMBOLS

X	Number of successes in independent Bernoulli trials
n	Number of independent Bernoulli trials
p	Probability of success
\hat{n}	Point estimate of sample size
\tilde{p}	Point estimate of probability of success
α	Level of significance

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CHAPTER 1

INTRODUCTION

This chapter provides insight on the background on the motivation for the research. In addition to this, the chapter also provides a brief introduction to the key concepts involved in the research. Finally, the problem statement of the research is presented.

Background

The history of construction dates back to the development of civilizations (Schexnayder and Mayo, 2003). Over the years, innovation of equipment, materials, and management processes driven by factors such as technology, market demands, and competition has helped improved the construction industry (Veshosky, 1998). The effects of innovation are reflected in all aspects of a construction starting from concepts such as front end planning techniques to the development of contracts and execution. In the past few years, there has been significant increase in research studies addressing the problems and concerns of the construction industry (Abudayyeh et. al., 2004). This research contributes to the body of knowledge and enhances the efforts of furthering research on the construction industry by exploring the project controls process for shutdowns, turnarounds, and outages (STOs).

Each construction project is unique due to the unique nature of distinctive products and the constraints or challenges involved, and hence have unique deliverables. Deliverables are the tangible outcomes of a project that are delivered to the owner or stakeholders. However, there

are basic performance measures that are expected of all projects. Performance measures are instruments used to compare the outcomes of the project to an established benchmark or a planned value to evaluate success. Performance measures include being on time and budget while meeting the safety and quality requirements. There have been several studies over the years to understand cost, schedule, safety, quality and other performance measures (Dainty et. al., 2003; Chan et., al, 2004; Nitithamyong and Skibniewski, 2006). Yet, the construction industry still faces the challenges of cost and schedule overruns.

Planning is crucial to the success of a project. The planning phase begins at the conception of a construction project. The planning phase should proactively take into consideration all the risks and uncertainties that could possibly affect the success of a project. However, good management practice requires that proactive and detailed planning be followed by tracking, monitoring, reporting, and mitigating (De Wit, A., 1988). Ideally, a project is successful when the actual deliverables are the same as the planned deliverables. Good construction management practices or best management practices aid in minimizing any deviations from the planned deliverables, for example, minimizing cost and schedule overruns (Attalla and Hegazy, 2003). Good project controls help to monitor and track deviations from planned outcomes, if any, in a timely fashion to deliver successful projects.

Project Controls. Olawale (2010) defines project control as a task undertaken by project managers to overcome problems like delays and budget overspends. According to Olawale (2010) project controls is a complex and iterative process that is achieved through setting performance standards, comparing the actual performance of a project to planned performance standards and taking corrective actions if required. Though the process can be used to track any objective including cost, schedule, safety, and quality, this research will focus mainly on the

aspects of cost and schedule. The main steps of the project controls process include tracking, monitoring and controlling, reporting, and mitigation of variances. A variance occurs when the project outcome is different from the planned outcomes. The required corrective action depends on the variance. For example, if the cost at a certain phase of the project is higher than the planned cost for the phase, the change is reported to the project manager or cost estimator. The project team analyzes the reason for this variation. If the variance was due to a factor like an act of God the effects cannot be rectified and steps need to be taken to reduce costs in other components to ensure the final cost is the same as the planned cost. This is a constant and continuous cyclic process.

Using project controls is a project management practice that is designed to ensure that a project successfully delivers the planned deliverables (Morris et. al., 2010). Olawale et. al., (2010) state that project controls help to ensure that a project finishes on time, and within budget while achieving other project specific objectives. It involves planning, monitoring, and taking any required corrective actions. The project control process includes constant measuring of the progress of a project and taking corrective actions (Kerzner, 2003). Figure 1 adapted from Morris et. al., demonstrate the project control process outline.

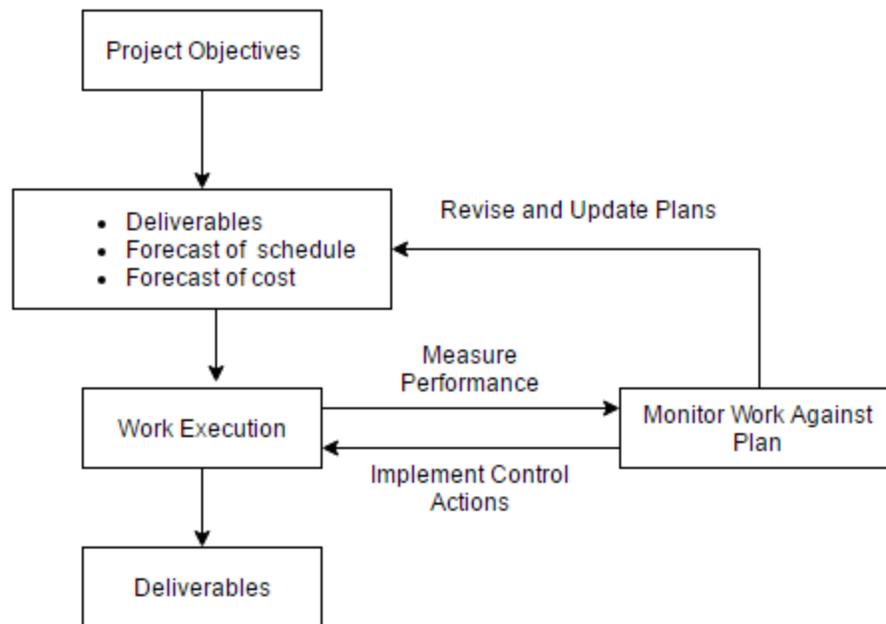


Figure 1 The Project Control Process

Figure 1 shows how project controls are integrated within the life cycle phases of a project. The first step is to clearly define the objectives of a project. The next steps are the planning of the deliverables, and forecasting of the cost and time necessary to carry out the work and complete the deliverables. A feedback loop is shown to represent the measuring of the performance of a project, monitoring to compare it against the plan, implementing control actions, and revising and updating the plans to carry out the work and finally complete the planned deliverables.

There are several tools and techniques that are part of the project management practices. Tools include aids like software packages that help in tracking and measuring project performance. Techniques are methods and calculations used to identify expected deliverables and to measure and interpret actual performance, changes, and implications of the changes. Project control tools and techniques are developed to address not only the processes and steps

required to successfully complete a project, but also considers the human factors such as labor skillset that play a significant role.

Some of the most commonly used tools that are used in project controls include Gantt Bar Charts, network diagrams, and the Critical Path Method (CPM) (Olawale, 2010; Wiley, 2007). There are several software packages that aid in the project control practices and some examples include Microsoft Project and Primavera. These software tools are designed to aid a project management process and help the project control process by providing summaries and outputs that help track features including percentage complete of each task, comparisons of the predicted budget to the actual cost, and allocation of resources including workers and materials.

Some of the most common project control techniques include earned value analysis (EVA), the balanced scorecard (BSC), and using critical success factors. EVA involves the comparison of the actual performance of a project to the predicted performance to monitor and report the performance against the planned deliverables including the schedule and the budget. BSC was originally proposed by Kaplan and Norton (1992) and was developed to overcome the effects of metrics that relied strongly on finances. Metrics are used to obtain insight into the performance of a project and to ensure effectiveness (Gunasekaran et. al., 2001). Critical success factors can be defined as the underlying factors that are essential to successfully meet the objectives (Wiley, 2007). These techniques are commonly used to measure and improve the performance of a project and facilitate good project management practices.

There have been several studies conducted over the years to improve the existing tools and techniques and to develop new tools and techniques (Olawale, 2010; Wiley, 2007); however projects often still fail to meet the planned deliverables. Cost overruns and schedule delays continue to be of concern to researchers and practitioners in the construction industry. The high

level of uncertainty and the unique nature of each construction project play a role in contributing to the deviations that can possibly lead to project failure. The higher the uncertainty in a project, the greater is the need for a more effective project control process. For the purpose of this research, the scope is limited to a particular sub-section of construction projects called STOs that typically involve higher level of uncertainty in comparison to traditional construction projects.

The existing literature on the topic of project controls provides adequate insight about the existing tools and techniques for project controls related to traditional construction projects. The management techniques for projects controls are the most crucial element of the project controls process. The project controls process is a constant and continuous process that requires constant monitoring. Any variances should be identified in a time efficient manner. Once these variances are identified, they have to be reported to the individual or the team responsible for mitigating these variations. Any changes as a direct result of the mitigation needs to be implemented efficiently. The implementation can be considered efficient if it is successful in aligning the project outcomes to the planned outcomes. The effect of the changes on the construction process needs to be monitored and the process is repeated throughout the construction process. Once a project is completed, a documentation of all the variances should be recorded along with the mitigation performed and the causes for the variation. This whole process depends profoundly on the management capability of an individual or a team to be able to transition between the different steps involved in a timely manner. Studying the behavior of this individual or team can provide insight into the best management practices that contributes to project success.

Having an efficient project controls process, inclusive of the tools, techniques, and management practices, is crucial to the success of a construction project. The monitoring and feedback loop is considered to be a critical success factor by several researchers (Pinto, 1988;

Baker, 1983; Locke, 1984; Martin, 1976; Sayles, 1971). The identification of current practices for project controls, improvisation and improvement of existing practice, and development of new tools, techniques, and management practices for project controls are research areas that need attention due to the impact they have on project success.

As demonstrated, several studies have been made to identify existing project control tools, techniques, and management practices for traditional construction projects, to improve the project controls, and the development of new tools, techniques, and management processes. For this research, a traditional construction project is used synonymous to a new construction project starting from inception to startup and commission phases. What was not sufficiently addressed was the existing tools, techniques, and management processes for specialized project types including maintenance projects.

A subset of the maintenance projects is those associated with renovation and revamp. Shutdowns, turnarounds, and outages (STOs) are a subset of renovation and revamp projects. STOs are significantly more challenging to plan and execute in comparison to traditional construction projects. Poor project controls process for STOs has been a concern for the past few decades (Willenbrock, 1987). One of the major challenges associated with STOs is the poor scope control due to higher risk and unforeseen tasks. Most of the best management practices related to STOs are unique to the firm working on a project. Enabling the experts to provide information on the existing tools, techniques, and management practices and documenting them will enable project teams to obtain sufficient information to be able to develop a more comprehensive scope definition that can enable project success.

The severity in the lack of literature on STOs is validated by the lack of a standardized definition for the terms ‘shutdown’, ‘turnaround’, and ‘outage’. The Construction Industry

Institute (CII) classifies STOs as a subset of renovation and revamps type projects. Since much of the little literature available on STOs has been published through CII supported research attempts, this research agrees with their definitions. CII defines STOs as “a project or portion of a project(s) that is executed during a planned disruption in normal operation, where return to service is a business priority” (CII, 2009).

STOs vary significantly from traditional construction projects. The poor scope definition, interaction with an active facility, and short execution phase result in high risk. Considering the higher risk and uncertainty involved, it can be assumed that the project control process has to be more robust and efficient to deliver a project successfully. Each construction firm, working on STOs, seems to follow a management process that is unique to the firm. There is an absence of a standardized guidance that provides information on the various tools, techniques, and management practices related to project controls that may be utilized on STOs. The availability of this information can provide significant guidance to the practitioners. Since STOs vary significantly from traditional construction projects, these tools, techniques, and especially the management practices can be reasonably assumed to be unique to STOs. The need to address higher risks generate the need for highly efficient management practices which if identified could be of significant benefit to traditional construction projects as well.

One of the greatest challenges involved in the execution of STOs are those pertaining to the scope definition. Unforeseen work is very common in the case of STOs (Whittington, 2009) and hence, even with extensive front-end planning (FEP), the need for a very robust project controls process becomes extremely necessary to be able to complete a project successfully after accounting for any scope change. During the execution phase of STOs, one of the major

challenges is driven by the concurrent projects and maintenance activities that render controlling the construction activities increasingly difficult.

Shutdowns/Turnarounds/Outages

Shutdown/Turnaround/Outages (STOs) are planned interruptions to the normal activity of a plant/industry in part or whole. Some of the intended purposes of these projects include expanded need for overhaul, retrofitting, and accelerated maintenance of an existing facility (Willenbrock, 1987). They are an integral part of major industries including the power industry, chemical plants, and other process plants. There are significant costs associated with both the construction phase and the loss in production in the event of a delayed project completion. Avoiding consistent maintenance can also result in increased costs due to downtime. Every day a facility is offline; there is significant loss of revenue generated. These projects are necessary for maintaining facilities and to keeping them up to date with product needs and design codes.

Some of the most common reasons for requiring these types of projects include a new market demand as the result of a new competitive challenge, an expanding market or the emergence of a new market; profit enhancement needs to improve operational efficiency and/or energy efficiency and to reduce waste; and customer requirements to increase throughput or to improve quality (Levitt, 2004). The advantages and benefits of these planned interruptions and the impacts of failure of components/processes and loss of production as the result of the absence of these maintenance projects are major drivers of STO type projects.

Shutdowns. Shutdowns include stopping the operations of a facility partially. These are planned interruptions and are usually for maintenance projects. Often, they are part of an inspection process. Apart from construction elements such as updating a particular technology,

these may involve dealing with turbines, pumps, and other similar components. They involve intense front end planning processes that may take longer than the execution of the work itself.

Turnarounds. The second broad classification of maintenance projects that are a subset of renovation and revamp projects are called turnarounds. Turnarounds are typical to the oil, gas, and petrochemical processing industries. Turnarounds are routine maintenance that is performed in order to ensure uninterrupted operations of the plant or facility. Turnarounds are planned well in advance and are executed in a periodic and systematic fashion since it has a direct impact on the cost of maintaining the facility and also, the production and bottom line profitability. The quality of the turnaround determines the reliability of the facility (Bevilacqua et.al, 2009). Turnarounds also play a crucial role in determining the lifecycle cost of the facility.

Turnarounds, like shutdowns and outages, are more complex than traditional construction projects. A short execution phase and hence, a tight schedule increase the complexity of these projects considerably (Bevilacqua et.al, 2009). Delays and expanding work scope due to discovery of unplanned work also contribute to the increased risk associated with turnarounds (Raoufi, 2014).

Outages. Outages are most common in the power industry and are considered to be partial shutdowns. The urgency is higher in these projects and typically takes longer to perform. The facilities have to perform continuously even if not at full capacity. Reduced capacity is also not allowable beyond a certain period of time. Workforce buildup is fast and the work schedule is intense in these projects; work schedules can be a 7 day workweek, 12 hour days, and two shifts to perform these operations (Hinze, 2005). The contract is usually awarded to a single contractor.

Outages, like turnarounds have higher levels of complexity and challenges in comparison to traditional construction projects. The level of control is often limited due to interaction from an active work environment and the schedule is limited (Willenbrock, 1987). There is very little flexibility or latitude in the completion time due to the economic impacts affiliated with the inability to complete on time.

Summary

In essence, there is limited literature available providing insight into STOs and the project controls process used for these projects by industry practitioners. There is literature available on the project controls for traditional construction projects. However, due to significant differences between STOs and traditional projects and the increased uncertainty on STOs, it is unlikely that the project controls for traditional projects are directly applicable to STOs. Apart from this, there is a need to identify the existing proactive strategies used to minimize the high risk involved in these projects. There is a need to address the knowledge gap and to summarize existing project controls used by construction industry professionals.

Problem Statement

Delivering a project on time and on budget are two of the most crucial requirements of any construction project. Project controls are fundamental to ensuring that these requirements are met through monitoring, controlling, analyzing, and remediating any variations.

Shutdowns/turnarounds/outages (STOs) have significantly shorter construction or execution phase in comparison to traditional construction projects. The challenges and risks involved in STOs are high due to factors including the integration with an active working environment, shorter duration, and multiple independent tasks. This generates a need for a more robust project controls process that is more frequent and efficient than the process used for

traditional construction projects. The project controls process involves several tools, techniques, and management practices. There is a need to understand and documents these tools, techniques, and management practices to be able to obtain a comprehensive understanding of the project controls process for STOs. These provide the basis for generating a list of best management practices and also in the identification of the barriers to the implementation of some of these best management practices.

Though STOs have been executed for years, the expertise required to manage these projects seem to be limited to a few people who have significant experience. The lack of documentation of the existing tools, techniques, and management practices is compounded the lack of guidance through a comprehensive set of best management practices. This greatly limits project managers with little or no STOs from implementing a thorough and efficient project controls process. Documenting this information will provide project managers with a checklist of the factors to be taken into consideration for developing an efficient project controls process. It also helps the entire team to obtain an understanding of the general processes involved thus improving the team alignment. The identification of the barriers to the implementation of the best management practices will help the risk analysts in the risk management process by identifying some of the possible risk factors that may be encountered on a project.

The purpose of this research is to identify and document the tools, techniques, and management practices for project controls that are applied STOs by the construction industry professionals. Identifying and documenting these specific and unique project controls will be used to identify management practices that may be used to improve project success of traditional project.

For the purpose of obtaining the information on the existing tools, techniques, and management practices, the most favorable source was identified to be the construction industry professionals with experience working on STOs. Delphi was identified as the ideal methodology for the study since it allows interaction between the experts in an anonymous fashion. The methodology involves a feedback loop which allows the experts to view the results of each round and to provide further insightful information. The methodology includes two rounds of questionnaire surveys and a round of semi-structured interviews to obtain the information required to meet the objectives of this research. Since there is very little or no information available from the literature, the multiple rounds and interactive nature of Delphi methodology allows continuous improvement of the questionnaire and the data collection process.

Objectives and Scope

There is very little or no information available about the project control process for shutdowns/turnarounds/outages (STOs). The main purpose of this research is to provide a comprehensive documentation of the existing tools, techniques, and management process comprised in the project controls for STOs. This will help obtain a better insight and understanding of the processes involved in project controls. The three objectives of this research are:

1. To establish that STOs vary significantly from traditional construction projects:

The limited literature on STOs does provide some evidence to support the fact that STOs vary significantly from traditional construction projects. It provides some information on the factors that contribute to some of these variations. It is critical to be able to verify and validate these assumptions to justify the need for this research.

2. To investigate the existing tools, techniques, and management practices used in the project controls process for STOs:

Provide a comprehensive understanding of the project controls process for STOs, it is essential to obtain information on the existing tools, techniques, and management processes.

3. To identify and rank the barriers to the best management practices for project controls process for STOs:

This objective is based on the assumptions that there may be some management practices known to the construction industry experts that are not being executed on STOs due to the existence of certain barriers. Documenting these barriers and ranking them based on the consequence will help provide risk analysts with a list of possible risk factors. Though there may not be a solution available to completely eliminate the risk, the awareness can help mitigate the risk factors.

Research Contributions

This research has three main contributions to the body of knowledge:

1. Validation of the fact that STOs do vary significantly from traditional construction projects. The purpose of this validation is primarily to justify the need for this research. However, documentation of the varying nature helps project managers and risk managers working on STOs to obtain a better understanding of the process involved. This type of validation does not exist in existing literature.

2. Generation of a comprehensive list of existing tools, techniques and management practices. This facilitates entry level engineers and project managers with little or no experience working on STOs to be able to successfully manage and execute these projects. This objective also addresses the severe lack of literature on STOs. The

generated list can be used as a guide or checklist to assess the tools, techniques, and management practices required for a particular shutdown, turnaround, or outage project. This documentation is crucial to the identification of some of the best management processes for project controls for STOs.

3. Creation of a list of barriers to the implementation of some of the best management practices. This list is a compilation of possible risk factors that can possibly alter the outcomes of a project. The list can be used by risk managers to understand and mitigate the risk factors in a proactive manner during the front end planning of a project.

Dissertation Outline

Chapter 1 introduces the dissertation research and provides the motivation for conducting this research. It establishes the problem statement and identifies the research objectives. The first chapter also provides a brief summary of the methodology and the contributions of the research. The second chapter provides a summary of the comprehensive literature review that was conducted. It provides information on the existing research on project controls and on Shutdowns/Turnarounds/Outages (STOs). It is used to demonstrate the severe lack of literature on STOs and project controls for STOs. The third chapter provides a literature review of the existing quantitative/qualitative that were evaluated to identify the most appropriate and efficient methodology for this research. The actual methodology used in this research will be presented in this chapter. The fourth chapter will present the analysis of the data collected for the purpose of this research. The fifth chapter will provide a summary of the results of the study. It will also include a discussion of the results and the conclusions drawn. The sixth chapter will present the recommendations, limitations of the research, and the future work.

CHAPTER 2

LITERATURE REVIEW

Research on identification of existing practices and best management practices are designed to serve the purpose of developing better project processes and outcomes. In addition to generating strategies to improve and enhance project performance, such research often generates guidelines that serve as useful tools to project managers and teams. The purpose of this research is to provide a documentation of the existing tools, techniques, and management practices that are unique to project controls for shutdowns, turnarounds, and outages (STOs). Previous research clearly state that the use of tools, techniques, and management practices designed for traditional construction projects often result in poor project outcomes owing to their inadequacy (Asrilhant, 2006; Loch, 2006). However, limitation of this research is the exploratory nature and hence is subject to poor predictive power. Future research will involve investigation of the effects of these tools, techniques, and management practices on project performance.

The construction industry, like most business firms, is susceptible to the concept of internal benchmarking. Internal benchmarking is defined as “the process of identifying, sharing, and using the knowledge and practices inside its own organization” (O'dell, 1998). Internal benchmarking greatly limits the knowledge sharing process thereby contributing to the significant gaps in the literature involving existing tools, techniques, and management practices.

The purpose of this literature review is to intensively explore the existing academic publications and literature on STOs and project controls for traditional projects. A comprehensive literature search confirmed there is very little information available about STOs and little or no significant information on the topic of project controls for STOs. The findings of the literature review are presented below in three main sections. The first part of the literature review is a summary of the tools, techniques, and management practices applied to the project controls process in traditional construction project. For the purpose of this research, a traditional construction project is used synonymously to a new Engineering Procurement Construction (EPC) type project. A typical EPC project is one where the contractor is responsible for detailed engineering, procuring all materials, and the actual construction. The purpose is to provide an in-depth understanding of the general project controls process, in addition to providing the guidance for the questionnaire used for the data collection in this research.

