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Successful Delivery of Mega-projects

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Successful Delivery of Mega-projects

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Abstract

Successful Delivery of Mega-projects

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The term “mega-projects” is generally used to describe those projects whose capital budgets exceed one billion dollars. Many recent studies assessing the performance of mega-projects have concluded that cost and schedule overruns are common in all industry segments and world regions. Mega-projects are of importance not only to the stakeholders involved in development and construction, but also to the societies, economies, and environments impacted by these projects. There are very few studies that provide guidance on the effective planning and execution of megaprojects. Given the enormous amount of capital dollars at stake and the prevailing trend towards poor performance, the Construction Industry Institute initiated Research Team 315 (RT 315), Successful Delivery of Mega-projects, to attempt to identify why these failures happen and what can be done to prevent or reduce mega-project performance failures. The primary research question the team was tasked to find answer was: “What sorts of changes in project development and execution are needed to increase the likelihood of success on mega-projects?”

After conducting a thorough literature review the RT finalized the following two hypothesis to validate (1) there are factors that have higher occurrence and performance impacts on mega-projects. (2) These factors require changes in mega-project planning and execution to improve the chances of successful outcomes. Through preliminary interviews, surveys, follow up interviews and case studies, the research identified 34 impact factors with high occurrence and high negative performance impact on mega-projects. The research also prioritized the most impactful factors that should be avoided or mitigated to increase the likelihood of successful mega-project outcomes. The research went deeper by identifying specific case examples of how the negative impacts might manifest. Furthermore, for each of the factors, the research identified specific mitigation strategies and recommendations that should be adopted during front-end-planning and execution. All of these results have been compiled into an Excel-based Implementation Resource, IR 315-2 Mega-Project Assessment of Criticality Tool (MPACT). MPACT provides project teams the means to a structured assessment process of critical factors on mega-projects, enabling more accurate and thorough mitigation planning on these impact factors, in order to improve mega-project performance.

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CHAPTER-1 INTRODUCTION

In 2013, the Construction Industry Institute (CII) initiated a research effort to identify changes required in the planning and execution of mega-projects to improve chances of mega-project success. To achieve this goal, Research Team (RT) 315 was formed, comprising of industry subject matter expertise and academic researchers. I was the Graduate Research Assistant with the RT 315 team and worked with Professor Carlos Caldas, Principal Investigator, to produce this report.

1.1 Problem Statement

Mega-projects in simple terms are defined as projects having a billion dollar plus budget. Mega-projects are also categorized by complexity, uncertainty, ambiguity, dynamic interfaces, significant political or external influences, and time periods reaching a decade or more (Florice & Miller, 2001). Mega-projects are often classified in the highly complex program category facing numerous challenges and facing the most extreme project characteristics (Kardes, Ozturk, Cavusgil, & Cavusgil, 2013). Incorporating both complexity and budget criterion in the context of the research, a mega-project is defined as any project with a total installed cost greater than \$1 billion dollars with one or more of the following complexity criteria: significant number of stakeholders; large number of interfaces; challenging project location; inadequate supply of resources; unfamiliar technology; difficult regulatory constraints; extensive infrastructure requirements; geographically dispersed teams; and significant political, economic, environmental, or social influence.

Mega-projects are now common in capital projects industry and are witnessing a rapid rise in the size and number of mega-projects. A 2012 Schlumberger Consulting report stated that

annual capital spent on oil and gas exploration and production capital mega-projects has more than tripled in the past 10 years, with the number of projects above \$1 billion nearly quadrupled in number (Procaccini, Lea-Cox, & Hoop, *Challenges of E&P Megaproject Delivery*, 2012). Spending on infrastructure in emerging markets was estimated by Merrill Lynch to be \$2.25 trillion annually between 2009 and 2012. Many other reports provide similar insights, indicating more mega-projects to come.