The second part of the literature review is designed to obtain literature to support the theory that STOs vary significantly from traditional construction projects. Firstly, this enables an understanding on the features of STOs that render them unique. Secondly, they justify the need for a project controls process that is exclusive to STOs. The third part of the literature review is a summary of the very limited existing literature on STOs. The literature review will also be used as a tool to explore possible methods of data collection and data analysis in addition to summarizing the alternatives that were considered. The information on data collection will be summarized in the methodology chapter.

Search for literature on STOs included searches conducted on but not limited to Google Scholar, American Society of Civil Engineering (ASCE) journals, Web of Science, and Scout library at the University of Alabama. Though the Google Scholar search generated 26,700

results, there was no article or book that directly addressed project controls for STOs. A Scout search for engineering based books and journal articles dating since 1980 resulted in merely 249 results and no exact matches. The scout search for the exact phrase “shutdowns, turnarounds, outages” related peer-reviewed journal article generated merely 8 results.

The utilization of project controls is a project management practice that is designed to ensure that a project successfully delivers the planned deliverables (Morris et. al., 2010). Olawale et. al., (2010) state that project controls help to ensure that a project finishes on time, and within budget while achieving other project specific objectives. It involves planning, monitoring, and taking any required corrective actions. The project control process includes constant measuring of the progress of a project and taking corrective actions (Kerzner, 2003). Figure 2 shows the project control process outline suggested by Morris et.al (2010).

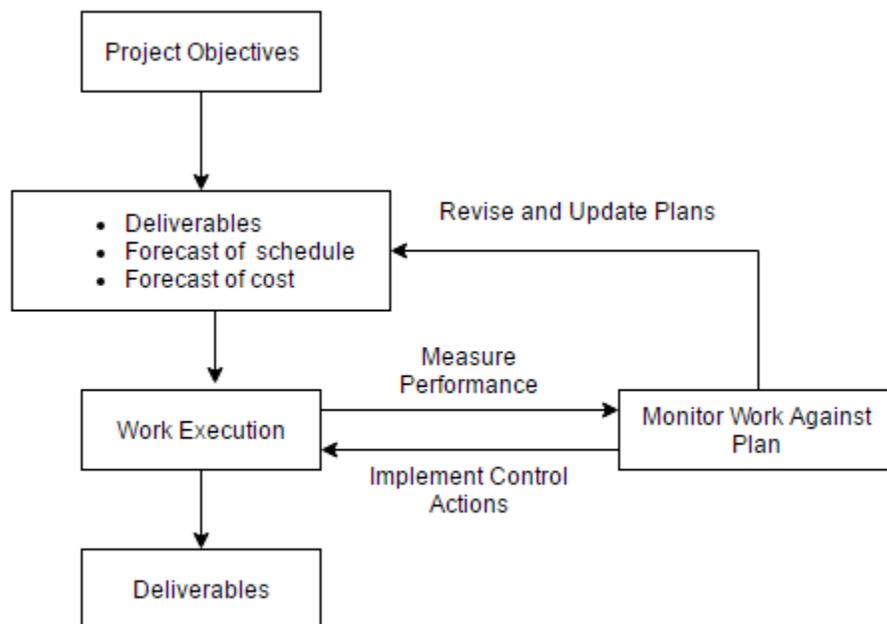


Figure 2 The Project Control Process (Adapted from Morris et. al, 2010)

Figure 2 shows how project controls are integrated with a project life cycle phases of defining objectives, planning, and implementation. The first step is to clearly define the objectives of a project followed by the planning of the deliverables, and the forecasting of the cost and time. The work is carried out to meet the deliverables identified in the previous step. The continuous measuring and feedback loop includes measuring the performance of a project, monitoring to compare it against the plan, implementing control actions, and revising and updating the plans to carry out the work to deliver the planned deliverables. There are several tools and techniques that are part of a project management practices. These tools and techniques were developed to address not only the processes and steps required to successfully complete a project, but also considers the human factors that play a significant role.

Some of the most commonly used tools used in project controls include Gantt Bar Chart, network diagrams, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) (Olawale, 2010; Wiley, 2007). In addition to these tools, there are several software packages that aid in the project control practices and some examples include Microsoft Project and Primavera. These software tools are designed to aid the project management process and help the project control process by providing summaries and outputs that help track features including percentage complete, comparisons of the predicted budget to the actual cost, and resource allocation.

Some of the most common project control techniques that are currently popular include earned value analysis (EVA), the balanced scorecard (BSC), and critical success factors (CSF). EVA involves the comparison of the actual performance of a project to the predicted performance to monitor and report the performance against the planned deliverables including the schedule and the budget. BSC was originally proposed by Kaplan and Norton (Kaplan, 1992)

and was developed to overcome the effects of metrics that relied strongly on finances. Critical success factors can be defined as the underlying factors that are essential to successfully meet the objectives (Wiley, 2007). These techniques are commonly used to measure the performance of a project.

Though there has been several studies conducted over the years to improve the existing tools and techniques and to develop new tools and techniques, several projects still fail to meet the planned deliverables. Cost overruns and schedule delays continue to be of concern to the researchers and the practitioners. The high level of uncertainty and the unique nature of each construction project have a certain role in contributing to the deviations from planned deliverables. The higher the uncertainties in a project, the higher the need for a more effective project control process. This research focuses on Shutdowns/Turnarounds/Outages (STOs) that have significantly higher uncertainties than traditional capital projects.

Project Controls for Traditional Capital Projects

STOs have a high level of risks and uncertainties. The unique challenges such as integration with an active work environment and scope creep make these projects more complex and complicated. Ideally, all projects, both traditional capital projects and STOs, expect that the planned objectives be met. However, it is almost impossible to avoid deviations like cost and schedule over budgets and underruns. For STOs, the margin of error is more severe than in the case of traditional capital projects due to the impacts of these deviations. For example, the extremely high liquidated damages and interrupted service. This requires a process to continuously monitor, report, and mitigate a project.

One of most important targets in a construction project is to ensure that a project is completed on time and within the planned budget. Project controls are a way to meet this

objective. Whittington et al (2009) defines project control requirements as a method for “measuring and reporting progress” that is well established. It is important to measure and report the actual performance against the plan in a timely fashion to be able to identify deviations from the plan if any and to take the necessary steps to address these deviations at the earliest to help meet the planned deliverables. The most common deliverables that are typically addressed in a project are those related to the cost, schedule, safety, and quality.

The project management book of knowledge (PMBOK) defines project controls as “a project management function that involves comparing actual performance with planned performance and taking appropriate corrective action (or directing others to take this action) that will yield the desired outcome in a project when significant differences exist” (PMBOK).

PMBOK presented the Figure 3 below is an adaptation to provide a general outline of how project controls work on a construction project.

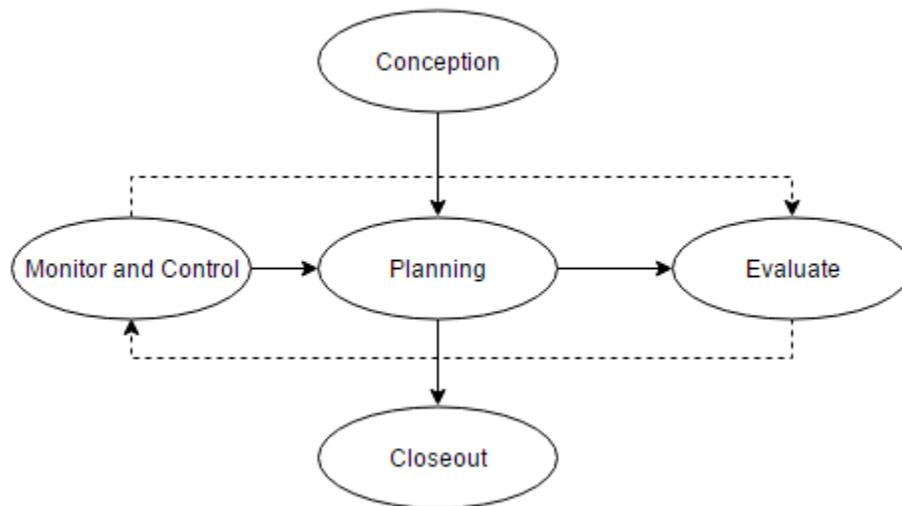


Figure 3 Integration of Project Control Process with Project Phases

Figure 3 shows how the project controls process is integrated with the construction process, and is a continuous cycle that exists throughout a project until the deliverables are completed. PMBOK discusses about use of metrics, reports, and a baseline that are used to identify variances. The project control process allows project managers to identify variances and evaluate them. Reviewing the variances helps to determine if any mitigation is required and to develop mitigation strategies to ensure successful delivery of a project. Project controls can also be used as a reporting tool to provide the owners and/or stakeholders on the progress of a project and the performance against the planned deliverables. Project controls tools, techniques and management processes that are required should be designed as a part of the planning process. The project control process needs to take into consideration scope control, schedule control, contract administration control, cost control, risk control, and quality control among other aspects.

Several studies have been conducted to understand project controls and the factors that contribute to the project controls process. It is a common practice to address project controls during the front end planning process. Sohail and Baldwin (2004) identified 69 performance indicators to measure and monitor projects- general indicators, time indicators, cost indicators, quality indicators, inter-organizational co-operation and socio-economic. Ling (2013) identified 24 project management practices that are significantly correlated with project performance. Chan (2001b) studied project team commitment, client's competencies and contractor's competencies- overall performance of design and build projects. Lee et al. (2005) identified pre-project planning, project change management, and design/information technology are critical practices with important impacts on cost and schedule performance. White and Fortune (2002) identified

clear goals and objectives, support from senior management, and adequate funds resources as the three leading critical project success factors.

The project controls processes traditionally use a batch mode approach where tracking is done once a week or once a month. However, there is an increase in updating tools and technologies to have a more instantaneous approach (CII, 2015). These can be due to factors including a rapid growth of technology including wearable technology, cloud-based collaboration, and reduction of hardware constraints (Hardin, 2015). Most common wearable technologies include Google Glass, Apple Watch, and the Oculus Rift virtual reality goggles. The use of Building Information Modeling (BIM) technology is one of the most popular technologies affecting the project controls process for construction. According to Hardin (2015) here exists the consideration of a more 3D type work environment. Recently, a trend of increased use of BIM due to owner requirements has been observed since late 2000s.

Geographic Information Systems (GIS) technology has also seen an increased used in the construction industry (Hardin, 2015). GIS is often used along with BIM to improve the level of detail. Other new technologies include drones and barcoding materials and tools.

Shutdown/Turnaround/Outages (STOs)

The Construction Industry Institute (CII) is a consortium of construction owners and contractors with 69 owner companies and 72 owner companies (CII, 2015). CII has been an integral part of several research ventures and funds research attempts by academics by providing the necessary funding and data to over 30 U.S. universities. They have been instrumental in providing guidelines and best practices in several areas of construction including alignment, change management, front end planning, constructability, and project risk assessment (CII, 2015). CII defines STOs as “a project or portion of a project(s) that is executed during a planned

disruption in normal operation, where return to service is a business priority” (CII, 2009). CII has conducted extensive research on the construction industry. Some of the CII literature relevant to this research includes research summary 161-1 on “*Small Projects Execution*” which identifies the best practices associated with small project execution and the problems encountered during the execution. It also studies the approaches, procedures, and processes associated with small projects. Research summary 242-1, “*Front End Planning for Renovation/Revamp Projects* (CII, 2008a and CII, 2001), resulted in the development of tools to help in team alignment and risk reduction for renovation and revamp projects.

CII considers STOs to be a subset of “renovation and revamp” projects (CII, 2008a and Whittington, 2009). Renovation and Revamp (R&R) projects account for 30% of expenditures on capital projects (CII, 2008a). Shutdown/turnarounds/outages (STOS) are a sub category of R&R projects (Whittington et al., 2009). Revamp projects include retrofitting, rebuilding, upgrades, modernization, shutdowns, and turnarounds (CII, 2001).

Shutdown/Turnaround/Outages (STOs) are planned interruptions, typically for maintenance purposes. Some of the common sectors that involve STO projects include chemical manufacturing plants, refining, or power plants (Möhring et.al., 2011). STOs are large scale operations that are very complicated due to the unique environmental factors and constraints involved at the jobsite. Construction sites, though well defined in a geographic sense, are unique due to the integration with the existing facility which is usually still operational. Severe space constraints may apply due to existing crew, machinery, and operations. An example of a constraint specific to STOs would be the extremely time sensitive nature due to interruptions to facility production.

Shutdowns are essential in ensuring long-term, continuous operation of a facility. There are several reasons which mandate STOs and these can be considered as drivers for STOs. Some of these include market demand, profit enhancement, maintenance needs, and customer requests (Levitt, 2004). Market demand can stem from meeting a competitive challenge, meeting the needs of an expanding market, or competition from a new market. Profit enhancement aspects include improving either the operational efficiency or the energy efficiency and reduction in scrap. Maintenance needs can be the result of a need for increased reliability, increased repeatability, and increase in life span. Customer's request may include process improvement or automation to increase throughput or quality (Levitt, 2004). Levitt (2004) illustrated some of these differences in a table comparing and contrasting typical projects to maintenance related shutdowns. Table 1 below is a revised version of Levitt's table.

The categories column is used to classify the differences between the two types of projects into jobs, activities, scope, visibility/uncertainty, schedule, end point, safety, planning, staffing, and span of project. Apart from the differences listed in the table, typical projects vary from STOs in other aspects too. Typical projects have a more hierarchical job structure and the uses of software might also vary significantly.

STOs are usually subject to a tight schedule due to the severe implications of not completing a project on time. Based on the literature review above, it has been established that the risks and uncertainties are very high in STOs. The challenges that are unique to STOs have also been discussed above. Due to these unique risks, challenges, tight schedule, and implications of not being successful, STOs typically have a relatively long planning phase and a short execution phase in comparison to traditional capital projects. These unique circumstances lead to several differences in traditional capital projects and STOs.

Table 1 Comparing elements of STOs and Traditional Projects

CATEGORIES	TRADITIONAL CAPITAL PROJECT	MAINTENANCE RELATED SHUTDOWN
Jobs	Many related jobs	Many unrelated jobs
Activities	Logical steps to an end result	More one-step activities
Scope	Scope clear and stable	Scope not clear; undefined right up to beginning of shutdown Scope change as items dissembled
Visibility	Work visible	More unknowns and greater emergency Much of the work is invisible (inside tanks)
Schedule	Schedule updated weekly/monthly	Updating by shift or more often
End point	Understandable end point	No end point
Safety	Less needs for safety permits and clearances	Extensive safety permitting requirement per shift
Planning	Planned well in advance	Planning must wait till scope is pinned down
Staffing	Staffing requirements static	Staffing level varies widely; resource leveling issues
Span	Span is days, weeks, or months	Span of time in hours and shifts

On a broader scale, STOs are similar to traditional projects with activities ranging from planning, execution, and startup. The planning phase is crucial to the development of scope definition, schedule, cost estimates, and project controls. The execution phase is the actual construction and the startup phase involves substantiating that the planned deliverables have been successfully provided. Typical phases in traditional construction include concept, design, execution, and operation (Kartam, 1996, and Pinto, 1988). Levitt (2004) provides five phases for

STOs. The first phase is the initiation phase and addresses feasibility and initial discussions. The second phase includes planning, designing, and engineering. The third phase is production and execution. This phase includes building, assemble, removal, and replacement. STOs might have some demolition and other similar activities involved depending on the scope of the work. For example, increased market demand might require a plant to use bigger pipelines. In this case the existing pipeline or parts of it have to be removed prior to the placement of the new pipelines. Phase four is turnover and work completion and includes testing and start-up. The final phase is the completion of project paperwork and closeout. Figure 4 presents the shutdown cycle provided by Levitt (2004) for the phases described above.

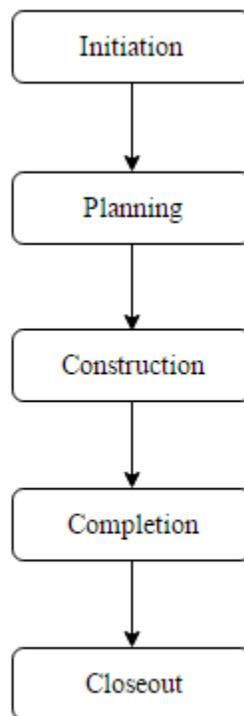


Figure 4 The Shutdown Cycle

During the initiation phase the purpose and need for an STO is established. During the planning phase, the stakeholders input are obtained and the process of execution is planned. The

execution phase is very short and intense. The actual construction is completed during this phase.. All documentation and review of files is completed during the closeout. The deliverables of these phases were identified by Levitt (2004) and are presented in Table 2:

Table 2 Deliverable of STOs based on Phases

Phase	Description of Phase	Deliverable
1	Feasibility, initial discussions, initial scope of work and budget, approval of approach. Initiation.	Completed feasibility study. Documentation in hand for engineering to begin, business case study complete.
2	Plan, design, and engineering phase include engineering, drawings, planning documentation, and firm budgets.	Planning package, completed job list, engineering drawing package and bidding packages available for review. Contractor chosen.
3	Production and execution process includes building, assembly, removal and replacement.	Ends with substantial completion of shutdown job list. Delivery of punch list items.
4	Turnover and work completion is completed with quality assurance, life safety testing, and start-up completed.	All shutdown works completed, accepted by end-user, start-up completed. Plant or facility in normal operation. All bills from vendors and contractors booked.
5	Completion of Project paperwork and closing out and review of meetings. Beginning of new phase 1.	Final manuals, as-built drawings, updated planning packages, operator directions or manuals. Lessons learned book written and distributed. Index for files. Final job list.

The unique phases of STOs change the strategy for status updating, project controls, reporting, and other functions that are critical to project success. Levitt (2004) provides details on justification of STOs, phases including, critical success factors, and key performance indicators as part of the planning process. The book briefly explores the execution, start-up, and closeout. However, there is very little detail provided about the execution and start-up.

Previous studies have concluded that planning for cost and schedule control in the early phases in the lifecycle of a project results in a higher probability of successful project outcomes (Hamilton and Gibson, 1996). The Construction Industry Institute (CII, 2008 a.) and Whittington (2009) developed a tool, Shutdown Turnaround Alignment Review (STAR) designed to aid in the front-end planning process for renovation and revamp type projects. The STAR tool is applicable to STOs. However, one of the major concerns in the execution of STOs is the high probability of unplanned work and scope creep. For example, during the replacement of a part of a machine, more unplanned work can be encountered while dismantling the unit which was not previously identified as a task. The higher risks in the construction phase create a need for a more effective project controls process. Limitation in the time period for executing STOs require a more robust process of identifying variance, reporting them, analyzing the drivers of these variances, and mitigating in a time efficient manner to improve project performance and ensure project success. The significance of the control processes during the construction phase of STOs is considerably higher than in the case of traditional construction projects. Hence, this research will focus on the actual construction phase of STOs

Existing proactive strategies. Due to the high risks involved, it is typical to have a proactive strategy to mitigate the risks. CII developed the STAR tool to address some of these issues (CII, 2008 a). One of the key strategies is to have an early and robust Front End Planning

(FEP) process. CII suggests using Third Editions of the PDRI to improve performance. Another suggested tool in the CII Front End Planning Toolkit. STAR tool itself help address the risks along with the use of Project Control Investigation (PCI) tools

. One of the key risk elements considered is the safety issue. Remedial actions are developed to address issues including cluttering, noise, falling objects, proximity to operating equipment, dust, open pits and ditches, chemical spills, and fumes (CII, 2001). The workers are ideally briefed on risks related to the issues listed above. According to CII (2001), the contractors working on STOs are required to have an Insurance Experience Modification Rate (EMR) of 1.0 or less, an Occupational Safety and Health (OSHA) Recordable Rate of 12.0 or less, and a Lost Workday Rate of 6.0 or less.

Construction industry in general has a fatality rate that is 50% higher than all other industries (CII, 2001). Safety issues are enhanced for STOs. Hence, these projects typically involve establishing a safety culture that encourages safety responsibilities and safety education & promotion.

Summary

In essence, STOs have higher risks and uncertainties in comparison to a traditional construction project. Apart from this, the challenges such as limited space and interaction with an active work environment increase the challenges of executing STOs. These risks and challenges generate a need for a robust project controls process for STOs to enable successful project delivery.

There is considerable literature available on the various project controls tools, techniques, and management practices that are currently being used in the construction industry. However, this information is mostly applicable to traditional construction projects that vary significantly

from STOs. The lack of information on project controls for STOs is a barrier to the standardization of the project controls process for STOs. The lack of information makes it challenging for project managers and other team members without much experience working on STOs to develop a robust project controls process.

This creates a need for the documentation of the existing tools, techniques, and management processes for project controls that are specific to STOs. In addition, there is a need to understand the barriers to the implementation of some of these tools, techniques, and management processes in order to generate the optimum project controls for an STO. For the purpose of this research, optimum project controls are those which are most ideal to a particular STO. Most ideal project controls are those that result in successful project outcomes.

CHAPTER 3

METHODOLOGY

This chapter research is comprised of two main sections. The first section addresses the literature review conducted to design the data collection and analysis for this research. This includes evaluation of the different methods of data collection and the motivation for selecting Delphi as the most suitable method for data collection. The second section details the data collection and analysis design and strategy specific to this research.

Evaluation of Potential Data Collection Methods

The main purpose of this research was to gain insight into STOs, with an emphasis on analyzing management practices, specifically cost and schedule related project controls. A literature review was conducted to evaluate the advantages and disadvantages of using different approaches to analyze qualitative data. The literature review also provided information used to develop the questionnaires and the expert interviews for data collection; information that listed the requirements of research studies of similar nature, and alternatives for analyzing the data.

Available literature was explored to identify and evaluate the different methods of data analysis for qualitative data. The methods identified were those that could provide a more accurate representation of the most efficient project controls. Since one of the research objectives is to bridge the gap between theory and practice, the source of the information required is restricted to industry experts. The review also focuses on management practices which can only

be obtained through interactions with industry practitioners. Hence, methods that would accommodate the restriction of involving obtaining the required information from a group were considered. These included consensus groups, the Delphi method, staticized groups, interacting groups, and the Nominal Group Technique (Hallowell and Gambatese, 2010).

Consensus groups are designed to have discussions that result in a decision that has the consensus of the group although individual opinions may vary. Consensus groups have an unstructured nature and addresses conflicting resolving behaviors (Hall and Watson, 1970). The unstructured nature can be defined as questions that are open ended in nature and allow respondents to answer without being influenced by the researcher. The interaction between the experts is unstructured in nature. Nemiroff and King (1975) concluded that the participants in consensus group type interviews did not ensure an effectively functioning group. This was identified as being not very effective since it does not allow for an iterative process which is required in this research.

The Delphi method uses multiple rounds and feedback to obtain a consensus. Hallowell et al (2010) suggests the approach to the Delphi method as show in Figure 5:

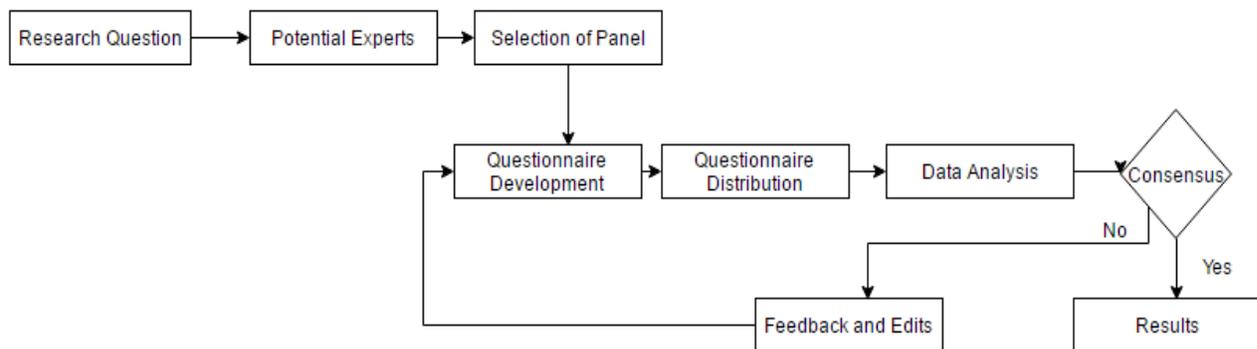


Figure 5 The Delphi process

Figure 5 identifies the key components of the Delphi process. The first step is the identification of research question(s) followed by identification of potential experts on the research subject based on predefined criteria defined by the researcher. Figure 5 explains the cycle required to collect data, analyze it, provide feedback, and the flowchart for deciding when consensus has been achieved to make reliable conclusions from the study. As Figure 5 demonstrates, there is a continuous loop of feedback that is continued until consensus is obtained. The Delphi process will be further discussed later in this chapter.

Another process similar to the Delphi method to obtain data from a group is the use of staticized groups. The difference between this method and the Delphi method is the absence of a feedback system. The method was concluded to be not suitable for the purpose of this research since a more iterative process is required. Due to the limitations in data availability, reaching conclusive results in the absence of an iterative process is not feasible.

Interacting group methodology is conducted by requiring the participants to be in a group that requires direct interaction either by being at the same geographical location or by being in a discussion through a virtual platform at the same time. The interacting group method was concluded to be not a suitable method for the purpose of this research due to issues relating to lack of anonymity, requirement for all the participants to interact, and bias due to dominance (Hallowell and Gambatese, 2010).

The Nominal Group Technique (NGT) is a more structured process and is similar to the Delphi method. This method is most suitable for the purpose of idea generation and fact finding type of problems (Erffmeyer and Lane, 1984). The advantage of this process is that the feedback is through face-to-face meetings and hence often results in a more efficient data collection. Most of the literature suggests that this method is almost exclusive for idea generation (Green, and

Hughes, 1977; Chung and Ferris, 1971). Other applications of this method include evaluating problems that require ranking (Herbert and Yost, 1979). The method was concluded to be not suitable for the purpose of this research based on the literature review which suggests that there are bias issues related to the process (Erffmeyer and Lane, 1984).

Delphi allows for an iterative process which is necessary for meeting the objectives of this research. It allows for anonymity and the availability of a continuous feedback loop which are required for this research since it helps obtain maximum information from the experts. A discussion of the available information of the Delphi process and the adaptation of the process to obtain the information required for this research is described in the following sections. For these reasons, Delphi was concluded to be the most suitable method to obtain the required data to connect theory and industry practice.

The Delphi Method. According to Hallowell and Gambatese (2010), the Delphi method is “a systematic and interactive technique for obtaining the judgment of a panel of independent experts on a specific topic”. There are predefined guidelines for the purpose of identifying and selecting the experts or participants of a Delphi study. The guidelines help in justify the selection of the experts, verifies that the experts have been rightly identified, and provides information on the criterion that is used to select the identified experts. The selection of the experts may vary based on the requirements and design of the research. The following criteria were observed:

1. Experience with at least one shutdown, turnaround, or outage project.
2. Minimum education of High School Diploma or equivalent degree.
3. Has to be a construction professional/industry expert.

One of the main advantages of the Delphi process is the nature of anonymity that is provided to the participants which helps to express opinions to the best of their belief. As shown

in Figure 5, the process allows the researcher to evaluate the consensus of the experts based on the questionnaire which can be used as a feedback used to design an iterative process. The presence of this feedback system and iterative process is the key reason for selecting the Delphi method. The feedback system coupled with the iterative nature of the process allows the participants to consider the opinions of other experts and provides them an opportunity to explore their responses, review them, and make changes if needed. This process might also result in reduced variability in the responses and help in making more conclusive observations.

A schematic of Cortés et al (2011) version of the Delphi process by Hallowell and Gambatese (2010) is shown below in Figure 6.

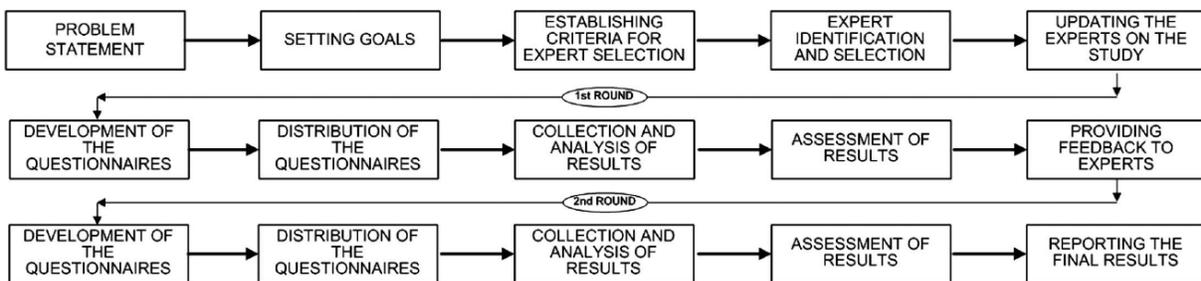


Figure 6 Improved Delphi Method

As shown in Figure 6, the first step in the process is to establish a problem statement. After identifying the problem statement and setting the goals, the criteria for expert selection has to be established. The number of participants varies according to the need of the research. It can vary from three to up to eighty (Rowe and Wright, 1999). The number of panels range from one to four (Hallowell and Gambatese, 2010). The Okoli and Pawlowski (2004) guideline for the number of participants is considered. Okoli (2004) suggests 10-18 experts since Delphi methodology is based on group dynamics for arriving at consensus rather than statistical power of the data. Since this research is very specific regarding the type of construction project

addressed (STOs), the sample of experts was restricted. The selection criteria was designed to be flexible to meet the objectives and was included experts from both academia and construction industry. Though the participant selection may be flexible, there are minimum criteria that have to be met in order to qualify as experts for this research as noted earlier in this chapter.

The next step of the Delphi process is to develop the questionnaire. The purpose of the questionnaire was to validate the list generated from the literature review, identify the most efficient controls through the rating, and identify any project control or category that was not identified through the literature review. The project controls in the questionnaire was categorized based on the literature. Cortés et al (2011) designed a webpage where all the information about the research was made available to the experts who could access the page with a username and password. The questionnaire was electronically emailed in Microsoft Word format or made available online through survey software to the experts. Once the questionnaires were completed and analyzed, the next step was to conduct interviews. Cortés (2012) contacted the experts through face to face interviews, phone calls, and other methods prior to the study to update the experts on the study as show in Figure 6. This research used a combination of online surveys and phone calls.

The next step in the Delphi process (as shown in Figure 6) will be to compile the results of the first questionnaire. The results will then be made available to the experts in a summary format during the interview process. This allows the experts to consider other perspectives, which were provided anonymously, and make changes to the survey questions if needed. This step of a Delphi process contributes to obtaining a reliable group opinion from a panel (Listone and Turoff, 1975). This and the iterative nature of the process allows maximum consensus and maintains maximum autonomy among participants. Providing feedback to the participants also

contributes to improved accuracy of the study (Best, 1974). The number of iterations varies according to the study. Having several iterations reduces the variance in the responses and makes the results more precise. The number of rounds can typically vary from two to six (Gupta and Clark, 1996) and convergence is usually attained after a maximum of three iterations. Dalkey et al. (1970) suggest an optimum of two rounds as they believe the accuracy is compromised after two iterations. Two iterations of the questionnaire and one round of interviews were conducted to obtain reasonable conclusions while factoring in time constraints. The high consensus contributed to this decision.

The role of the researcher or facilitator was to identify the experts and the criteria required, develop the questionnaire based on the problem statement and the goals, analyze the results and feedback, and to extract conclusions based on these. Once the Delphi was selected the next step was to develop a design for implementing Delphi.

Research Design to Implement Delphi. Olawale et. al., (2013) developed the following approach to study project control and inhibiting factors management model (PCIM). Their methodology included collection of quantitative and qualitative data using literature review, questionnaires and interviews as the tool for collecting the required data. An adaptation of their schematic for an outline of the research methodology is presented in Figure 7.

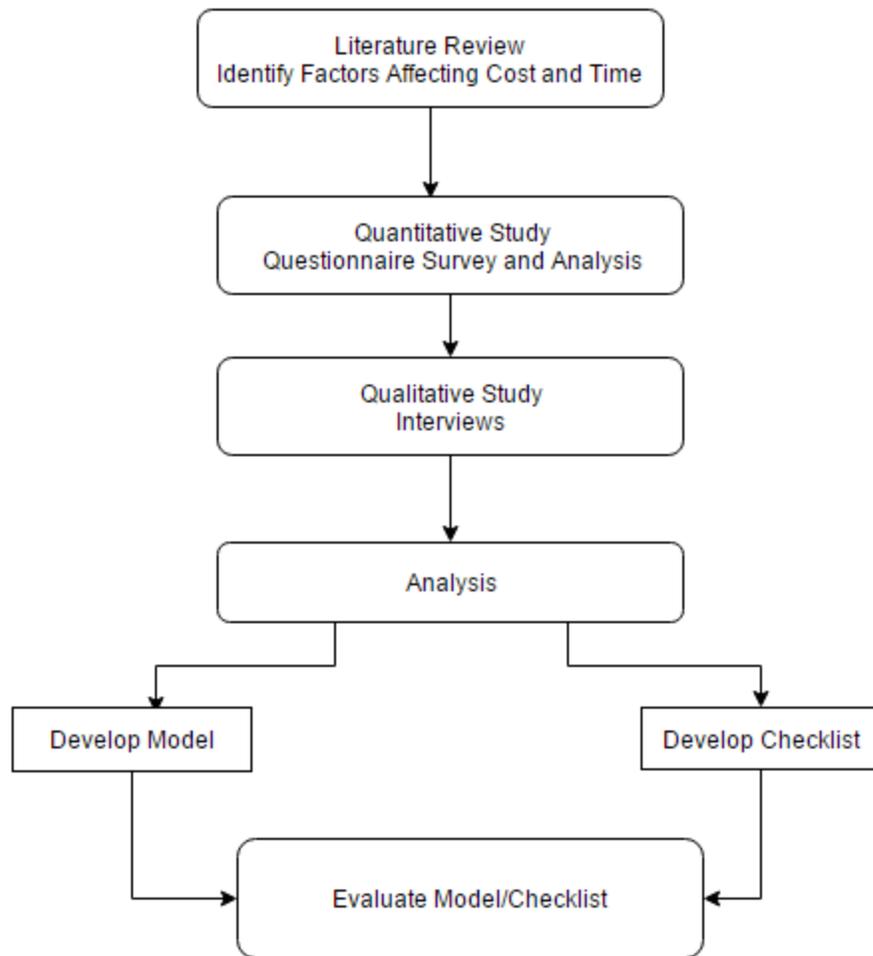


Figure 7 Project Control and Inhibiting Factors Management Model

Some of the objectives of Olwale’s study align with the objectives of this research. For example, both require an exhaustive literature to identify a list of existing practices. Both require a questionnaire followed by a semi-structured interview to help understand current practices. However, the methodology had to be modified to tailor to the needs of this research. For the purpose of data collection on the management practices for project controls for STOs from the construction industry, it is necessary to contact the experts with considerable experience working on STOs.

Implementing PCIM model. Literature demonstrates a substantial lack of literature on STOs and project controls for STOs. The methodologies in Figure 6 and Figure 7 allow for multiple interactive rounds that allows for optimum data collection for a research topic with limited literature availability. The design used to implement the PCIM model in this research is described in this section. A combination of two survey methods, namely, questionnaire survey and semi-structured interviews are used.

After the identification of the problem statement and the development of the criteria for expert selection, initial contact of the experts was established through phone calls. A snowball type participant selection was observed. A snowball effect is when an initial contact is identified and more participants are suggested by the initial contact. The initial list of contacts was generated from a previous study: “Near Miss information Visualization Application for Building Information Modeling (BIM) conducted by Dr. Eric Marks (CPWR, 2016).

To meet the objectives discussed in chapter 1, the first step in the research design used was to develop a questionnaire. The questionnaire helps to collect information to demonstrate that STOs vary significantly from traditional construction projects, to collect information on the project control tools, techniques, and management practices for STOs, and to identify the barriers to the implementation of some of the project controls. More information on the development of the questionnaire will be discussed in chapter 4, data collection.

Once the questionnaire was completed, the next step was collection and analysis of the result is completed followed by an assessment of the results. The questionnaire survey was followed by interviews with the participants via phone calls or through Skype, a web based teleconference or other web based services. At the beginning of the interviews the participants were be provided a summary of the results of the first round of questionnaire orally and a one

page report of the same was be emailed if required. Once the interviews are completed, they were coded to protect the anonymity of the participants and transcribed.

The results from the first round of the questionnaire and the feedback from the interviews were used to develop the questionnaire for the Survey Round 2. A repetition of the process involved for the Survey Round 1 was be observed. The design for this research is to be able to make significant consensus and conclusions after the second round of the questionnaire survey, taking into account time limitations.

The following three rounds of survey were selected:

1. Round One of Survey: Questionnaire one.
2. Round Two of Survey: Semi-structured interviews.
3. Round Three of Survey: Questionnaire two.

The methodology was designed to successfully facilitate information transfer from industry experts to the publication. A survey was decided as the best fit for this purpose. The different methodologies considered are discussed at the beginning of this chapter. The following paragraphs provide further information on the actual survey methods selected. Questionnaires and interviews are both survey methods.

Surveys can be structured or unstructured in nature (DiCicco-Bloom et. al, 2006). Once the method is selected, the next step is to form the actual questions required to meet the objectives of the research. There are different question types to be taken into consideration. One of the most common types is dichotomous questions which are designed to obtain yes/no answers. Other types include nominal questions, ordinal type questions, and Likert scale response type (Social Research, 2016). For the questionnaire surveys, several factors were taken into consideration while designing the questions including sufficiency of questions, checking of

the questions are loaded, and checking for biases. The number of questions and the type of questions depends on the nature of the data to be collected. Since the questions are both precise and concise, there is a possibility that the information collected might be limited. To overcome this limitation, interviews were conducted to facilitate more efficient knowledge transfer.

Interviews can be structured or unstructured. Since the interviews in this case are designed to further discuss the questions in the questionnaire survey, it was decided to follow a semi-structured format. Typically, these interviews involve discussion of predetermined questions that may possibly result in further questions. Semi structured interviews are the most commonly used data collection method for qualitative analysis (DiCicco-Bloom et. al., 2006). Once the interview type was selected, the next step was to decide how to conduct the interviews. Several methods including video calls and phone calls were considered. In order to protect the anonymity of the participants, group meetings were ruled out as a possibility. Taking into consideration time and travel restrictions, face-to-face interviews were also deemed not feasible.

Phone calls were selected since they are cheap, easy, and ensures interviewer safety (Aday, 1996; Bernard, 2002). However, telephone interviews are more commonly used in quantitative data collection. Qualitative research typically favors face-to-face interviews (Opdenakker, 2006; Sweet, 2002). One of the main advantages of phone interviews is that participants are more open and ready to provide more information over phone interviews. Telephone interviews also have certain disadvantages associated with them. Some of these include the absence of visual cues, potential distractions, and limited time in comparison to face-to-face interviews (Garbett, 2001; McCoyd, 2006, Chapple, 1999). Taking into considerations the requirements and the limitations of this research, telephone interviews were selected as the optimum method for administering the semi-structured interviews.

To summarize, several methods of obtaining data from a group of experts were evaluated and the Delphi methodology was identified as being the most suitable to meet the objectives of this study. The steps of the Delphi process identified were broken down into several tasks. A list of these tasks is presented:

The following are the tasks necessary to meet the research objectives and address the problem statement:

Task 1: Conducted a comprehensive literature review to understand STOs and project controls for STOs.

The literature review served the purpose of validating the hypothesis that there is very little or no information available providing insight into STOs. The literature review helped obtain the available literature on STOs. It also helped develop the methodology required to obtain the data required for this research. Information was gathered on existing project controls in the construction industry.

Task 2: Developed demographics questions, cover letter and questionnaire.

In order to understand the data collected for the purpose of the research, it is important to obtain insight into the participants of the survey. The quantitative and qualitative data required was obtained on a project basis. However, each participant was required to provide demographic information including designation and experience. The cover letter was provided to the participants with a brief summary of the conclusions from the literature review, an overview of the methodology, and the purpose of the research. The questionnaire was made available online or emailed in word format based on the preferences of the participants.

Task 3: Identified experts for interviews and questionnaire.

Since the field selected for the research is very specific and since there is very little information available on STOs and project controls for STOs it is essential to obtain all required data from experts with significant experience working on STOs. This task helped in identifying these experts and in contacting them to ensure their willingness to participate in the survey and interviews.

Task 4: Conducted pilot study for validation of the questionnaire.

Since the questionnaire is one of the key tools used in this research to obtain data, it was essential to ensure that it has been designed to efficiently obtain the required data. The purpose of the study is to validate that the questionnaire as a tool, works efficiently. It helped to identify the insufficiencies and any existing biases. The participants of the pilot study were not be participants of the main survey and expert interviews.

Task 5: Emailed questionnaires to experts along with the cover letter.

This task involved making the questionnaire and the cover letter being made available to the participants. Based on participant preference, the questionnaire was mailed in Microsoft Word format along with the cover letter or made available online through an online survey webpage. Any information or instructions required to complete the survey was included in the email.

Task 6: Conducted expert interviews to discuss the questions in the questionnaire and collect data for the constructs. Discussed data analysis based on the first questionnaire. The questionnaire survey was to be followed by interviews with the participants either face-to-face or through a video call platform like Skype. The purpose of the expert interview is to further discuss the questions on the questionnaire to identify any contributing factors. The interview was be recorded with the permission of the

participants. The recording was transcribed and was be analyzed to identify key constructs that will be used to identify the best practices, especially for project controls in STOs. During the interview, the participants were provided with a summary of the results of the analysis of the first questionnaire.

Task 7: Identified key constructs to identify best management practices for project controls in STOs.

The data obtained from all the expert interviews was transcribed and analyzed to identify patterns, similarities, and commonality. These were then used to identify key constructs. The constructs were essential in identifying the best management practices for project controls in STOs.

Task 8: Conducted Delphi study and edit questionnaire if needed based on the expert interviews.

Due to the limited availability of data on STOs, there was the possibility of identifying additional questions that are required to obtain the required data that were not addressed in the initial questionnaire. Also, the summary of the analysis of the first survey during the questionnaire provides the participants to rethink their answers on the first questionnaire. This required an additional questionnaire that addresses any changes or additional questions that need to be answered. Delphi methodology addressed this issue. The second questionnaire was made available to the participants in the same format choices as in the case of the first questionnaire.

Task 9: Analyzed the final questionnaire.

This task involved analyzing the second and final questionnaire. Both qualitative and quantitative data were analyzed. The qualitative data was analyzed to obtain information

on the best practices for project controls in STOs. The quantitative data was analyzed to obtain information on the relative importance of the project controls.

Task 10: Drew conclusions and write statistical summary.

Based on the analysis of the questionnaire and the constructs identified from the expert interview, a report was developed to describe the best management practices for STOs; with emphasis on project controls. This task required summarizing the information gathered and conclusions made to help provide insight and more information be made available.