Given the size and scale, mega-projects are of importance not only to the stakeholders involved in development and construction, but also to the societies, economies, and environments impacted by the projects. The scale of mega-projects is so large that the failure and success of even a single project can have significant bearing on the sponsoring governments or countries (Flyvbjerg, Bruzelius, & Rothengatter, 2003). For instance, the operating problems with Hong Kong's new US \$20 billion Chek Lap Kok airport, which opened in 1998, initially caused havoc only to the costs and revenues at the airport. The problems then spread to the Hong Kong economy, with negative effects on growth in gross domestic product (CNN, *Financial News*, 16 July 1988). After nine months of operation, *The Economist* dubbed the airport a "fiasco", said to have cost the Hong Kong economy US \$600 million (*The Economist*, 28 August 1999). The criticality of these projects as observed by Edward Merrow in a RAND study of mega-projects quotes, "Such enormous sums of money of money ride on the success of mega-projects that company balance sheets and even government balance of payments accounts can be affected for years by the outcomes...The success of these projects is so important to their sponsors that firms and even governments can collapse when they fail" (Merrow E. W., *Understanding the Outcomes of Mega-projects: A quantitative analysis of very large civilian projects* pg 2-3, March, 1988).

Despite their impact and significance, many recent studies assessing the performance of mega-projects have concluded that cost and schedule overruns are common in all industry segments and world regions. After analyzing more than 300 mega-projects, Merrow concluded that approximately 65 percent failed to achieve the performance objectives established at sanction. The results were even worse in the oil and gas sector, where close to 78 percent of the mega-projects failed (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success*, 2011). Another recent study by Ernest & Young (EY, 2014) concluded that 73 percent of the mega-projects they studied experienced schedule overruns and 64 percent had cost overruns. On average, actual costs were 59 percent higher than original estimates. The Construction Owners Association of Alberta (COAA) and others who have also studied the issue arrived at similar conclusions (McTague & Jergeas, 2002) (Slootman, 2007) (Jergeas, 2009) (Flyvbjerg, Bruzelius, & Rothengatter, 2003). By definition, mega-projects are large, complex, and problematic, with planning subject to error. Mega-project failures can be dramatic. Failure to deliver a mega-project on time, within budget, or in accordance with regulatory or environmental requirements can have major repercussions on an organization's reputation and revenue performance (EY, 2014).

There are very few studies that provide guidance on the effective planning and execution of mega-projects. It is important to verify if some practices are more difficult to implement on mega-projects, or if there are certain practices in need of modification to suit mega-projects. Conversely, it is important to identify other practices that may be critical to the success of mega-projects. Other research has suggested that mega-projects produce a culture of optimism. On the Big Dig, Boston's Central Artery/ Tunnel Project, the initial estimated cost was \$2.56 billion, the project cost escalated to \$14.8 billion in 2007. The overrun budget resulted from the unrealistic initial cost estimation (Greiman, 2013). In this regard, previous studies highlighted the importance

of the project planning and the alignment between the business planning team and the project management team.

The current body of knowledge suggests that mega-projects are more sensitive to certain factors than smaller-sized projects. The capital projects industry has expanded, but it is underprepared to successfully execute mega-projects. For all the reasons mentioned above, the industry must identify what sorts of changes in project planning and execution are needed and implemented to improve the probability of success on mega-projects.

1.2 Purpose and Objective

After conducting an initial literature review it was evident that there exist a need to focus research effort into learning what factors impacts mega-projects the most and how project teams can mitigate these factors. This research project focused on adding value to the capital projects industry by contributing to the body of knowledge by providing recommendations, guidelines, and tools to successfully plan and execute mega-projects.

Based on the needs, the primary purpose of this research project was to identify and characterize changes in project planning, and execution practices that are needed in order to improve the probability of successful mega-project **outcomes. RT 315, composed of owners, contractors, and academic researchers, was chartered to gather data** through interviews, surveys, and industry case studies to fulfill the following specific research objectives:

1. Describe the current state-of-the-art of delivery of mega-projects.

The first objective was to conduct a thorough literature review for a better understanding on the practices and procedures being currently used in planning and executing mega-projects. The objective was important so as to be able to build on previous findings and

add value to the overall research on mega-projects. This included learning the various definitions of mega-projects, understanding the current trends with mega-project performance, and identifying some high-level success and failure factors of mega-projects.

2. Identify and prioritize the primary success and failure factors on mega-projects.

The second objective focused on identifying and prioritizing factors that have higher occurrence and greater impact on mega-projects, this would help project teams focus on critical areas on their mega-project. The prioritized list will provide an industry reference for teams and provide awareness of these factors.

3. Identify changes in shaping, planning, or execution practices.

After identifying the primary success and failure factors on mega-projects, guidance will be provided on the planning and execution of the identified factors to enable effective mitigation. Through the findings, mega-project organizations will better understand how to address the organizational, managerial, political, cultural, environmental, social, and economical issues involved, as well as how to establish appropriate strategies.