CHAPTER 4

DATA COLLECTION

This chapter details the data collection process used to obtain the data required to meet the objectives of this study. The chapter includes a description of the process involved in the development of the questionnaire used for the data collection process, the distribution process for the questionnaires, the pilot study process, and the interview process for the discussion of the questionnaire.

Development of Survey

As identified in Chapter 3 (methodology), Delphi was selected as the most suitable method for the collection of data to meet the objectives of this research. The primary reason for this selection was the iterative and interactive nature of Delphi that allows for obtaining maximum information from a group of experts in the field of construction engineering with experience working on Shutdowns/Turnarounds/Outages (STOs). Obtaining judgmental information from the experts is essential to meeting the objectives of this research and Delphi is primarily used for such research purposes (Okoli, 2004).

The data collection process associated with the Delphi process consists of three different steps that uses two types of survey methods. The first step is a questionnaire survey, the second step is a semi-structured interview, and the third and final step is a second round of questionnaire survey. Figure 8 demonstrates the different rounds and steps of the Delphi study used.

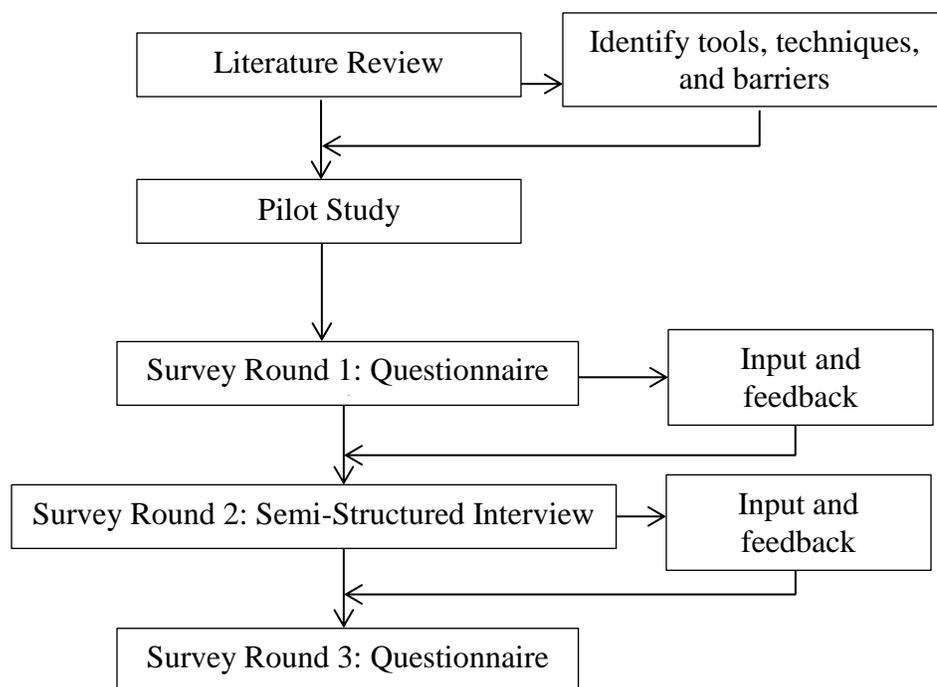


Figure 8 Outline of Delphi Process

As Figure 8 demonstrates, there are 3 rounds of the survey. The first round was a questionnaire survey, the second round was semi-structured interviews, and the third round was a follow up questionnaire survey. After each step, results were provided to the participating experts to facilitate interaction between experts. Though the participating experts did not have access to the individual responses of other experts, access to the results allowed the experts to obtain insight into the group perspective. Prior to the data collection process, a pilot study to test the sufficiency and efficiency of the questionnaire as a data collection tool was conducted. Since the purpose of the pilot study was restricted to testing the questionnaire, the results were not analyzed to reach any conclusions based on the answers. The results of the pilot study were used to analyze if the answers met the anticipated results and to validate that the questions would be understood by the experts.

Development of Questionnaire. The first step in the data collection process was to develop the questionnaire. This questionnaire was used in the pilot survey and provided the basis for the questionnaires used in Survey Round 1 and Survey Round 3. A major challenge in the

development of the questionnaire was framing the questions. The format of the questions had to be decided. For example, in order to evaluate the barriers, a Likert scale of one to ten was developed since it allowed the experts to rate the barriers. The rating obtains information on the most detrimental barriers. Due to the limited literature available on STOs, questions about project controls for STOs were developed using information on project controls for traditional construction projects as a guide.

Two separate parts were developed for the first round of questionnaire survey. The first part, part A was designed to obtain demographic information on the experts such as educational background and work experience. The second part, part B, was divided into three different sections. The first section was designed to validate the fact that STOs vary significantly from traditional construction projects. The information required to compare and contrast the two project types were obtained mostly from Levitt (2004). The second section was designed to identify the existing project control tools, techniques, and management practices for STOs with a focus on cost and schedule.

The third section asks experts to rank the barriers to implementation of the most suited practices for project controls for STOs. The list of most suited practices was developed based on the available literature on STOs with a primary focus on the studies conducted by CII on renovation and revamp projects (2008a) since STOs are included under the category of renovation and revamp projects.

For Survey Round 1, Part B included a total of 61 questions. 15 questions were designed to obtain background information of each project. The second section included 11 dichotomous or yes/no questions that allowed the experts to agree or disagree if a certain factor rendered STOs unique in comparison to traditional construction projects. Fifteen questions each were developed

to obtain information on cost and schedule related project controls. They included tools, techniques, reporting information, and team autonomy related questions. The third section listed ten barriers for Survey Round 1 and 12 barriers for Survey Round 2.

The pilot study was initially developed using Survey Monkey. Survey Monkey is a free online survey development tool. Survey monkey allows users to create online surveys with limited features. For example, the number of questions a user is allowed to create is limited, and a fee based subscription that allows a user access to more features and flexibility is available. Survey Monkey allows for several formats of questions including multiple choices, true/false, and open-ended questions. It allows for data to be exported to statistical software like SPSS. Due to the limitations on several features such as the number of questions and the cost associated with the addition of the features required, Survey Monkey was concluded to be not feasible

The questionnaire was then developed using Qualtrics. Qualtrics is also a web-based survey development tool that allows for online data collection and analysis. However, the benefits of using Qualtrics included free access to students and faculty at the University of Alabama and the ability to incorporate the University of Alabama logo which provided a professional appearance. Qualtrics allows users to export data directly to statistical software programs like SPSS and other software platforms including PDF, and Microsoft Office products such as Word, Excel, and PowerPoint.

Semi-Structured Interviews. Survey Round 1 was followed by semi-structured interview – Survey round 2. The results of Survey Round 1 were verbally presented to the participating experts prior to the interview. The semi-structured interviews were necessary to further discuss the responses in Survey Round 1. Since there was very little information on STOs in the available literature, there was a possibility that the questionnaire limited information

transfer from the experts through the questionnaire. For example, there was a possibility that there weren't enough questions on the current tools to be able to obtain sufficient insight. The semi-structured interviews were designed to allow the experts to provide more information about the questions addressed in the questionnaire. Questionnaires are designed to obtain precise and concise responses. However, due to limited information availability, there was a need to further discuss the questions to identify patterns and obtain better insight into the project controls process for STOs. A semi structured interview format was identified as the best fit for the purpose of this study.

Five semi-structured interviews were conducted via phone calls with STO experts. The responses on both Survey Round 1 and Survey Round 2 showed consensus. Consensus was evaluating based on the degree to which the experts agreed or disagreed to a certain result obtained in Survey Round 1. For example, all experts who participated in Survey Round 2 agreed that STOs are significantly different from traditional construction projects. Due to the high consensus and limited time and availability of the experts, further interviews with more experts were not conducted. Each interview lasted for approximately 15-30 minutes. The experts discussed the reasoning behind some of the questions in Survey Round 1. Based on the discussions, clarifications were made to obtain better understanding of some of the questions and responses. For example, the demographics questionnaire had questions addressing the percentage of STOs that used project controls for cost and schedule. The answers were in percentile ranges. This could mean a 76% or a 100% if the expert chose 76%-100%. The interview allowed the researcher to establish that it was 100%.

Once the semi-structured interviews were completed, the recorded phone calls were then transcribed. This generated about 20 pages of text and contained 7500 words. The next step was

to conduct within-case analysis (Eisenhardt, 1989) to identify and extract relevant statements from the transcripts. Phrases and words that were identified as patterns were shortlisted. Patterns occur when people identify similar behaviors, barriers, incidents etc. For example, most experts identified discovery work as being a driver of scope creep. Discovery work is the unplanned work encountered on STOs. Similarly, the experts identified communication as a crucial factor for the success of STOs. These patterns were then used to identify constructs.

Constructs are often referred to as categories or codes (Glaser and Strauss, 1967). Constructs can be defined as a grouping of all incidents/words that provide further insight toward a certain theme. The transcriptions were analyzed a second time to make sure that no words or sentences contributing to a certain construct were omitted. The constructs were also used to identify questions that needed to be added to the questionnaire in Survey Round 3. For example, poor safety measures were identified as a barrier for the implementation of optimum project control practices. Therefore, poor safety measure was added as a barrier in Survey Round 3.

Since Delphi is an iterative process, a minimum of two rounds of questionnaire are required to collect sufficient data. Based on the results of the Survey Round 1 and the semi-structured interviews, changes were made that were reflected in Survey Round 3 questionnaire. The questionnaires were designed in the same format as the questionnaires in Survey Round 1 and had three key sections. The three sections were the same as in the case of the first questionnaire. The first section was to obtain evidence to support the assumption that STOs vary significantly from traditional construction projects. Since the consensus requirement for Delphi is 50% or more agreement by the group, only two rounds of questionnaire survey were required as was assumed during the design of the methodology.

Once the methodology design was developed, the next step was to estimate an approximate sample size that is required to represent the target population. If a population of 100,000 with a 5% margin of error and 95% confidence interval is assumed for construction projects, renovation and revamps accounts for 5%. STOs are a subset of these projects and hence about 1% of the total population. That generates a sample size of about 16. The actual sample required would be much less.

Pilot Study

A pilot study was conducted to test the sufficiency and efficiency of the questionnaire. The purpose of the pilot study included testing the adequacy of the data collection instrument, evaluating the feasibility of the research, identifying logistical problems if any, collecting some preliminary data, obtaining a better understanding of the resources that were needed in conducting the research, and it provided some experience on conducting the research (Van Teijlingen and Hundley, 2001). The pilot study used in this research was used to collect preliminary data and helped the researcher obtain some experience conducting survey research.

Panel Selection

The panel selection process is a key part of the Delphi process. The panel constitutes of independent experts. Though there are several guidelines available on how to select a panel, it depends primarily on the objectives of the research (Rajendran, 2006; Rogers and Lopez, 2002; and Veltri, 2006). One of the key factors in the selection process includes demonstration of knowledge regarding the area of the research (Veltri, 1985). The guidelines of selecting these experts are predefined and have to be accounted for while conducting the pilot study. The criteria required are summarized below

- Experience with at least one Shutdown, Turnaround, or Outage project.

- Minimum education of High School Diploma or equivalent degree.
- Has to be a construction professional/industry expert.

Survey Distribution. For the pilot study, Qualtrix was selected as the tool to distribute the electronic survey. Having the University of Alabama name mentioned in the survey link and having the University of Alabama logo displayed on the survey web page helped communicate the relevance of the survey and the research as a part of the University's effort in furthering academic research. Using Qualtrix with the name of the University of Alabama being mentioned helped in gaining the attention of the participants and making them aware that this was not a spam or irrelevant mail that could potentially waste their time.

A link to the pilot study was emailed to the selected experts using the University of Alabama email server. The email template used to contact the experts is attached in Appendix A. The email included the links to the Qualtrics questionnaire and a brief description of the study and the pilot study questionnaires.

To protect the anonymity of the participants, their names were coded numerically. This is in accordance with the design of the Delphi process. Delphi allows for anonymous interactions through several iterations and a feedback system. This minimizes the probability of personal bias and any pressure to conform to the opinions of the group. A cover letter was attached to the email to provide the contact information of the researcher and a brief description of the survey methodology. The cover letter corresponding to the pilot survey correspondence is provided in Appendix B. The demographics pilot questionnaire (Survey Round 1, Part A) is presented in Appendix C and the project controls pilot questionnaire (Survey Round 1 Part B) in Appendix D. Three experts were contacted to participate in the pilot study. Two of the experts completed both

Part A and Part B of the pilot questionnaire and one expert did not complete Part A. Therefore, only the responses obtained from the first two experts were used.

Background of the panelists/respondents/experts. For the purpose of obtaining a holistic understanding of STOs and the project controls for STOs, effort was made to include participants from different backgrounds and roles/designations. Experts were expected to range from project managers and construction managers to safety professionals and supervisors. It was important to include a diverse population of participants though it might be challenging to reach a consensus in Delphi due to differences in perspectives about STOs. For example, while rating the barriers to implementation of the best management practices, a project manager might consider poor front end planning as a high risk barrier, whereas a supervisor might consider safety issues being of high risk.

Table 3 Summary of the Background of the Experts

	Respondent #1	Respondent #2
Highest degree obtained	Graduate Degree	High School/GED
Professional License	No	No
Primary title	Construction Manager	SCS Construction Manager (maintenance)
Years of experience working in the construction industry	20 years	32 years
Industry type	Power	Power
Number of STO projects worked on	25	40+

The lack of consensus does limit the feasibility of research since the Delphi process considers it to be acceptable to have low consensus when it reflects the true nature of the actual population being studied. Based on the results of the pilot study obtained from the demographics

questionnaire, the background information of the participants was collected. A brief summary of the two experts who participated in the pilot study is presented in Table 3 above:

Part B of the pilot questionnaire was designed to address the objectives for this research:

- Establish that STOs vary significantly from traditional construction projects.
- Identify existing tools, techniques, and management practices used for the project control process in STOs.
- Identify the barriers to the implementation of best management practices.
- Obtain an overall understanding of the project controls process including frequency of tracking and monitoring and the chain of command for decision making.

Table 4 Summarization of the Project Controls Questionnaire

	Respondent #1	Respondent #2
Project type	Power	Power
Cost	>\$100,000,000	\$1,000,001-\$10,000,000
Common project control technique	Earned Value Analysis	Earned Value Analysis
Common project control tools	Primavera	Primavera
Project duration	86 days	42 days
Frequency of tracking variances	Twice a week	Once a day

Some of the key observations from Part B of the pilot questionnaire are summarized in Table 4 above. The pilot study results showed some consensus that STOs vary considerably from traditional construction projects. This supports the research hypothesis. The consensus on key questions like the higher probability of unplanned work and several one step activities support the hypothesis that there exists a more robust project controls process for STOs. Though there is

very little consensus for a lot of the questions, much of this can be attributed to the sample size of two.

Summary of Suggested Changes: Based on the feedback from the pilot study, no major changes were suggested or requested. The only change that was requested by the participants was to include skill set of labor as one of the barriers to the implementation of the best management practices. Since labor and materials are major factors that are subject to variability, both were addressed in the first round of the Delphi.

Challenges: Once the pilot study questionnaire was developed, the major challenge was to identify and contact the experts or panel members required to participate. Since there was very little published information available on Shutdowns, Turnarounds, and Outages, approaching researchers who have conducted similar research was challenging. Also, as mentioned in the panel selection section above, the experts were restricted to industry practitioners.

A previous study and the participants for the study were used to obtain the contacts required for this study. The participants were initially approached about the study through emails. After establishing the initial contact, interested participants were then contacted through phone calls to explain the purpose, methodology, and expected outcomes of the research. Once it was established that participants were interested and met the criteria required to be in the panel, the electronic survey was emailed to them.

CHAPTER 5

RESULTS AND DISCUSSION

This chapter provides the results and the discussion of the Survey Round 1 – the first questionnaire, Survey Round 2 – the semi-structured interviews, and Survey Round 3 – the second questionnaire. Survey Round 1 conducted using a questionnaire was designed to conclusively prove the assumption that STOs vary considerably from traditional construction projects and existing project control tools, techniques and management practices. Survey Round 1 and Survey Round 3 questionnaires were designed to identify and rank the barriers to the implementation of optimum project controls. The Survey Round 2 was the semi-structured interviews. The interviews were designed to allow an iterative process where the experts could provide further insight into the project controls process for their respective projects. Survey Round 3 was a questionnaire similar to the Survey Round 1 questionnaire, but revised to reflect all the changes identified in Survey Round 1 and Survey Round 2. The results are followed by a discussion section to summarize the implications of the study.

Survey Round 1 – Questionnaire 1

Survey Round 1 questionnaire had two separate parts. The first part, Part A, was designed to obtain demographic information such as general information about the project and the expert. The survey was distributed using the Qualtrics software previously discussed in Chapter 4, after

obtaining IRB approval and signed consent from the experts. The IRB approval, is presented in Appendix I.

As discussed in the methodology and data collection chapters, the initial list of potential experts was identified through a previous study unrelated to STOs. The study was conducted in May of 2016 by a faculty member and the topic was related to Building Information Modeling (BIM). A list of 78 construction industry practitioners was obtained. Initial attempts to contact the practitioners via email requesting participation in the study resulted in fourteen total responses with eight willing participants. The eight participants are here forth referred to as experts, since they meet the criterion identified for panel selection in Chapter 4 (data collection). The remaining six participants responded that they did not have any experience working on STOs, and hence could not participate since they did not meet the panel requirements. The possibility of encountering participants who were not classified as experts was anticipated since the initial list of possible experts was based on a study on unrelated research area. This initial list was used as a starting point to identify a convenient sample to best represent the population of industrial practitioners working on STOs for the Survey Round 1.

Two of the initial eight experts participated in the pilot study and the outcomes were presented in the Chapter 4, since the results were used only to test the questionnaire. On the completion of the pilot study, the eight experts recommended six other experts who were then contacted for participation, resulting in a sample size of 14. For the Survey Round 1, fourteen responses were obtained using the snowball effect described in the methodology chapter. Each participant completed a Survey Round 1 questionnaire-both Part A and Part B represented in Appendix C and Appendix D respectively. Since no expert completed Part B for multiple projects, there were 14 completed questionnaires or both Part A and Part B.

Survey Round 1: Part A. The Survey Round 1 used questionnaires, and included two parts – the demographics questionnaire (Survey Round 1, Part A) and the project controls questionnaire (Survey Round 1, Part B). Part A of Survey Round 1 included 21 questions designed to obtain information on the background on projects and experts. Part A is presented in Appendix C. Each expert completed Part A once. The experts had a minimum educational qualification of a bachelor’s degree. The sample included experts from both the public and private sector of the construction industry. Based on Part A, 50% of the projects were from the public sector. To obtain a diverse perspective, experts of different roles such as project managers, project inspectors, and safety professionals were included though the selection was not intentional. It was observed that 57 % of the experts worked for owner companies, 14% were consultants, and 29% were contractors. The years of experience of the experts in the construction industry ranged from 10 – 41 years inclusive of all project types including both STOs and traditional construction projects. Figure 9 shows the number of STOs worked on by the experts:

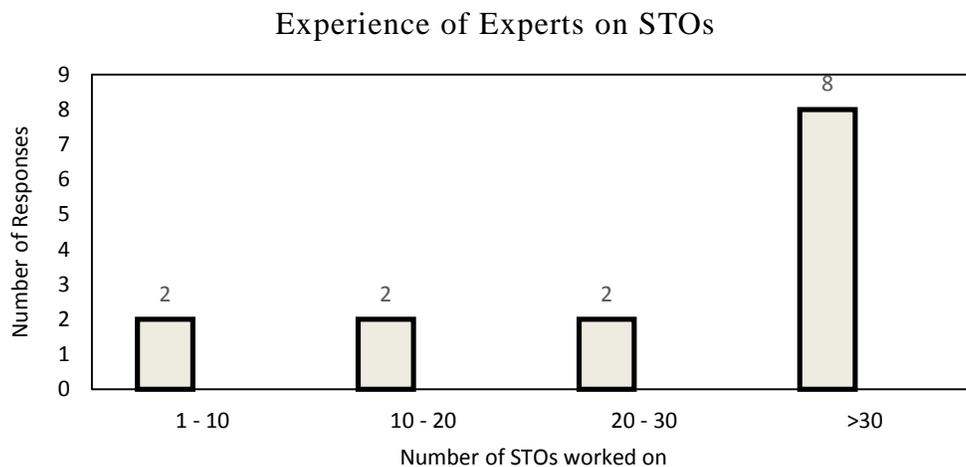


Figure 9 Number of STOs Worked On

Figure 9 shows that the majority of experts have worked on over 30 STOs. Their experience helped to obtain insight into key practices for project controls used in the construction

industry as they relate to STOs. The results in the figure represent the experience of the fourteen experts.

Once it was established that the sample was diverse with respect to factors including roles and project ownership, the next section of questions in Part A of Survey Round 1 was used to understand delays and overruns as related to STOs. Frequency of cost overruns and schedule delays of projects they worked on were taken into consideration to support the assumption that there exists a more robust project controls process. The results are presented in Figure 10.

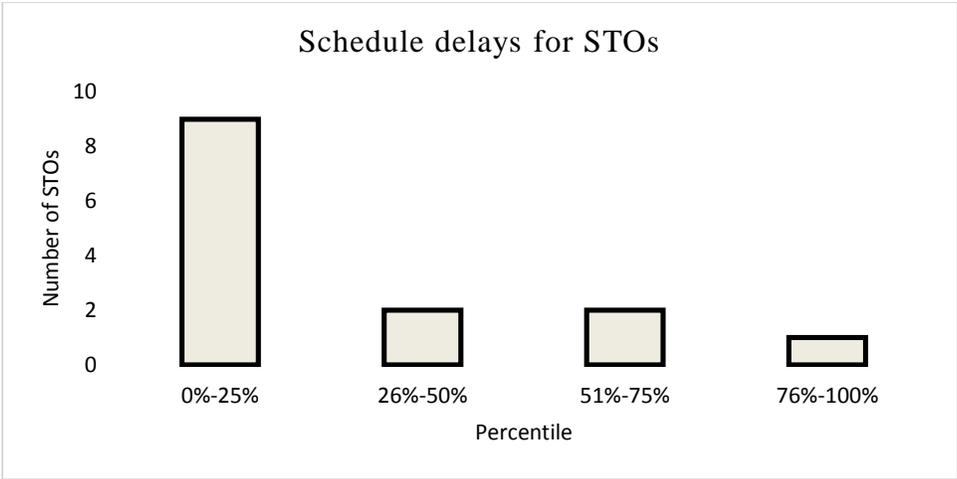


Figure 10 Percentage of Schedule Delays

Figure 10 shows that of all the projects the experts worked on, most STOs have less than 25% delays. The results also showed that all STOs represented in this study had less than 25% cost overrun. This shows a lower percentage of overruns and delays in comparison to traditional construction projects.

The average cost overrun for projects inclusive of rail, road, tunnels, and bridges was estimated to be 28% (Flybjerg et.al., 2003). Flybjerg et.al., (2003). Railway projects showed the highest variance of about 45% on average and roads had a variance of 20.4% on average. This low percentage of deviations in the form of cost and schedule despite the high risk nature of

STOs demonstrate that there is probably a robust project controls process. The current research is based on the assumption that STOs vary significantly from traditional construction projects. Survey Round 1-Part B provides more evidence to validate this assumption. Another key assumption, based on the lower rate of overruns and delays in STOs is that they have a more effective project controls process to address the differences higher uncertainty versus traditional construction projects. This new evidence supports the assumption of a more effective project controls process for STOs.

To validate that these low percentages were the results of a project controls process, the experts were asked what percentage of the STOs implemented cost and schedule controls. Figure 11 and Figure 12 demonstrate the percentage of STOs that implemented project controls for cost and schedule.

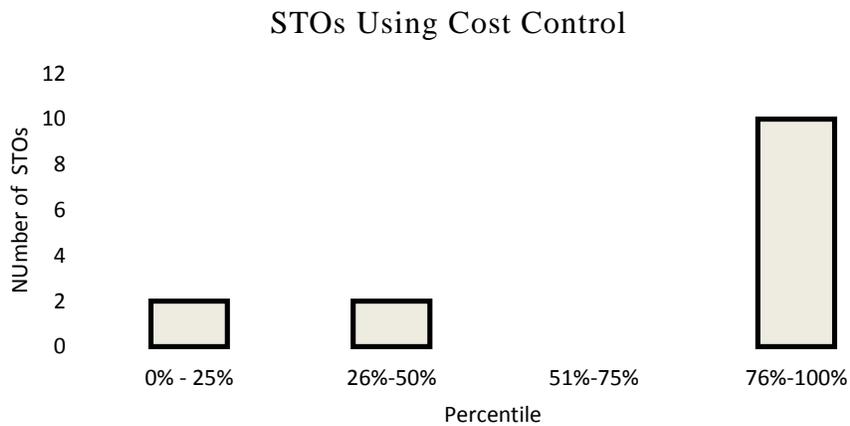


Figure 11 Percentage of STOs using Cost Controls

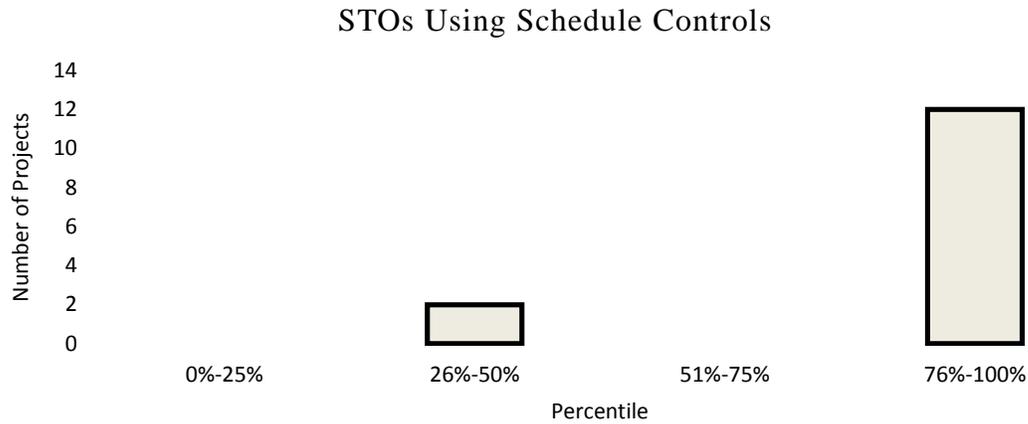


Figure 12 Percentage of STOs using Schedule Controls

As demonstrated by Figure 10 and Figure 11, almost all STOs implemented cost and schedule controls. Since the experts were given options to select ranges, Survey Round 2 (the semi structured interviews) was used to further explore if these percentages implied that all STOs represented in this research used project controls.

Based on the results of Survey Round 1 Part A, it can be observed that the data collected represents different industry sectors of STOs and provides perspective from experts with a wide range of designations across these sectors. Most of the STO projects surveyed had low cost overruns and schedule delays and a majority of the projects implemented cost and schedule control practices. The next step is to understand what the project control tools, techniques, and management practices are and to examine if they are different from the control used for traditional construction projects.

Survey Round 1: Part B. As discussed earlier, the Survey Round 1 questionnaire included two parts. The results of the Part B are presented in this section. Part B is presented in Appendix K..

The first section of questions of Part B was designed to obtain general background information on the project. The projects were geographically located all over the United States ranging from Maine to Oregon. 70% of the projects were power plants, 20% chemical or other process plants, and 10% were classified as other. The total cost of the projects ranged from \$10,000,000 to higher than \$100,000,000. 75% of the projects were subject to penalty in case of a delay.

The experts were asked to identify different phases of STOs they worked on to compare to results obtained from the literature (Levitt, 2004). However, some experts were contractors who worked only on construction phase, they were familiar only with the construction phase. In general, it was observed from the Part B responses that there was an agreement to the following sequence of phases for an STO type project; phases identified are presented in Figure 13.

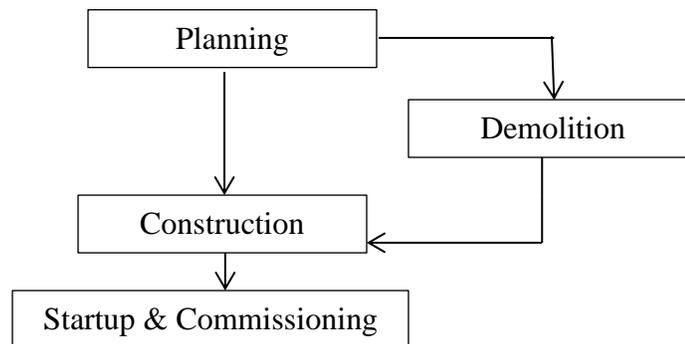


Figure 13 Phases of STOs

As Figure 13 demonstrates, the general consensus among STO experts is that the planning phase is followed by the construction phase and the startup and commissioning phase for STOs. Some projects involved demolition prior to the construction phase although this was not a common practice based on the survey results. The scope of the project determines the need for a demolition phase. Literature provides no evidence that can help obtain a general

standardized representation of the phases of STOs, thus one was created based on Part B results helping to bridge the knowledge gap on STOs.

Part B was divided into subsections. The first few questions were to obtain background information of projects for the researcher to better understand the results. There were four power plants, two chemical processing plants, four oil & gas plants, and four categorized as “other”. Ten of the projects were privately funded and four were a mix of public and private funding. Thirteen of the experts agreed that the project controls process was more effective for STOS.

The first key subsection of the project controls questionnaire was used to evaluate the assumption that STOs vary significantly from traditional construction projects. This included a total of eleven questions. The information on factors that are unique to STOs, from Levitt (2004), was used to generate a list of factors that were used for the comparison of STOs to traditional projects. These factors included staffing requirements, resource leveling, and permit requirements. The results from Part B are presented in Figure 14.

Comparison of STOs to Traditional Projects

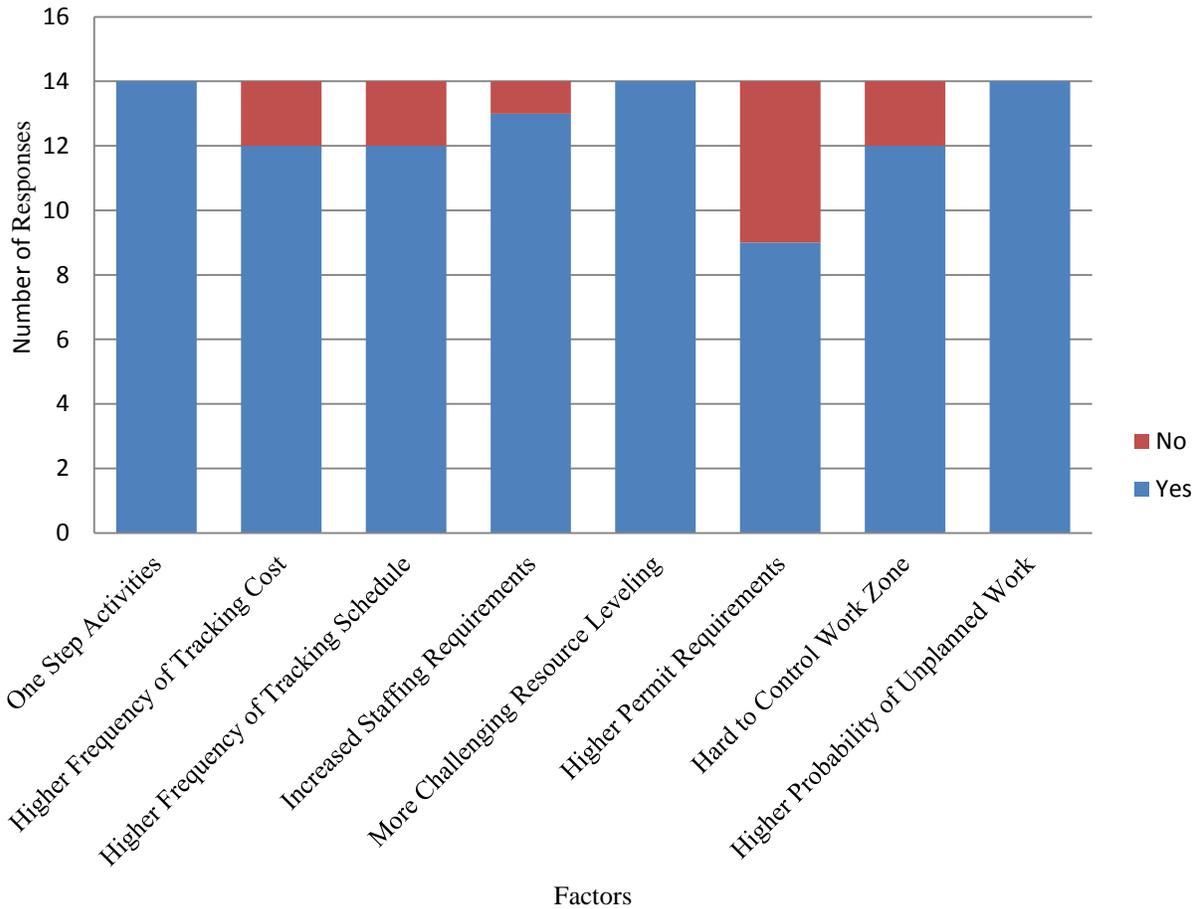


Figure 14 Compare and Contrast Traditional Projects and STOs

The x-axis represents the factors identified by Levitt (2004) and the y-axis represents the total number of STOs. ‘Yes’ represents the agreement of the expert with the literature. For example, all fourteen experts agree that STOs have several one step activities. The presence of several one step activities is unique to STOs. As demonstrated in Figure 14, STOs vary considerably from traditional construction projects. For example, 13 of the total 14 projects demonstrate several one step activities. Similarly 13 STOs showed higher probability of unplanned work. The data collected indicates that STOs have several one step activities, higher frequency of tracking cost and schedule, increased staffing requirements, increased challenge

associated with resource leveling, difficulty in controlling work zone, and higher probability of unplanned worked. Since the methodology is a Delphi approach, consensus is assumed at 50% agreement with the experts. Considering the 50% agreement criteria (Hallowell et. al., 2010) and the results in Figure 13, it can be concluded that STOs vary significantly from traditional construction projects.

Apart from the above frequency distribution, the data was also analyzed to understand the proportions of the successes for each response. The proportions were then analyzed to assess the upper and lower limit for a 95% confidence interval. The results are presented in the Table 5 along with the Binomial distribution vales. Binomial distribution was selected to analyze the data since it is frequently used to analyze frequencies.

The first column lists the distinguishing features of STOs identified by Levitt (2010), the second column “n” represents the number of STOs (one per expert), the third column “X” represents the number of success (represented by ‘Yes’ response in the survey, the fourth column \tilde{n} represents the proportion of successful responses, the fifth column “ \tilde{p} “ represents the probability of getting exactly X successes, columns six and seven represent lower limits and upper limits respectively calculated using Agressi-Coull intervals.

The last column represents the binomial values calculated using Microsoft Excel using the function BINOMDIST (X, n, p, FALSE) for probability distribution function. \tilde{p} values had to be used since the sample size is small. Agressi-Coull intervals are most suited for analyzing confidence intervals for frequencies and provide reliable estimates for any sample size (Navidi, 2006).

Table 5 Confidence Intervals for Factors of Comparison of STOs to Traditional Projects

	n	x	\tilde{n}	\tilde{p}	LL	UL	Binom
STOs have several one step activities	14	13	17	0.8823	0.7291	1.0355	0.3815
The frequency of tracking and updating cost is higher in STOs	14	12	16	0.875	0.7129	1.0370	0.2920
The frequency of tracking and updating the schedule is higher for STOs	14	12	16	0.875	0.7129	1.0370	0.2920
Staffing requirements increased considerably in the case of STOs:	14	11	15	0.8666	0.6946	1.0386	0.2523
Resource leveling (for staffing) is more challenging for STOs	14	14	18	0.8888	0.743	1.0340	1
Permit requirements are higher for STOs	14	10	14	0.8571	0.6738	1.0404	0.2306
Controlling work-zone is more complicated for STOs	14	13	17	0.8823	0.7291	1.0355	

The upper and lower limits of the 95% confidence interval represent the range of probability of observing a similar \tilde{p} value for any given sample set. Therefore, the probability of getting the same percentage of “yes” responses for each factor distinguishing STOs from traditional construction projects. Each “yes” response supports the hypothesis that STOs vary significantly from traditional construction projects. Based on the results obtained, the probability of getting a particular number of “yes” responses or the number of successes is noted in Table 5 as “X”. “n” represents the total number of projects being represented. “ \tilde{p} ” represents the probability for obtaining an “x” value for each factor listed within the limits represented in the upper and lower limit columns for a 95% confidence interval. The upper limits of the confidence interval often

exceeds 1 and this is due to the small sample size. However, it is considered as simply 1 (Navidi, 2006).

The Binomial distribution can be represented as:

$$X \sim \text{Bin}(n, p)$$

Where X is the number of successes in n independent Bernoulli trials with a success probability of p. Since the sample size is small, these are converted to \tilde{n} and \tilde{p} using equations 1 and 2 respectively.

$$\tilde{n} = n + 4 \quad \text{Equation 1}$$

$$\tilde{p} = (X+2)/\tilde{n} \quad \text{Equation 2}$$

The Agressi-Coull intervals for a level 100 (1- α) % for a 95% confidence interval was calculated using Equation 3:

$$\tilde{p} \pm Z_{\alpha/2} \sqrt{\frac{\tilde{p}(1-\tilde{p})}{\tilde{n}}} \quad \text{Equation 3}$$

The second subsection was to obtain information on the cost and schedule related project control tools, techniques, and management practices. This included a total of thirty questions. The first fifteen questions related to cost control. The frequency of comparison of the actual cost to the planned cost varied across the projects. The frequency was once a week for five projects, twice a week for four projects, once a day for one of the projects, and “other” for three. The frequency of reporting these variations followed a similar trend. The frequency of using specific cost control techniques were examined. Eight of the projects used Earned Value Analysis (EVA), Five used Program Evaluation and Review Technique (PERT), none used Leading Parameter Method or Balance Score Card methods, and one used “other”. Similarly, the cost control tools were examined. Seven of the projects used Primavera, three used Timberline, none used

Microsoft Project, and four used “Other”. All the experts agreed that the team had autonomy to make decisions thereby reducing the time for making changes if required.

There were fifteen questions pertaining to schedule related project controls. The key findings are summarized. Thirteen of the projects were completed on time. The frequency of comparison of the actual schedule to the planned schedule varied across the projects. Five of the projects reported once a week, six reported once a day, and three chose “other”. The frequency of reporting followed a familiar trend. The tools used were examined. Twelve of the projects used Primavera, one used Microsoft Project, none used Asta Power Project, and one chose “other”.

The last sub section of Part B of Survey Round 1 was used to rank the barriers to the implementation of project controls tools, techniques, and management practices on STOs. The list of barriers was identified from the available literature. A list of 10 barriers was identified including site conditions, poor front-end planning, and lack of standardized industry guidelines as previously indicated in Table 6. Each barrier was rated on a scale of range 1-10. A value of 10 represents the highest negative effect which implies that a factor rated 10 would be the greatest barrier to the implementation of good project control practices. The experts picked a number between 1-10 based on their experience working on STOs. The results are presented in Table 6. The first column lists the barriers, the second column represents the minimum value that was assigned to the barrier by the experts, the third column represents the maximum value that was assigned to the barrier by the experts, the fourth column represents the mean value of the rating, and the last column represents the standard deviation for each of the mean values assigned to the barriers.

Table 6 Barriers to Implementation of Project Controls

BARRIER	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Poor Scope Definition	1	10	6.4	3.2
Inadequate Experience	1	10	6.2	3.87
Lack of Alignment	1	8	5.4	2.58
Poor Labor Skill	1	10	5.2	3.31
Site Conditions	2	10	4.8	3.49
Poor Front-End Planning	1	9	4.4	3.44
Short Duration	2	10	4.2	3.12
Lack of Standardization	1	8	4.2	2.32
Poor Information Management	1	8	3.4	2.73
Interference of Host Facility	1	9	3.2	2.93

Poor scope definition is the barrier with the highest potential to affect the implementation of project controls process. *Interference of host facility* is the least threatening barrier. The top three barriers are *poor scope definition*, *inadequate experience*, and *lack of alignment* of the stakeholders. Understanding the project controls process, options for tools, techniques, and management practices and having a standardized process can help overcome these barriers.

Poor scope definition was identified as the barrier with the highest mean value of 6.40 and a standard deviation of 3.20. This high mean value suggests that there is a need for more detailed planning required for STOs. STOs are also subject to unplanned work that cannot be addressed during the front end planning. The unplanned work also contributes to the scope creep on STOs.

From Table 5, it can be observed that the mean value for the barrier *inadequate experience* is 6.20 with a standard deviation of 3.87. *Inadequate experience* had the second highest mean value implying that this barrier represents very high negative effects on the implementation of the most effective project controls for cost and schedule. The relatively smaller standard deviation for this barrier demonstrates that the experts agreed on the mean value observed for *inadequate experience*.

From the results observed from Table 6, the top three barriers to the implementation of project controls for STOs ranging from the most detrimental to the least detrimental are *poor scope definition*, *inadequate experience*, and *lack of alignment*.

The experts were also asked to suggest any additional barriers to the implementation of the optimum project controls at the end of the questionnaire. Most experts did not have any suggestions. The one barrier that was identified by one of the experts was poor safety measures. This could be as a result of a poor understanding of the impact of poor safety as a risk factor for STOs. Obtaining the rating from the experts for poor safety measures as a barrier helps in obtaining a better insight.

Survey Round 2 – Semi Structured Interviews

The Survey Round 2 was conducted using semi-structured interviews. The semi-structured interviews were conducted via telephone interviews. This method was selected due to ease of use and time and geographic constraints. As discussed in the methodology chapter, it is common practice to implement semi structured in ethnographic data collection methods. A subset of the experts from the Survey Round 1 were requested to participate in the Survey Round 2.

Five experts who participated in Survey Round 1 were contacted to participate in the second Round of the Delphi study. Four of the experts were selected based on their availability.

The fifth expert was selected due to a higher lack of consensus in the Survey Round 1. Expert five disagreed on most questions that addressed the unique nature of STOs in Part B. The purpose of including expert five was to understand the discrepancy in the responses and to see if the iterative nature of the Delphi process would lead to a different outcome of responses. As discussed in the methodology chapter, the design was to conduct interviews till theoretical saturation was reached. Since theoretical saturation was obtained after five interviews, thus constituting a sufficient sample size. Theoretical saturation implies that the response patterns do not change after a certain number of rounds. In other words, there is no new information obtained.

The telephone calls were digitally recorded using the record option on the cell phone and transcribed. The semi-structured interviews generated about 20 pages of text and about 7500 words. As discussed in the Chapter 3, within-case analysis was conducted to recognize patterns in the transcribed text by identifying relevant statements and repetitive words related to the concepts being investigated in this research. The data was open-coded to identify broad constructs and sub-constructs. Open coding is a common data analysis technique for qualitative research. It is used to define and develop categories. Sub-constructs are words or phrases that support a broader construct. Table 6 presents the list of the constructs and sub-constructs identified from the data collected in the Survey Round 2. The first column lists the constructs that represent the broader umbrella of factors. The second column represents the sub-constructs that are grouped together to represent the constructs that have been identified. This helps to obtain better insight into the patterns of the factors that provide information on STOs.