4. Develop tools to support proactive mega-project planning and execution.

The final objective was to develop simple tools that would help mega-project teams use the research findings to better plan for the factors identified. The tool would be a project readiness or assessment tool. The main aim behind this objective was to complement existing organization processes and help make them better fit for mega-projects. At the end, the researchers aim to provide in-depth guidance and tools for the successful delivery of mega-projects, considering the unique characteristics and challenges of this type of project.

1.3 Assumptions and Limitations

- As a result of the data collected, the focus of the analyses and findings represent heavy industrial mega-projects. However, the findings may be applicable to other sectors of the capital projects industry.
- More than 100 projects participated in the data collection efforts. All participants were approached as volunteers for the study.
- The research focused on the performance of mega-projects in terms of cost, schedule, and business goals. The research did not include safety and quality performance in its data gathering and analysis.

1.4 Organization of the report

This report will first provide a description of the research methodology adopted in Chapter 2 listing the various research steps. Chapter 3 will then describes in detail the background review conducted to explain the current state-of delivery of mega-projects. Chapter 4, Chapter 5, and Chapter 6 will each detail the methodology and findings of the different data collection and analyses phases. Chapter 4 will deal with preliminary interviews, Chapter 5 with survey and follow up interviews, and Chapter 6 with case studies. Chapter 7 will successively present the application and implementation of the research along with information about impact factors on mega-projects. Chapter 7 will also introduce and explain the assessment tool prepared to assess the criticality of factors on mega-projects. Finally, Chapter 8 will detail the conclusions and recommendations made from the research.

CHAPTER 2- RESEARCH METHODOLOGY

The Construction Industry Institute (CII) is a consortium of more than 100 leading owner, engineering-contractor, and supplier firms from both the public and private arenas. Its mission is to improve the cost effectiveness of the capital facility project life cycle, from pre-project planning through completion and commissioning. By collaborating on important industry issues and providing guidance on best practices discovered through research. In summer of 2013, CII formed the Research Team 315 (RT315). The team was composed of experienced industry representatives, who provided valuable input regarding every step of the research in this report. The names of the team members are listed in Appendix A. This chapter describes the methodology adopted to fulfill the research objectives.

Figure 1 gives an overview of the methodology.

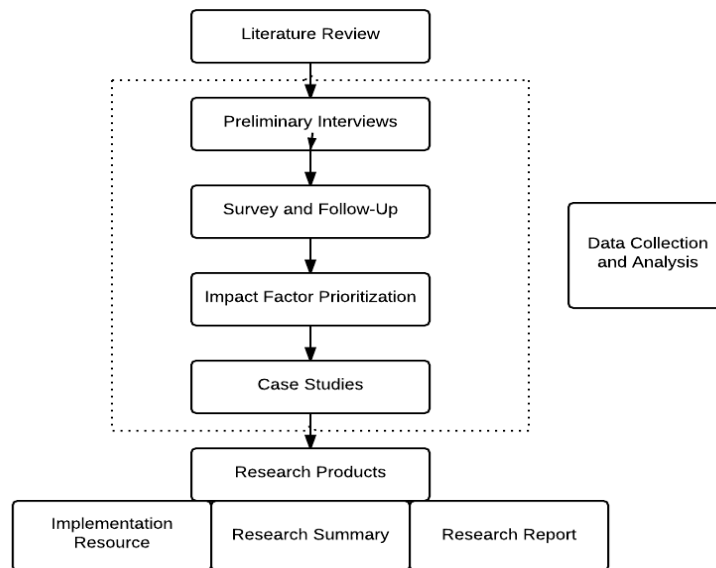


Figure 1. RT Research Methodology

Considering the breadth of this research topic, an extensive literature review was conducted in order to understand key lessons learned from previous successful and unsuccessful mega-projects.

Previous publications on mega-projects from academia and industry, as well as mega-project case studies, recent reports from consulting firms, and mega-projects in other industries were reviewed to understand the current state-of-art of mega-project delivery. The background review was helpful in finalizing and refining the research hypothesis and future data collection efforts.