Table 6 Constructs and Sub-constructs

CONSTRUCTS	SUB-CONSTRUCTS
Discovery Work	Unplanned Work
Communication	Communication between team members Communication with stakeholders
Alignment	Alignment between team members Alignment with stakeholders Alignment with existing workers
Frequency of Reporting	Reporting regular updates Reporting variances Reporting to owners
Safety Measures	Safety measures to address limitations Skilled workers

All of the experts identified *discovery work* as a major contributor to scope creep in STOs. One participant suggested that discovery work can contribute to 40% of the actual work completed on STOs. All the experts identified *communication* as being crucial to the success of STOs. One expert noted “communication is crucial to the successful delivery of any project, it can make or break the success of a project. But, the impacts of the lack thereof can be more detrimental to the shutdown just due to the compressed schedule.”

Communication for STOs has two key channels. A channel is the line or flow of how the information is conveyed. The first channel is between the team members executing the project and the second channel is a broader one including the stakeholders. The experts agreed that stakeholder participation was higher for STOs.

The construct *alignment*, has three sub-constructs – alignment between team members, alignment with stakeholders, and alignment with existing workers. Unlike traditional

construction projects, the teams on STOs work simultaneously. For example, the mechanical and the electrical teams have to work on the same component at the same time. Due to the high probability of discovery work, having all stakeholders updated is crucial to the successful delivery of an STO project. Due to the presence of an existing work environment which might interfere with the STO, it is important to have alignment between the project team and the workers already present at the site or the facility.

All of experts discussed the detailed planning required for STOs. Along with detailed planning, there is a need for a higher *frequency of reporting*. The *frequency of reporting* practice is often on an hourly basis. Reporting includes reporting the comparison, reporting variances if any, and reporting back to the owners to account for discovery work and change orders.

The last construct identified is *safety measures*. Lack of proper *safety measures* that functions as a major barrier to the implementation of optimum project controls practices. The second sub-construct associated with *safety measures* as a construct is the skill level of the worker. A skilled worker is more aware of the needs of STOs and hence has a higher probability of following safety practices.

Survey Round 2 helped obtain a better understanding of STOs. The experts benefitted from being able to see the results of Survey Round 1 since it allowed them to re-evaluate their responses in Survey Round 1. The experts were also given the opportunity to clarify any responses that seemed like an outlier. This helped to improve the accuracy of responses in Survey Round 3.

Survey Round 3 – Questionnaire 2

The last step of the Delphi process designed is the third round of the survey. Based on the results and suggestions obtained in the first and second rounds of the survey, a second

questionnaire was developed using Qualtrics. Further discussion and results of Survey Round 3 are presented in the section below.

Based on the feedback obtained from Survey Round 1 and Survey Round 2, it was concluded that only minor changes were required in questionnaire 2. The changes are as follows:

- **Discovery work:** The first change was to quantify the percentage of discovery work involved in STOs. For the purpose of this research, discovery work is defined as unplanned work that is not included in the original scope of the project. This type of work is very common for STOs and can have direct impact on the project outcomes including cost, schedule, and safety. Hence, based on the feedback and the importance of assessing this factor, it was added to the second questionnaire.
- **Worker Safety:** Based on the discussion included in Survey Round 2, worker safety was identified as a possible barrier to the implementation of project controls for STOs. The participants suggested that worker safety related issues due to poor safety measures and poor safety training can impact the project outcomes. It can lead to delays and taking into consideration of the short construction phase of STOs, it is crucial that that worker safety issues are taken into consideration, evaluated for the impact, and remediation steps required be taken. Hence, worker safety was added in Part B (project controls questionnaire) of the second questionnaire.

Survey Round 3: Part A. Qualtrics was used to distribute the Survey Round 3 questionnaires to the participating experts from Survey Round 1. Similar to the Survey Round 1, there were two parts for the questionnaire in the Survey Round 3. Questionnaire A was designed to collect demographic information of the participants and each participant was required to complete this questionnaire one single time. Based on the feedback from the first two rounds of

the survey, it was concluded that this questionnaire did not require any modifications. The questionnaire is attached as Appendix G.

Survey Round 3: Part B. Part B of the Survey Round 3 questionnaires was designed to obtain the information related to STOs, project controls, and barriers to the implementation of project controls for STOs. The changes discussed above were made to this questionnaire to assess discovery work and worker safety. Each participant was allowed to complete this part of the questionnaire for multiple projects.

Seven of the experts who participated in Survey Round 1 participated in this round of survey and hence there are seven data points for Part A or demographics questionnaire. Three of the experts completed Part B or the project controls questionnaire twice and hence information related to ten projects was obtained.

Part B was divided into subsections. First few questions were to obtain background information of projects for the researcher to better understand the results. There were three power plants, one chemical processing plants, two oil & gas plants, and three categorized as “other”. Six of the projects were privately funded and four were a mix of public and private funding. Nine of the experts agreed that the project controls process was more effective for STOS.

As in the case of the Survey Round 1-questionnaire 1, Part B was divided into subsections. Part B was divided into three subsections. The first subsection of the project controls questionnaire was used to evaluate the assumption that STOs vary significantly from traditional construction projects. The information on factors that are unique to STOs from Levitt (2004) was used to generate a list of factors that were used for the comparison of STOs to

traditional projects. These factors included staffing requirements, resource leveling, and permit requirements. The results from Part B are presented in Figure 15.

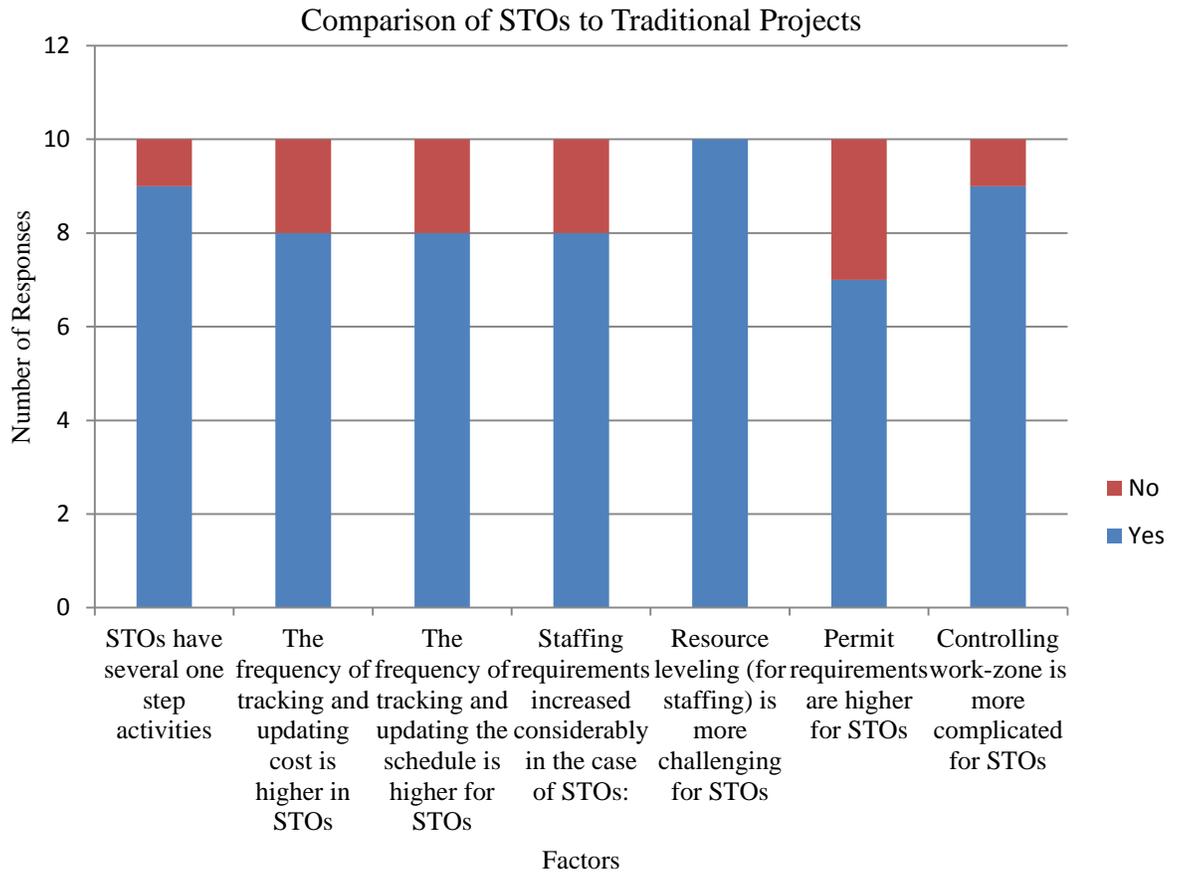


Figure 15 Compare and Contrast Traditional Projects and STOs

The x-axis represents the factors identified by Levitt (2004) and the y-axis represents the total number of STOs represented in this research. ‘Yes’ represents the agreement of the expert with the literature. For example, all fourteen experts agree that STOs have increased challenges associated with resource leveling. As demonstrated in Figure 15, STOs vary considerably from traditional construction projects. The data collected indicates that STOs have several one step

activities, higher frequency of tracking cost and schedule, increased staffing requirements, increased challenge associated with resource leveling, difficulty in controlling work zone, and higher probability of unplanned worked. Since the methodology is a Delphi approach, consensus is assumed at 50% agreement with the experts. Considering the 50% agreement criteria (Hallowell et. al., 2010) and the results in Figure 14, it can be concluded that STOs vary significantly from traditional construction projects.

Apart from the above frequency distribution, the data was also analyzed to understand the proportions of “yes” or success responses. The proportions were then analyzed to assess the upper and lower limit for a 95% confidence interval. The results are presented in the Table 7 along with the Binomial distribution vales. Binomial distribution was selected to analyze the data since it is frequently used to analyze frequencies. The first column lists the distinguishing features of STOs identified by Levitt (2010), the second column “n” represents the number of STOs (one per expert), the third column “X” represents the number of success (represented by ‘Yes’ response in the survey, the fourth column \tilde{n} represents the proportion of successful responses, the fifth column “ \tilde{p} ” represents the probability of getting exactly X successes, columns six and seven represent lower limits and upper limits respectively calculated using Agressi-Coull intervals, and the last column represents the binomial values calculated using Microsoft Excel using the function BINOMDIST (X, n, p, FALSE) for probability distribution function. \tilde{p} values had to be used since the sample size is small. Agressi-Coull intervals are most suited for analyzing confidence intervals for frequencies and provide reliable estimates for any sample size.

The Binomial distribution can be represented as:

$$X \sim \text{Bin}(n,p)$$

Where X is the number of successes in n independent Bernoulli trials with a success probability of p. Since the sample size is small, these are converted to \tilde{n} and \tilde{p} .

$$\tilde{n} = n + 4$$

$$\tilde{p} = (X+2)/\tilde{n}$$

Table 7 Confidence Intervals for Factors of Comparison of STOs to Traditional Projects

	n	x	\tilde{n}	\tilde{p}	LL	UL	Binom
STOs have several one step activities	10	9	13	0.8461	0.6500	1.0422	0.3874
The frequency of tracking and updating cost is higher in STOs	10	8	12	0.8333	0.622	1.0441	0.3019
The frequency of tracking and updating the schedule is higher for STOs	10	8	12	0.8333	0.6224	1.0441	0.3019
Staffing requirements increased considerably in the case of STOs:	10	8	12	0.8333	0.6224	1.0441	0.3019
Resource leveling (for staffing) is more challenging for STOs	10	1 0	14	0.8571	0.6738	1.0404	1
Permit requirements are higher for STOs	10	7	11	0.8181	0.5902	1.0461	0.2668
Controlling work-zone is more complicated for STOs	10	9	13	0.8461	0.6500	1.0422	0.3874

Based on the results obtained, the probability of getting a certain number of “yes” or the number of successes is noted in the Table as “X”. “n” represents the total number of projects being represented. \tilde{p} represents the probability for obtaining an “x” value for each factor listed within the limits represented in the upper and lower limit columns for a 95% confidence interval.

The second subsection was to obtain information on the cost and schedule related project control tools, techniques, and management practices. This included a total of thirty questions.

The first fifteen questions related to cost control. The frequency of comparison of the actual cost to the planned cost varied across the projects. The frequency was once a week for four projects, twice a week for four projects, and “other” for two. The frequency of reporting these variations followed a similar trend. The frequency of using specific cost control techniques were examined. Five of the projects used Earned Value Analysis (EVA), Four used Program Evaluation and Review Technique (PERT), none used Leading Parameter Method or Balance Score Card methods, and one used “other”. Similarly, the cost control tools were examined. Six of the projects used Primavera, two used Timberline, none used Microsoft Project, and Two used “Other”. All the experts agreed that the team had autonomy to make decisions thereby reducing the time for making changes if required.

There were fifteen questions pertaining to schedule related project controls. The key findings are summarized. All ten of the projects were completed on time. The frequency of comparison of the actual schedule to the planned schedule varied across the projects. Three of the projects reported once a week, five reported once a day, and two chose “other”. The frequency of reporting followed a familiar trend. The tools used were examined. Nine of the projects used Primavera, none used Asta Power Project or Microsoft Project, and one chose “other”.

The last sub section of Part B of Survey Round 3 was used to rank the barriers to the implementation of project controls tools, techniques, and management practices on STOs. The list of barriers was identified from the available literature. A list of 11 barriers was identified including site conditions, poor front-end planning, and lack of standardized industry guidelines as previously indicated in Table 8. Each barrier was rated on a scale of range 1-10. A value of 10

represents the highest negative effect which implies that a factor rated 10 would be the greatest barrier to the implementation of good project control practices.

Table 8 Barriers to the Implementation of Project Controls

BARRIERS	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Poor front-end planning	8	10	8.8	0.98
Poor Safety Measures	7	10	8.8	1.47
Inadequate project team expertise/experience	7	10	8.4	1.2
Insufficiency of scope definition	6	9	8	1.26
Poor labor skill set	5	8	7.2	1.17
Discovery Work	6	8	7.2	0.75
Lack of alignment between stakeholders	3	9	6.4	2.33
Site Conditions	1	10	6.2	2.99
Lack of standardized industry guidelines for implementing project controls	4	10	6.2	2.4
Information management issues	3	10	6	2.76
Participation/interference of host facility management	1	8	5.4	2.65
Limited time due to short duration of project	1	8	4	2.37

The experts picked a number between 1-10 based on their experience working on STOs. The results are presented in Table 8. The first column lists the barriers, the second column represents the minimum value that was assigned to the barrier by the experts, the third column represents the maximum value that was assigned to the barrier by the experts, the fourth column represents the mean value of the rating, and the last c

According to the results observed in Table 8, *Poor front-end planning* and *poor safety* measures are the barriers with the highest potential to affect the implementation of project controls for STOs. *Limited time to short duration* was unexpectedly identified as the least threatening barrier. The top three barriers are *poor front-end planning*, *poor safety measures*, and *inadequate experience of the project team*. Understanding the project controls process, options for tools, techniques, and management practices and having a standardized process can help overcome these barriers.

Poor front-end planning is the barrier with the highest mean value of 8.88 and a standard deviation of 0.98. This implies that the long and intensive front-end planning process has a direct impact on the construction phase and hence to the project outcomes.

Poor safety measures was added as a barrier based on the feedback obtained from Survey Round 1 and Survey Round 2. *Poor safety measures* had a mean value of 8.8 and standard deviation of 1.47. It has a higher variability of rating in comparison to *poor front-end planning*. The high mean value implies that the experts agree that there is a need to provide better safety training and provide a highly safe working environment for STOs. Interaction with an existing active environment could be the key contributor for this result.

From Table 8, it can be observed that the mean value for the barrier *inadequate experience* is 8.4 with a standard deviation of 1.2. *Inadequate experience* had high mean value for both Survey Round 1 and Survey Round 3, implying that this barrier represents very high negative effects on the implementation of the most effective project controls for cost and schedule. The relatively smaller standard deviation for this barrier demonstrates that the experts agreed on the mean value observed for *inadequate experience*.

The experts were also asked to suggest any additional barriers to the implementation of the optimum project controls at the end of the questionnaire. The experts did not have any suggestions. The lack of need for more changes compounded with the extremely high consensus among experts contributed to the decision of not conducting further rounds of survey.

The results obtained for both sets of questionnaires in Survey Round 3 are aligned with those obtained for the two questionnaires in Survey Round 1. The change in the mean and standard deviation in comparison to the results from Table 8 of Survey Round 1 can be due to two main factors. The first factor is that Survey Round 3 had fewer participants. The second factor is that since Delphi is iterative and interactive, the experts were allowed access to the results of Survey Round 1 and Survey Round 2 and hence were allowed to re-evaluate their perceptions. The design of the Delphi process and the consensus in all the rounds of surveys contribute to the validity and reliability of the results obtained despite the small sample size.

This section of the dissertation is designed to provide a discussion of the results obtained to understand the implications of the results and to verify that the objectives of the research have been met.

There are three key findings based on the Survey Round 1:

1. STOs are significantly different from traditional construction projects.
2. The project control tools and techniques used in STOs are the same as those used for traditional construction projects. The differences are in the **implementation** of the tools and techniques and in the management practices.
3. A list of barriers to the implementation of optimum project controls was generated.

Based on the results obtained in the Survey Round 1, most experts answered “yes” to the questions addressing the differences between traditional construction projects and STOs. This is

crucial since the research is based on the assumption that the project control process for STOs is different from that used for traditional projects and is also more effective. The more effective project controls are, the lower the cost overruns and schedule delays. The first assumption listed above was validated by the results observed. The experts were also asked if they considered STOs to have a more efficient project controls process. The combined results generate the basis of this research – STOs have a more effective project controls process.

One of the objectives was to identify the list of the project control tools and techniques for cost and schedule that are being used for STOs. As discussed in the previous chapters, a list was generated using available literature for project controls for traditional construction projects. Though the initial attempt was to merely generate a comprehensive list of the tools and techniques, based on the results obtained, it can be concluded that the tools and techniques are almost the same for both traditional construction projects and STOs. The differences are in the implementation and the management practices. To obtain further insight into this theory, the experts were asked to discuss the questions in the second round of the survey administered through semi-structured telephone interviews.

Part B also resulted in the generation of a list of barriers to the implementation of the optimum project controls and the results were presented in Table 8. This allows the project team working on STOs to include the barriers identified in the risk management plan. Though the initial intent of the research was to generate a ranked list, the results presented further insight into STOs that contribute to the objectives of this project.

The first crucial observation was that inadequate experience was identified as an effective barrier to the implementation on optimum project control practices. This supports the assumption that there is a need for additional research on existing tools, techniques, and management

practices that can be used as a guidance document by young professionals with little or no experience.

As discussed, the questions presented in the questionnaire had to be explored further. The second round of Delphi was conducted through the administration of telephone interviews for this purpose.

The telephone interviews were brief and lasted for a maximum of 30 minutes. Most experts identified discovery work as a major concern on STOs. Despite detailed planning and use of project controls process, the process of executing STOs is greatly challenged by the presence of discovery work. Discovery work makes it challenging to plan an optimum project controls process. This generates the need for a more autonomous project team and constant reporting system that includes all stakeholders.

Communication is crucial to the success of any construction project. This is more crucial for STOs due to the compressed schedule and the presence of high risks and discovery work. A higher level of alignment is also a direct result of these factors. STOs require more skilled labor and higher safety measures due to the presence of an already existing active environment.

The experts suggested that though all STOs they worked on implemented project controls, the sophistication depended on the needs of the project. However, lack of information and need for a project controls process that is different from that in the case of traditional construction process, creates a need for an industry guideline. All experts agreed that this research will be beneficial to a young professional with little or no experience as well as well-experienced team members.

The results obtained in Survey Round 3, namely, the second questionnaire complemented the results of the first questionnaire. Since there were extremely minor changes made in the

second questionnaire, the summary of results for this round is the same as in the case of the first round.

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

This chapter provides a summary of the conclusions of the research based on the data analysis and results. In addition to the conclusions, the chapter presents recommendations of the optimum project controls for STOs with a focus on cost and schedule controls. Finally, the chapter will provide information on the future work based on this research.

Summary

Shutdowns, Turnarounds, and Outages (STOs) are a subset of renovation and revamp type of projects which represent 5% of all construction projects (CII, 2008 a). These projects vary significantly from traditional construction projects due to several factors. The principal distinguishing factors include a much longer planning phase and a very short construction phase. There is very little information available that provide significant insight into STOs.

Taking into the account the short construction phase, it can be assumed that the project controls for STOs must be significantly different for STOs. The little available literature focuses primarily on the planning phase and does not provide information on the execution of the actual project controls process. In fact, the literature review reflects the severe lack of literature on the project controls for STOs.

Based on the lack of literature on the project controls for STOs and the assumption that the project controls for STOs vary from that for traditional construction projects, the purpose of

this study was to identify and document the existing tools, techniques, and management practices for project controls for STOs used by industry professionals. Based on this the objectives of the study were developed.

The first objective was to establish that STOs vary significantly from traditional construction projects. Little existing literature supports the assumption. This research relies heavily on the perspective of industry professionals or experts on STOs to obtain a representation of the existing practices. Hence, the first objective was developed. The expertise of the industry professional was used to evaluate the factors identified from the literature. These factors were used to develop yes/no type dichotomous questions as a part of the questionnaires used in round one and round three of survey.

As expected, there was very high consensus on most of the factors suggesting that STOs vary significantly from traditional construction projects. Though there was the challenge of having a small sample size, the results agree with the assumption made. Meeting this objective is crucial to the research since it is the first step is distinguishing STOs from traditional projects and in supporting the theory that there is a need to further study STOs. This is one of the key contributions of this research.