In parallel to the extensive literature review, preliminary interviews were conducted with experienced industry professionals directly involved in the planning and execution of mega-projects. The main objective was to identify factors contributing to the success and failure of mega-projects. A master list of more than 100 factors that impacted mega-project performance was prepared using the findings from the preliminary interviews and the review of past publications. The master list of factors was analyzed, prioritized, and categorized to finalize a list of 34 impact factors organized into five categories.

Next, a survey was done on mega-projects (defined here as projects having a sanctioned budget of above \$1 billion) and large projects (defined here as projects having a sanctioned budget greater than \$100 million and less than \$750 million) to learn the occurrence and impact levels of the impact factors identified. Following the survey and the data analysis on the survey data, follow-up interviews were conducted with some survey respondents to clarify and better understand the findings from the survey.

The follow up interviews were a starting point of the case studies. Through the data analysis on the survey data, impact factor were prioritized and some key impact factors from the list of 34 impact factors were identified for further case studies. Case studies were then conducted with the objective to learn in-depth about the occurrence and impact of the selected impact factors and on determining what mitigation measures, if any, were adopted on mega-projects to mitigate the impact of these factors. The literature review, the data collection effort, and extended discussions

with subject matter experts enabled the researchers to prepare the research products and reports. The researchers prepared a mega-project preparedness MS Excel tool around the 34 impact factors as the implementation resource titled IR315-2 *Mega-project Impact Factor Criticality Preparedness* (CII, 2015). In addition, Research Summary RS315-1 (CII, 2015) and this thesis were also prepared.

This two-year research effort yielded conclusions and recommendations as to what steps should be taken during Front-End Planning Phase (Pre-Approval), Execution Phase (Post-Approval), and throughout the project duration in order to effectively plan for an impact factor.

CHAPTER 3- BACKGROUND REVIEW

An extensive background review comprised the first stage of the research. Previous publications on mega-projects from both academic and industry sources were reviewed. These included journal papers, articles, case studies, and recent reports on mega-projects inside and outside the capital projects industry. The two main objectives behind the background review were to characterize the current state-of-the-art in the delivery of mega-projects and to identify lessons learned from successful and unsuccessful mega-projects. The literature review was divided into three main sections:

- Understanding definitions of mega-projects
- Reviewing mega-project performance categorization
- Reviewing past performance of mega-projects
- Identifying factors behind mega-project successes and failures

3.1 Mega-project definitions

The first step in the literature review was to explore the categorization of mega-projects that make them unique and different from other regular sized projects. Mega-projects have been defined by many researchers in varied contexts. There exists many perceptions of mega-projects across industry sectors and they have been defined by many in most dramatic ways. Sociologist Zygmunt Bauman perceptively class it the “Great War of Independence from Space.” Bauman sees the resulting new mobility as the most powerful, most coveted stratifying factor in contemporary society (Flyvbjerg, Bruzelius, & Rothengatter, 2003). Bill Gates, founder and chair of Microsoft Corporation, has dubbed the phenomenon “frictionless capitalism” and sees it as a novel stage in capitalistic evolution(s) (*Time*, 3 August 1998). Bent Flyvbjerg in his book, *Mega*

Projects and Risk, defines mega-projects as a term that signifies a qualitatively different stage of social and economic development(s) (Flyvbjerg, Bruzelius, & Rothengatter, 2003). These definitions demonstrate the magnitude of impact of mega-projects upon societies and economies. In capital projects, industry mega-projects have existed from some time and have captured the imagination of many researchers. There exist many definitions of mega-projects. Below are some definitions that demonstrate how mega-projects are categorized and defined:

“Mega-projects are very large investment projects, that cost more than US \$1 billion, or projects of a significant cost that attract a high level of public attention or political interest because of substantial direct and indirect impacts on the community, environment, and budgets.” (Flyvbjerg, Bruzelius, & Rothengatter, 2003).

“Mega-projects are typically defined as costing more than US \$1 billion and attracting a lot of public attention because of substantial impacts on communities, environment, and budgets.” (Altshuler & Luberoff, 2003).

“Mega-projects are defined broadly as projects which transform landscapes rapidly, intentionally, and profoundly in very visible ways, and require coordinated applications of capital and state power.” (Lynch & Gellert, 2003).