The second objective of the study was initially ascertained to be the key conclusion of this research. The objective was to identify the existing tools, techniques, and management practices related to STOs that are currently used by the construction industry professionals. Questions were developed in the first and the third round of the survey to identify tools and techniques that are currently being used. However, it was observed that the tools and techniques itself did not vary significantly from those for traditional construction projects. It was observed

that it was the management practices that varied. This was mainly identified through the semi-structured phone interview as a part of the second round of the survey.

The management practices were addressed in the first and third round of survey through questions in the project controls questionnaires. For example, the chain of communication and decision-making was analyzed. The short construction phase takes away the luxury of having a more elaborative communication channel observed in the case of traditional construction projects. Any deviations from the planned cost, schedule, and other project outcomes have to be identified immediately, reported, mitigation strategy developed, and executed within a very short time frame. Hence, questions were developed to identify the frequency of reporting, who the changes were reported, and the autonomy of the project team to make decisions. This is a key contribution since the available literature does not address this aspect of STOs and the results can be beneficial in developing management practices for improving the success of traditional construction projects.

The results provide a representation of the different tools and techniques that were used. The results suggested that the tools and techniques are not crucial to the distinguishing of STOs from traditional construction projects. However, the results can be used in future work for developing a tool to standardize the construction phase of STOs. The list of tools and techniques can be used by project managers and other team members who have little experience working on STOs to have guidance on the available tools and techniques.

The third objective of the research was to identify the barriers to the successful implementation of the optimum project control practices. The research design was developed to address the barriers to obtain insight into the implementation of the project controls process during the construction phase of STOs. However, the results obtained helped develop significant

contributions to the body of the knowledge and provided surprising evidence to support the need for this study.

For example, the barrier inadequate experience had the second highest mean value with a reasonable standard deviation. This supports the need for this research. This research can provide insights and information that can be used by industry professionals with little or no experience working on STOs to be a better equipped team member through a better understanding of STOs. The standard deviations observed for the barriers evaluated did not vary much indicating a high level of consensus among the industry experts. The barriers can be used as risk factors in the risk management process to develop a more robust risk management and remediation process.

Since the research involves obtaining information primarily based on the expertise and perceptions of the industry professionals, Delphi was selected as the method for data collection. The reasoning for selecting Delphi above other group techniques are discussed in the literature and methodology chapters. Delphi is an iterative process and hence is self-validating. The results based on Delphi relies heavily on the consensus of the group of experts identified based on a pre-defined set of criterion. Hence, it does not require a robust statistical analysis. However, to improve the contributions and implications of the study, statistical analysis was conducted on the data obtained.

One of the key contributions of this study is the confirmation from the experts that STOs vary significantly from traditional construction projects. The responses from the questionnaires addressing this aspect were analyzed using binomial distributions treating the responses as Bernoulli trials. Point estimates and modified confidence intervals were used to address the small sample size. Further statistical analysis based on the mean and standard deviations were used to understand the results obtained addressing the barriers.

The primary limitation of the research is the sample size as mentioned above. It greatly limits the extrapolation of the results obtained to the population. However, based on the size of the population – the number of STOs which is merely 1% -2% of all construction projects and the extremely high degree of consensus, the results do provide significant insight into STOs, the distinct nature of STOs, management practices, and the barriers to the implementation. And hence, the contributions of the research can provide basis for further robust investigation of STOs and the project controls process for STOs.

Future Work

The scope of the research was limited due to time and resource constraints. The most challenging aspects were related to the sample size. The first challenge was identifying the experts. However, the most crucial limitation was the sample size due to poor participation. So, in order to extrapolate the results obtained in the research and to improve the validity, one of the possible future efforts is to develop a grant proposal based on the results obtained and to submit the proposal to an organization like CII to encourage industry participation. The results of the research can be used as preliminary research to encourage participations. Having industry collaboration will resolve the challenges due to the small sample set and encourage more feedback that can help improve the data collection tool.

1. Based on the industry participation, the research can be further enhanced to collect data related to traditional construction projects to be able to make a direct comparison of the project controls process for traditional projects and STOs. Further, more data can be used to develop a tool similar to the STAR tool for STOs, that helps to standardize the construction phase and provide guidance to project managers and other members of the project team. The

data can also be used to identify direct correlation between particular management practices and project outcomes.

The statistical analysis required for the purpose of this future research will be similar to the methodology used in this dissertation. The only requirement would be to have a much larger sample size and more active industry participation.

2. Project controls is a constantly evolving area with much focus on developing more instantaneous and real-time methods to reporting and control. For the purpose of this research, the latest technologies were not investigated in detail. This was based on three key factors. The first factor was the limited existing literature suggested that small projects including renovation and revamp projects use Critical Path Method (CPM) or bar charts. The second factor was based on the pilot study and initial discussions with the pilot study participants. They did not suggest enhanced use of the modern day tools and technology for project control. Finally, Survey Round 1, Survey Round 2, and Survey Round 3 provided the experts an opportunity to list any new tools and technology apart from the once provided in option. This did not result in any significant findings. This could be due to the limited sample. Having data collected from more firms and more recent projects might help address this issue.

Considering the accelerated schedules for STOs, it is highly likely that STOs can hugely benefit from the use of more instantaneous and real-time project controls process versus a more traditional batch mode reporting. There is a need to identify these project controls processes to develop a toolkit to help execute project controls for STOs. This can be obtained by collecting data that can be used to conduct case studies. Some of the key areas

that will be addressed will include but are not limited to business strategies, reporting strategies, technologies, barriers, and control action strategies.

3. Identifying the correlation can be instrumental in identifying the management practices that have the most significant effects on the project outcomes. The results can be used to explore the possibility of applying these management practices to traditional construction projects to improve the probability of project success.

Another aspect would be to see the effects of each of the barriers on the project outcomes based on their effect on critical success factors or project performance indicators identified in the literature review. This can also be used to develop regression models that can predict the performance of STOs based on the risk factors and barriers relevant for a particular project.

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APPENDICES

APPENDIX A
EMAIL REQUESTING PARTICIPATION

Dear Sir/Madam,

I am a PhD candidate at the University of Alabama (Tuscaloosa) and I work with Dr. Stephanie Vereen. I am currently working on my dissertation research: “Evaluating project controls for Shutdowns/Turnarounds/Outages”.

I am looking for possible participants to take part in a survey as part of my data collection. I have attached the links for the survey and the cover letter describing the project. Please feel free to call/email with any questions. We are hoping to wrap up round one **by the end of this month**.

There are two questionnaires. Each participant needs to complete each questionnaire. It should take 15-20 minutes maximum for both questionnaires.

Demographics: This questionnaire needs to be completed once by each participant.

https://universityofalabama.az1.qualtrics.com/jfe/form/SV_8bMxTcXvmVr1Xc9

Project Controls: This questionnaire needs to be completed one for each STO type project the participant was a part of.

https://universityofalabama.az1.qualtrics.com/jfe/form/SV_cY0Cfi3NHWAtdEF

Please feel free to forward it to anyone you might consider qualifies to take part in the study.

Thanks,

Tisha.

APPENDIX B

COVER LETTER

Title of Research Study: Evaluating Project Controls for Shutdowns/Turnarounds/Outages

Tisha Premraj (PhD Candidate) and Dr. Stephanie Vereen (Academic Advisor)

The University of Alabama, Tuscaloosa

Department of Civil, Construction, and Environmental Engineering

Ph: (541)207-6149

Email: ppremraj@crimson.ua.edu

You are being requested to participate in a research project being conducted by a PhD candidate as a requirement of completion of PhD dissertation research. There is very little published literature on shutdowns/turnarounds/outages and project controls for these projects. Identifying the project controls for these projects with relatively short construction time and documenting them will help in addressing the identified knowledge gap. It will help develop best management practices that are currently being practiced and can be used as a checklist. Some of the project controls identified can also help improve the project control process for traditional projects.

Methodology:

Pilot Study: To test the adequacy and sufficiency of the questionnaire, a pilot study was completed. Two questionnaire surveys were emailed through Qualtrics. The first questionnaire was for demographic information of the experts and the second questionnaire was to meet the objectives of the project. The first questionnaire is to be completed once by each participant. The second question is to be completed for each STO type project that the participant has worked on.

Delphi: A minimum of two rounds of survey of both questionnaires and a round of interviews will be conducted to identify existing practices project controls for STOs and best management practices.

Thanks,

Tisha.

APPENDIX C

PILOT SURVEY – PART A

Demographics

DEFINITIONS:1. Shutdowns/Turnarounds/Outages (STOs): Any project defined under shutdowns, turnarounds, and outages above and any other type of renovation and revamp type project. The Construction Industry Institute (CII) defines STOs as " a project that is executed during a planned disruption in normal use or operation, where return to service is a business priority".2. Traditional projects: Any construction project that is not included in the STOs category is considered a traditional project for the purpose of this research.

Q1 Full name of participant:

Q2 Name of the organization:

Q3 What is the highest level of school you have completed or the highest degree you have received?

- High school degree or equivalent (e.g., GED) (1)
- Some college but no degree (2)
- Associate degree (3)
- Bachelor degree (4)
- Graduate degree (5)
- Other (please specify) (6) _____

Q4 Do you have a Professional Engineering (PE) license ?

- Yes (1)
- No (2)

Q5 List any other licenses or certifications (please list licenses including LEED, EIT):

Q6 Describe your primary title in the company:

- Project Manager (1)
- Senior Manager (2)
- Cost Estimator (3)
- Engineer (4)
- Other (please specify) (5) _____
- Contractor (6)
- Project Planner (7)
- Project Scheduler (8)
- Project Inspector (9)

Q7 The organization you work for is:

- Public Sector (1)
- Private Sector (2)
- Other (please specify) (3) _____

Q8 Under what category would you classify your organization:

- Contractor (1)

- Owner Company (2)
- Consultant (3)
- Other (please specify) (4) _____

Q9 Under what category provided by the Bureau of Labor Statistics (BLS) would you classify your organization? [<http://www.bls.gov/iag/tgs/iag23.htm>]

- Construction (1)
- Heavy & Civil Engineering Construction (2)
- Special Trade Contractors (3)
- Other (please specify) (4) _____

Q10 Number of years/months that you have been working for your current company:

Years (1)

Months (2)

Q11 Number of years/months of experience in current industry (including previous employers, if any):

Years (1)

Months (2)

Q12 Number of construction projects worked on (all types; approximately):

Q13 Number of shutdowns/turnarounds/outages projects worked on:

Q14 Years/months of experience working on shutdowns/turnarounds/outages

Years (1)

Months (2)

Q15 Years/months of experience working on project controls

Years (1)

Months (2)

For questions 16- 21: What percentage of shutdowns/turnarounds/outages you worked on:

Q16 Experienced schedule delay:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q17 Experienced early completion:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q18 Experienced cost overrun:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q19 Was completed under budget:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q20 Used cost control tool & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q21 Used schedule control tools & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

APPENDIX D

PILOT SURVEY – PART B

Project Controls for STOs- Pilot

0 First 5 questions were designed to obtain background on the project and will be confidential.

The data will be used solely for demographic purposes. The next 7 were designed to obtain further information on project background and will be confidential as well.

Q1 Please enter your name:

Q2 Project name:

Q3 Project location:

Q4 Project start date (construction):

Q5 Owner of the project:

Q6 How would you classify the project?

- Power plant (1)
- Oil & gas (2)
- Chemical or other process plants (3)
- Other (please specify) (4) _____

Q7 How would you classify the project based on the actual cost at completion ?

- < \$10,000 (1)
- \$10,001 - \$1,000,000 (2)
- \$1,000,001 - \$10,000,000 (3)
- \$10,000,001 - \$50,000,000 (4)
- \$50,000,001 - \$100,000,000 (5)
- >\$100,000,000 (6)

Q8 How was the project funded ?

- Public (1)
- Private (2)
- Both public and private (3)
- Other (please specify) (4) _____

Q9 What was the procurement method used ?

- Traditional (1)
- Management Contracting (2)
- Design & Build (3)
- Project Management (4)
- CM at Risk (5)
- Other (please specify) (6) _____

Q10 Was there an award/a bonus for completion on time or earlier?

- Yes (1)

No (2)

Q11 Was there a penalty for delay ?

Yes (1)

No (2)

Q12 What percentage of the work, if any, was subcontracted ?

Q13 STOs versus Traditional Projects The following questions serve to compare shutdowns/turnarounds/outages to traditional projects.

Q14 What were the main phases in the project ?

- Demolition (1)
- Construction (2)
- Startup & Commissioning (3)
- Other (please specify) (4) _____

Q17 For the questions would you agree that the following are true for shutdowns/turnarounds/outages in comparison to traditional construction projects

Q18 STOs have several one step activities

- Yes (1) _____
- No (2) _____

Q19 The frequency of tracking and updating cost is higher in STOs:

- Yes (1) _____
- No (2) _____

Q20 The frequency of tracking and updating the schedule is higher for STOs:

- Yes (1) _____
- No (2) _____

Q21 Staffing requirements increased considerably in the case of STOs:

Yes (1) _____

No (2) _____

Q22 Resource leveling (for staffing) is more challenging for STOs:

Yes (1) _____

No (2) _____

Q23 Permit requirements are higher for STOs:

Yes (1) _____

No (2) _____

Q24 Controlling work-zone is more complicated for STOs:

Yes (1) _____

No (2) _____

Q25 There is a higher probability of unplanned/discovery work involved for STOs:

Yes (1) _____

No (2) _____

Q26 The following questions are designed to further understand shutdowns/turnarounds/outages (STOs) and the project controls process for STOs.

Q27 The project controls process for cost and schedule is more effective for STOs:

- Strongly Agree (1)
- Agree (2)
- Disagree (3)
- Strongly disagree (4)

Q28 Rank the key performance indicators (KPIs) used to monitor cost and schedule performance to evaluate project success for STOs (1 being most effective).

_____ Project completed on budget (1)

_____ Project completed on time (2)

_____ Safety measures (3)

_____ Others (4)

Q29 The following questions are regarding the cost and project controls for cost for STOs:

Q30 Estimated project cost:

Q31 Contract cost:

Q32 Actual cost at completion:

Q33 Did the client authorize the change in cost, if any ?

Yes (1) _____

No (2) _____

Q34 What percentage of the change was authorized by the client ?

100% (1)

Other (please specify) (2) _____

Q35 How often was the actual cost compared to the estimated cost ?

Once a week (1)

Once a day (2)

Twice a day (3)

Other (please specify) (4) _____

Q36 How often were variation(s) between actual and planned costs, if any, reported ?

- Once a week (1)
- Once a day (2)
- Twice a day (3)
- Other (please specify) (4)

Q37 Who were the changes reported to?

Q38 What were the major causes of cost variation(s), if any ?

- Price fluctuation (of labor and materials) (1)
- Inaccurate estimates (2)
- Change orders (3)
- Addendum (4)
- Weather (5)
- Other (please specify) (6) _____

Q39 How was the cost estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Other (please specify) (4) _____

Q40 What technique was used for the project control process ?

- Earned Value Analysis (1)

- Program Evaluation and Review Technique (2)
- Leading Parameter Method (3)
- The Balance Scorecard (4)
- Other (please specify) (5) _____

Q41 What software tools were used for the project controls process ?

- Microsoft Project (1)
- Timberline (2)
- Primavera (3)
- Other (please specify) (4) _____

Q42 Considering the short construction phase and time restrictions did you and/or the team have autonomy to make quick/immediate decisions to mitigate the cost related changes ?

- Yes (1) _____
- No (2) _____

Q43 was the team as a unit responsible for the mitigation decisions ?

- Yes (if yes, skip the next 2 questions) (1)
- No (2) _____

Q44 If the answer for the previous question was no, was there a particular individual in the team who was responsible for the decision making ?

- Yes (please specify role/designation) (1) _____

No (2)

Q45 Was there another individual who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

Q46 The following questions are pertaining to the schedule and project controls for schedule for STOs:

Q47 What was the planned duration of the construction (at the end of the planning phase) ?

Days (1)

Weeks (2)

Months (3)

Q48 What was the overall contractual duration of the project ?

Days (1)

Weeks (2)

Months (3)

Q49 Was the project completed on time ?

Yes (1)

No (2)

Q50 What was the length of the delay, if any ?

Days (1)

Weeks (2)

Months (3)

Q51 Did the client authorize the delays, if any ?

- Yes (1) _____
- No (2) _____

Q52 What percentage of the delay was authorized by the client ?

- 100% (1)
- Other (please specify) (2) _____

Q53 What were the major causes of schedule variances ?

- Labor shortage (1)
- Material/equipment unavailability (2)
- Subcontractor delays (3)
- Inaccurate estimates (4)
- Scope changes (5)
- Weather (6)
- Procurement related delays (7)
- Other (please specify) (8) _____

Q54 How often was the actual schedule compared to the planned schedule ?

- Once a week (1)
- Once a day (2)
- Twice a day (3)
- Other (please specify) (4) _____

Q55 How was the schedule estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Using logic and network diagrams (4)
- Other (please specify) (5) _____

Q56 What scheduling techniques were used ?

- Gantt Bar Chart (1)
- Critical Path Method (2)
- Program Evaluation and Review Technique (3)
- Precedence Diagram (4)
- Line of Balance (5)
- Simulation (6)
- Other (please specify) (7) _____

Q57 What software tools were used in the scheduling process ?

- Microsoft Project (1)
- Asta Power Project (2)
- Primavera (3)
- Other (please specify) (4) _____

Q58 Who were the changes reported to ?

Q59 Considering the short construction phase and time restriction did you and/or the team have the autonomy to make quick/immediate decisions to mitigate the cost related changes ?

Yes (1) _____

No (2) _____

Q60 Was the team as a unit responsible for the mitigation decisions ?

Yes (if yes, skip the next two questions) (1)

No (2) _____

Q61 If no for the previous question, was there a particular individual in the team who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

Q62 Was there another individual who was responsible for the decision making ?

Q64 BARRIERS For each of the following potential barriers to the implementation of the project controls that improve the probability of project success, please evaluate. 10 being the highest negative effect and 1 being lowest negative effect.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	8 (8)	9 (9)	10 (10)
Site Conditions (1)	<input type="radio"/>									
Limited time due to short duration of project (2)	<input type="radio"/>									
Participation/interference of host facility management (3)	<input type="radio"/>									
Poor front-end planning (4)	<input type="radio"/>									
Inadequate project team expertise/experience (5)	<input type="radio"/>									
Lack of standardized industry guidelines for implementing project controls (6)	<input type="radio"/>									
lack of alignment between stakeholders (7)	<input type="radio"/>									
Insufficiency of scope definition (8)	<input type="radio"/>									
Information management issues (9)	<input type="radio"/>									
Poor labor skill set (10)	<input type="radio"/>									

Q65 Please list any additional factors that are potential barriers to the implementation of project controls that improve the probability of project success.

APPENDIX E

SURVEY ROUND 1 PART A

Demographics - Round 1

DEFINITIONS:1. Shutdowns/Turnarounds/Outages (STOs): Any project defined under shutdowns, turnarounds, and outages above and any other type of renovation and revamp type project. The Construction Industry Institute (CII) defines STOs as " a project that is executed during a planned disruption in normal use or operation, where return to service is a business priority".2. Traditional projects: Any construction project that is not included in the STOs category is considered a traditional project for the purpose of this research.

Q1 Full name of participant:

Q2 Name of the organization:

Q3 What is the highest level of school you have completed or the highest degree you have received?

- High school degree or equivalent (e.g., GED) (1)
- Some college but no degree (2)
- Associate degree (3)
- Bachelor degree (4)
- Graduate degree (5)
- Other (please specify) (6) _____

Q4 Do you have a Professional Engineering (PE) license ?

- Yes (1)
- No (2)

Q5 List any other licenses or certifications (please list licenses including LEED, EIT):

Q6 Describe your primary title in the company:

- Project Manager (1)
- Senior Manager (2)
- Cost Estimator (3)
- Engineer (4)
- Other (please specify) (5) _____
- Contractor (6)
- Project Planner (7)
- Project Scheduler (8)
- Project Inspector (9)

Q7 The organization you work for is:

- Public Sector (1)
- Private Sector (2)
- Other (please specify) (3) _____

Q8 Under what category would you classify your organization:

- Contractor (1)

- Owner Company (2)
- Consultant (3)
- Other (please specify) (4) _____

Q9 Under what category provided by the Bureau of Labor Statistics (BLS) would you classify your organization? [<http://www.bls.gov/iag/tgs/iag23.htm>]

- Construction (1)
- Heavy & Civil Engineering Construction (2)
- Special Trade Contractors (3)
- Other (please specify) (4) _____

Q10 Number of years/months that you have been working for your current company:

Years (1)

Months (2)

Q11 Number of years/months of experience in current industry (including previous employers, if any):

Years (1)

Months (2)

Q12 Number of construction projects worked on (all types; approximately):

Q13 Number of shutdowns/turnarounds/outages projects worked on:

Q14 Years/months of experience working on shutdowns/turnarounds/outages

Years (1)

Months (2)

Q15 Years/months of experience working on project controls

Years (1)

Months (2)

For questions 16- 21: What percentage of shutdowns/turnarounds/outages you worked on:

Q16 Experienced schedule delay:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q17 Experienced early completion:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q18 Experienced cost overrun:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q19 Was completed under budget:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q20 Used cost control tool & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q21 Used schedule control tools & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

APPENDIX F

SURVEY ROUND 1 PART B

Project Controls for STOs- Round 1

0 First 5 questions were designed to obtain background on the project and will be confidential.

The data will be used solely for demographic purposes. The next 7 were designed to obtain further information on project background and will be confidential as well.

Q1 Please enter your name:

Q2 Project name:

Q3 Project location:

Q4 Project start date (construction):

Q5 Owner of the project:

Q6 How would you classify the project?

- Power plant (1)
- Oil & gas (2)
- Chemical or other process plants (3)
- Other (please specify) (4) _____

Q7 How would you classify the project based on the actual cost at completion ?

- < \$10,000 (1)
- \$10,001 - \$1,000,000 (2)
- \$1,000,001 - \$10,000,000 (3)
- \$10,000,001 - \$50,000,000 (4)
- \$50,000,001 - \$100,000,000 (5)
- >\$100,000,000 (6)

Q8 How was the project funded ?

- Public (1)
- Private (2)
- Both public and private (3)
- Other (please specify) (4) _____

Q9 What was the procurement method used ?

- Traditional (1)
- Management Contracting (2)
- Design & Build (3)
- Project Management (4)
- CM at Risk (5)
- Other (please specify) (6) _____

Q10 Was there an award/a bonus for completion on time or earlier?

- Yes (1)

No (2)

Q11 Was there a penalty for delay ?

Yes (1)

No (2)

Q12 What percentage of the work, if any, was subcontracted ?

Q13 STOs versus Traditional Projects The following questions serve to compare shutdowns/turnarounds/outages to traditional projects.

Q14 What were the main phases in the project ?

- Demolition (1)
- Construction (2)
- Startup & Commissioning (3)
- Other (please specify) (4) _____

Q17 For the questions would you agree that the following are true for shutdowns/turnarounds/outages in comparison to traditional construction projects

Q18 STOs have several one step activities

- Yes (1) _____
- No (2) _____

Q19 The frequency of tracking and updating cost is higher in STOs:

- Yes (1) _____
- No (2) _____

Q20 The frequency of tracking and updating the schedule is higher for STOs:

- Yes (1) _____
- No (2) _____

Q21 Staffing requirements increased considerably in the case of STOs:

Yes (1) _____

No (2) _____

Q22 Resource leveling (for staffing) is more challenging for STOs:

Yes (1) _____

No (2) _____

Q23 Permit requirements are higher for STOs:

Yes (1) _____

No (2) _____

Q24 Controlling work-zone is more complicated for STOs:

Yes (1) _____

No (2) _____

Q25 There is a higher probability of unplanned/discovery work involved for STOs:

Yes (1) _____

No (2) _____

Q26 The following questions are designed to further understand shutdowns/turnarounds/outages (STOs) and the project controls process for STOs.

Q27 The project controls process for cost and schedule is more effective for STOs:

- Strongly Agree (1)
- Agree (2)
- Disagree (3)
- Strongly disagree (4)

Q28 Rank the key performance indicators (KPIs) used to monitor cost and schedule performance to evaluate project success for STOs (1 being most effective).

_____ Project completed on budget (1)

_____ Project completed on time (2)

_____ Safety measures (3)

_____ Others (4)

Q29 The following questions are regarding the cost and project controls for cost for STOs:

Q30 Estimated project cost:

Q31 Contract cost:

Q32 Actual cost at completion:

Q33 Did the client authorize the change in cost, if any ?

Yes (1) _____

No (2) _____

Q34 What percentage of the change was authorized by the client ?

100% (1)

Other (please specify) (2) _____

Q35 How often was the actual cost compared to the estimated cost ?

Once a week (1)

Once a day (2)

Twice a day (3)

Other (please specify) (4) _____

Q36 How often were variation(s) between actual and planned costs, if any, reported ?

- Once a week (1)
- Once a day (2)
- Twice a day (3)
- Other (please specify) (4)

Q37 Who were the changes reported to?

Q38 What were the major causes of cost variation(s), if any ?

- Price fluctuation (of labor and materials) (1)
- Inaccurate estimates (2)
- Change orders (3)
- Addendum (4)
- Weather (5)
- Other (please specify) (6) _____

Q39 How was the cost estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Other (please specify) (4) _____

Q40 What technique was used for the project control process ?

- Earned Value Analysis (1)

- Program Evaluation and Review Technique (2)
- Leading Parameter Method (3)
- The Balance Scorecard (4)
- Other (please specify) (5) _____

Q41 What software tools were used for the project controls process ?

- Microsoft Project (1)
- Timberline (2)
- Primavera (3)
- Other (please specify) (4) _____

Q42 Considering the short construction phase and time restrictions did you and/or the team have autonomy to make quick/immediate decisions to mitigate the cost related changes ?

- Yes (1) _____
- No (2) _____

Q43 was the team as a unit responsible for the mitigation decisions ?

- Yes (if yes, skip the next 2 questions) (1)
- No (2) _____

Q44 If the answer for the previous question was no, was there a particular individual in the team who was responsible for the decision making ?

- Yes (please specify role/designation) (1) _____

No (2)

Q45 Was there another individual who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

Q46 The following questions are pertaining to the schedule and project controls for schedule for STOs:

Q47 What was the planned duration of the construction (at the end of the planning phase) ?

Days (1)

Weeks (2)

Months (3)

Q48 What was the overall contractual duration of the project ?

Days (1)

Weeks (2)

Months (3)

Q49 Was the project completed on time ?

Yes (1)

No (2)

Q50 What was the length of the delay, if any ?

Days (1)

Weeks (2)

Months (3)

Q51 Did the client authorize the delays, if any ?

Yes (1) _____

No (2) _____

Q52 What percentage of the delay was authorized by the client ?

100% (1)

Other (please specify) (2) _____

Q53 What were the major causes of schedule variances ?

Labor shortage (1)

Material/equipment unavailability (2)

Subcontractor delays (3)

Inaccurate estimates (4)

Scope changes (5)

Weather (6)

Procurement related delays (7)

Other (please specify) (8) _____

Q54 How often was the actual schedule compared to the planned schedule ?

Once a week (1)

Once a day (2)

Twice a day (3)

Other (please specify) (4) _____

Q55 How was the schedule estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Using logic and network diagrams (4)
- Other (please specify) (5) _____

Q56 What scheduling techniques were used ?

- Gantt Bar Chart (1)
- Critical Path Method (2)
- Program Evaluation and Review Technique (3)
- Precedence Diagram (4)
- Line of Balance (5)
- Simulation (6)
- Other (please specify) (7) _____

Q57 What software tools were used in the scheduling process ?

- Microsoft Project (1)
- Asta Power Project (2)
- Primavera (3)
- Other (please specify) (4) _____

Q58 Who were the changes reported to ?

Q59 Considering the short construction phase and time restriction did you and/or the team have the autonomy to make quick/immediate decisions to mitigate the cost related changes ?

Yes (1) _____

No (2) _____

Q60 Was the team as a unit responsible for the mitigation decisions ?

Yes (if yes, skip the next two questions) (1)

No (2) _____

Q61 If no for the previous question, was there a particular individual in the team who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

Q62 Was there another individual who was responsible for the decision making ?

Q64 BARRIERS For each of the following potential barriers to the implementation of the project controls that improve the probability of project success, please evaluate. 10 being the highest negative effect and 1 being lowest negative effect.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	8 (8)	9 (9)	10 (10)
Site Conditions (1)	<input type="radio"/>									
Limited time due to short duration of project (2)	<input type="radio"/>									
Participation/interference of host facility management (3)	<input type="radio"/>									
Poor front-end planning (4)	<input type="radio"/>									
Inadequate project team expertise/experience (5)	<input type="radio"/>									
Lack of standardized industry guidelines for implementing project controls (6)	<input type="radio"/>									
lack of alignment between stakeholders (7)	<input type="radio"/>									
Insufficiency of scope definition (8)	<input type="radio"/>									
Information management issues (9)	<input type="radio"/>									
Poor labor skill set (10)	<input type="radio"/>									

Q65 Please list any additional factors that are potential barriers to the implementation of project controls that improve the probability of project success.

APPENDIX G

SURVEY ROUND 3 PART A

Demographics - Round 2

DEFINITIONS:1. Shutdowns/Turnarounds/Outages (STOs): Any project defined under shutdowns, turnarounds, and outages above and any other type of renovation and revamp type project. The Construction Industry Institute (CII) defines STOs as " a project that is executed during a planned disruption in normal use or operation, where return to service is a business priority".2. Traditional projects: Any construction project that is not included in the STOs category is considered a traditional project for the purpose of this research.

Q1 Full name of participant:

Q2 Name of the organization:

Q3 What is the highest level of school you have completed or the highest degree you have received?

- High school degree or equivalent (e.g., GED) (1)
- Some college but no degree (2)
- Associate degree (3)
- Bachelor degree (4)
- Graduate degree (5)
- Other (please specify) (6) _____

Q4 Do you have a Professional Engineering (PE) license ?

- Yes (1)
- No (2)

Q5 List any other licenses or certifications (please list licenses including LEED, EIT):

Q6 Describe your primary title in the company:

- Project Manager (1)
- Senior Manager (2)
- Cost Estimator (3)
- Engineer (4)
- Other (please specify) (5) _____
- Contractor (6)
- Project Planner (7)
- Project Scheduler (8)
- Project Inspector (9)

Q7 The organization you work for is:

- Public Sector (1)
- Private Sector (2)
- Other (please specify) (3) _____

Q8 Under what category would you classify your organization:

- Contractor (1)

- Owner Company (2)
- Consultant (3)
- Other (please specify) (4) _____

Q9 Under what category provided by the Bureau of Labor Statistics (BLS) would you classify your organization? [<http://www.bls.gov/iag/tgs/iag23.htm>]

- Construction (1)
- Heavy & Civil Engineering Construction (2)
- Special Trade Contractors (3)
- Other (please specify) (4) _____

Q10 Number of years/months that you have been working for your current company:

Years (1)

Months (2)

Q11 Number of years/months of experience in current industry (including previous employers, if any):

Years (1)

Months (2)

Q12 Number of construction projects worked on (all types; approximately):

Q13 Number of shutdowns/turnarounds/outages projects worked on:

Q14 Years/months of experience working on shutdowns/turnarounds/outages

Years (1)

Months (2)

Q15 Years/months of experience working on project controls

Years (1)

Months (2)

For questions 16- 21: What percentage of shutdowns/turnarounds/outages you worked on:

Q16 Experienced schedule delay:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q17 Experienced early completion:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q18 Experienced cost overrun:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q19 Was completed under budget:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q20 Used cost control tool & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

Q21 Used schedule control tools & techniques:

- 0%-25% (1)
- 26%-50% (2)
- 51%-75% (3)
- 76%-100% (4)

APPENDIX H
SURVEY ROUND 3 PART B

Project Controls for STOs- Round 2

0 First 5 questions were designed to obtain background on the project and will be confidential.

The data will be used solely for demographic purposes. The next 7 were designed to obtain further information on project background and will be confidential as well.

Q1 Please enter your name:

Q2 Project name:

Q3 Project location:

Q4 Project start date (construction):

Q5 Owner of the project:

Q6 How would you classify the project?

- Power plant (1)
- Oil & gas (2)
- Chemical or other process plants (3)
- Other (please specify) (4) _____

Q7 How would you classify the project based on the actual cost at completion ?

- < \$10,000 (1)
- \$10,001 - \$1,000,000 (2)
- \$1,000,001 - \$10,000,000 (3)
- \$10,000,001 - \$50,000,000 (4)
- \$50,000,001 - \$100,000,000 (5)
- >\$100,000,000 (6)

Q8 How was the project funded ?

- Public (1)
- Private (2)
- Both public and private (3)
- Other (please specify) (4) _____

Q9 What was the procurement method used ?

- Traditional (1)
- Management Contracting (2)
- Design & Build (3)
- Project Management (4)
- CM at Risk (5)
- Other (please specify) (6) _____

Q10 Was there an award/a bonus for completion on time or earlier?

Yes (1)

No (2)

Q11 Was there a penalty for delay ?

Yes (1)

No (2)

Q12 What percentage of the work, if any, was subcontracted ?

Q13 What was the percentage of discovery work (unplanned work)?

0% - 25% (1)

26% - 50% (2)

51% - 75% (3)

76% - 100% (4)

Q14 STOs versus Traditional Projects The following questions serve to compare shutdowns/turnarounds/outages to traditional projects.

Q15 What were the main phases in the project ?

- Demolition (1)
- Construction (2)
- Startup & Commissioning (3)
- Other (please specify) (4) _____

Q16 For the questions would you agree that the following are true for shutdowns/turnarounds/outages in comparison to traditional construction projects

Q17 STOs have several one step activities

- Yes (1) _____
- No (2) _____

Q18 The frequency of tracking and updating cost is higher in STOs:

- Yes (1) _____
- No (2) _____

Q19 The frequency of tracking and updating the schedule is higher for STOs:

Yes (1) _____

No (2) _____

Q20 Staffing requirements increased considerably in the case of STOs:

Yes (1) _____

No (2) _____

Q21 Resource leveling (for staffing) is more challenging for STOs:

Yes (1) _____

No (2) _____

Q22 Permit requirements are higher for STOs:

Yes (1) _____

No (2) _____

Q23 Controlling work-zone is more complicated for STOs:

Yes (1) _____

No (2) _____

Q24 There is a higher probability of unplanned/discovery work involved for STOs:

Yes (1) _____

No (2) _____

Q25 The following questions are designed to further understand shutdowns/turnarounds/outages (STOs) and the project controls process for STOs.

Q26 The project controls process for cost and schedule is more effective for STOs:

Strongly Agree (1)

Agree (2)

Disagree (3)

Strongly disagree (4)

Q27 Rank the key performance indicators (KPIs) used to monitor cost and schedule performance to evaluate project success for STOs (1 being most effective).

_____ Project completed on budget (1)

_____ Project completed on time (2)

_____ Safety measures (3)

_____ Others (4)

Q28 The following questions are regarding the cost and project controls for cost for STOs:

Q29 Estimated project cost:

Q30 Contract cost:

Q31 Actual cost at completion:

Q32 Did the client authorize the change in cost, if any ?

Yes (1) _____

No (2) _____

Q33 What percentage of the change was authorized by the client ?

100% (1)

Other (please specify) (2) _____

Q34 How often was the actual cost compared to the estimated cost ?

Once a week (1)

Once a day (2)

Twice a day (3)

Other (please specify) (4) _____

Q35 How often were variation(s) between actual and planned costs, if any, reported ?

- Once a week (1)
- Once a day (2)
- Twice a day (3)
- Other (please specify) (4)

Q36 Who were the changes reported to?

Q37 What were the major causes of cost variation(s), if any ?

- Price fluctuation (of labor and materials) (1)
- Inaccurate estimates (2)
- Change orders (3)
- Addendum (4)
- Weather (5)
- Other (please specify) (6) _____

Q38 How was the cost estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Other (please specify) (4) _____

Q39 What technique was used for the project control process ?

- Earned Value Analysis (1)
- Program Evaluation and Review Technique (2)
- Leading Parameter Method (3)
- The Balance Scorecard (4)
- Other (please specify) (5) _____

Q40 What software tools were used for the project controls process ?

- Microsoft Project (1)
- Timberline (2)
- Primavera (3)
- Other (please specify) (4) _____

Q41 Considering the short construction phase and time restrictions did you and/or the team have autonomy to make quick/immediate decisions to mitigate the cost related changes ?

- Yes (1) _____
- No (2) _____

Q42 was the team as a unit responsible for the mitigation decisions ?

- Yes (if yes, skip the next 2 questions) (1)
- No (2) _____

Q43 If the answer for the previous question was no, was there a particular individual in the team who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

Q44 Was there another individual who was responsible for the decision making ?

Yes (please specify role/designation) (1) _____

No (2)

The following questions are pertaining to the schedule and project controls for schedule for STOs:

Q45 What was the planned duration of the construction (at the end of the planning phase) ?

Days (1)

Weeks (2)

Months (3)

Q46 What was the overall contractual duration of the project ?

Days (1)

Weeks (2)

Months (3)

Q47 Was the project completed on time ?

Yes (1)

No (2)

Q48 What was the length of the delay, if any ?

Days (1)

Weeks (2)

Months (3)

Q49 Did the client authorize the delays, if any ?

Yes (1) _____

No (2) _____

Q50 What percentage of the delay was authorized by the client ?

100% (1)

Other (please specify) (2) _____

Q51 What were the major causes of schedule variances ?

Labor shortage (1)

Material/equipment unavailability (2)

Subcontractor delays (3)

Inaccurate estimates (4)

Scope changes (5)

Weather (6)

Procurement related delays (7)

Other (please specify) (8) _____

Q52 How often was the actual schedule compared to the planned schedule ?

- Once a week (1)
- Once a day (2)
- Twice a day (3)
- Other (please specify) (4) _____

Q53 How was the schedule estimated ?

- Using historical data based calculations (1)
- By experience (2)
- Combination of historical data and experience (3)
- Using logic and network diagrams (4)
- Other (please specify) (5) _____

Q54 What scheduling techniques were used ?

- Gantt Bar Chart (1)
- Critical Path Method (2)
- Program Evaluation and Review Technique (3)
- Precedence Diagram (4)
- Line of Balance (5)
- Simulation (6)
- Other (please specify) (7) _____

Q55 What software tools were used in the scheduling process ?

- Microsoft Project (1)
- Asta Power Project (2)
- Primavera (3)
- Other (please specify) (4) _____

Q56 Who were the changes reported to ?

Q57 Considering the short construction phase and time restriction did you and/or the team have the autonomy to make quick/immediate decisions to mitigate the cost related changes ?

- Yes (1) _____
- No (2) _____

Q58 Was the team as a unit responsible for the mitigation decisions ?

- Yes (if yes, skip the next two questions) (1)
- No (2) _____

Q59 If no for the previous question, was there a particular individual in the team who was responsible for the decision making ?

- Yes (please specify role/designation) (1) _____
- No (2)

Q60 Was there another individual who was responsible for the decision making ?

Q61 BARRIERS For each of the following potential barriers to the implementation of the project controls that improve the probability of project success, please evaluate. 10 being the highest negative effect and 1 being lowest negative effect.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	8 (8)	9 (9)	10 (10)
Site Conditions (1)	<input type="radio"/>									
Limited time due to short duration of project (2)	<input type="radio"/>									
Participation/interference of host facility management (3)	<input type="radio"/>									
Poor front-end planning (4)	<input type="radio"/>									
Inadequate project team expertise/experience (5)	<input type="radio"/>									
Lack of standardized industry guidelines for implementing project controls (6)	<input type="radio"/>									
lack of alignment between stakeholders (7)	<input type="radio"/>									
Insufficiency of scope definition (8)	<input type="radio"/>									
Information management issues (9)	<input type="radio"/>									
Poor labor skill set (10)	<input type="radio"/>									
Poor Safety Measures (11)	<input type="radio"/>									
Discovery Work (12)	<input type="radio"/>									

Q62 Please list any additional factors that are potential barriers to the implementation of project controls that improve the probability of project success.

APPENDIX I

IRB APPROVAL LETTER

July 18, 2016

Stephanie Vereen, PhD, PI
Civil, Construction, & Environmental Eng.
College of Engineering
Box 870205

Re: IRB#: 16-OR-232 "Request for Exempt Status for Dissertation Research-IRB"

Dear Dr. Vereen:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Your application will expire on July 17, 2017. If your research will continue beyond this date, complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, complete the appropriate portions of the IRB Request for Study Closure Form.

Please use reproductions of the IRB approved stamped consent forms to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,


Director & Research Compliance Officer

APPENDIX J

GLOSSARY OF TERMS – BARRIERS

The following are the descriptions for the terminology used in the questionnaires in Survey Round 1 and Survey Round 3 to evaluate the barriers.

1. Poor front-end planning

The front-end planning (FEP) process is long and rigorous for STOs. However, during the execution phase, the lessons learned from the FEP process is often not well executed. Apart from this, STOs have discovery work which are not addressed in the FEP phase.

2. Poor Safety Measures

Poor safety measures for STOs stem due to several factors. The most important of these is the restricted space availability due to an existing active environment at the facility. Poor safety measures can also be the result for poor safety training provided to the workers on specialized projects like STOs. Other factors that need to be considered include confine work space, work area congestion, labor fatigue due to accelerated schedules, and presence of undocumented hazardous materials. There needs to be a more proactive and enhanced emergency response strategy.

3. Inadequate project team expertise/experience

Much of the STOs rely on the experience of experts working on these projects over several years since there is no industry standardizations or literature that is publicly available.

Problems due to inexperienced management due to limited executive personnel allocated to these projects versus larger traditional projects can be an issue.

4. Insufficiency of scope definition

The insufficiency of scope definition is due to two key factors. The first factor is poor FEP regarding the consideration of the existing active environment. The second is due to unplanned work that often results in scope changes.

5. Poor labor skill set

Due to the unique nature of STOs, highly skilled labor is required to work on these projects. Good craft workers who are productive and safety conscious are required to execute these projects

6. Discovery Work

Discovery work is any unplanned work that occurs during the execution of STOs. These do not include overlooked tasks. Unplanned work is when a new change to the scope occurs as a direct result of a new discovery. For example, the presence of faulty wiring is discovered during the replacement of a pump. The work cannot be predicted or foreseen during FEP. Project schedules are often subject to adjustments due to the unplanned work.

7. Lack of alignment between stakeholders

Due to the high probability and impact of discovery work, the stakeholders need to be constantly updated on changes, mitigation efforts, and progress. Alignment can help improve problems due to impact of tie-in with the operational facility. At the same time, it is important to avoid interruptions and unnecessary meetings.

8. Site Conditions

Site conditions for STOs is slightly different from the traditional sense. This mainly represents how well STOs can be integrated into a pre-existing active environment. Work space is often confined and restricted. There can be unwanted interactions between project area and the operating facility. Control of work-zone can be challenging.

9. Lack of standardized industry guidelines for implementing project controls

Due to the lack of industry standards and lack of publicly available information on STOs, these projects are mostly executed based solely on the experience of the team members.

10. Information management issues

Information management has several aspects. For this research, information management focusses mainly on the observation, reporting, and mitigation of variances in a timely fashion.

11. Participation/interference of host facility management

Due to the integration with a pre-existing active work environment, STOs are often subject to interference from management and workers at the host facility.

12. Limited time due to short duration of project

STOs are extremely schedule driven and hence often result in accelerated schedules.