The Federal High Way Administration (FAHWA) defines mega-projects as *“major infrastructure projects that cost more than US \$1 billion or projects of a significant cost that attract a high level of public attention or political interests because of substantial direct and indirect impacts on the community, environment, and state budgets.”*

Ed Merrow (IPA) (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success*, 2011), defines an industrial mega-project as a *“project with total capital cost of more than \$1 billion as measured on January 1, 2003.”*

While understanding key definitions of mega-projects it was considered essential to view mega-projects not only from the cost side but also to understand the complexities that differentiate mega-projects. **Building on the various definitions and in the context of the research, mega-projects were defined as capital projects with a total installed cost greater than \$1 billion dollars with any of the following complexity criteria:**

- **Significant number of stakeholders**
- **Large number of interfaces**
- **Challenging project location**
- **Inadequate supply of resources**
- **Unfamiliar technology**
- **Difficult regulatory constraints**
- **Extensive infrastructure requirements**
- **Geographically dispersed teams**
- **Significant political, economic, environmental, or social influence**

3.2 Mega-project performance characterization

The next step in the literature review focused on understanding performance metrics that have been widely accepted in benchmarking data to categorize mega-projects as a success or failure. IPA (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success*, 2011) has measured performance of mega-projects on five performance metrics:

- Cost overrun measured as the ratio of the actual final cost of the project to the estimate made at the full-funds authorization (sanction) measured in escalation-adjusted terms.

- Cost competitiveness measured how much the project spent (in constant dollars adjusted to a common location) relative to other projects with similar scopes.
- Slip-in execution schedules measured as the actual schedule (from the start of production until mechanical completion of facilities) divided by the schedule forecast at full-funds authorization.
- Schedule competitiveness is the length of the execution relative to similar projects.
- Production versus plan measuring the final production of the facility with the planned production targets.

IPA categorizes mega-projects as successful and unsuccessful on the basis of the above metrics. Mega-projects having either a cost overrun greater than 25 percent or cost competitiveness greater than 25 percent, or slip in execution schedule greater than 25 percent, or schedule competitiveness greater than 50 percent, or significantly reduced production into year two are termed as unsuccessful. Mega-projects experiencing below threshold performance metrics as stated above are termed as successful.

In another study done in 2003 by COAA (Construction Owners Association of Alberta) and CII to develop a benchmarking system for measuring performance of major projects in Alberta, COAA used CII's project performance metrics (e.g., cost, schedule, change, fieldwork, and Canada's existing safety metrics) to measure performance of projects in Alberta (Construction Owners Association of Alberta, 2009). The study does not characterize projects as success or failure in the study, but presents detailed metrics currently used to evaluate large to mega-projects. The following are the metric definitions as defined by CII and used by COAA for evaluation:

$$\text{Project Cost Growth} = \frac{\text{Actual total project cost} - \text{Initial predicted project cost}}{\text{Initial predicted project cost}}$$

Project Schedule Growth

$$= \frac{\text{Actual total project duration} - \text{Initial predicted project duration}}{\text{Initial predicted project duration}}$$

$$\text{Scope change cost factor} = \frac{\text{Actual cost of scope changes}}{\text{Actual total project cost}}$$

$$\text{Total field rework factor} = \frac{\text{Total direct cost of field rework}}{\text{Actual construction phase cost}}$$

Learning how mega-projects are categorized as successful and unsuccessful helped to illustrate how currently the performance on mega-projects is being evaluated. The performance metric based success criterion discusses the success or failure of a mega-project solely from the owner side. However, the perceptions of success or failure may be different for owner, contractor, or a supplier.

3.2 Performance of mega-projects

According to a report published by Schlumberger Business Consulting (SBC) in the summer of 2012, capital projects are becoming more common in today's upstream oil and gas industry. Annual capital spent in the exploration and production (E&P) sector has more than tripled in the past 10 years to reach \$550 billion in 2011, and the number of projects above \$1 billion has nearly quadrupled (Procaccini, Lea-Cox, & Hoop, *Challenges of E&P Megaproject Delivery*, 2012) (see Table 1).

Table 1. Growth in E&P CAPEX and Project Size During the Past Decade, (Procaccini, Lea-Cox, & Hoop, 2012)

E&P Trends	2001	2011
E&P capital spend	Approx. \$150 billion	Approx. \$150 billion
Number of ongoing project with budget > \$ 1 billion	Approx. 50	Approx. 200
Number of operators with CAPEX budget > \$4 billion	10	30 plus
Number of operators managing projects > \$1 billion	12	40 plus

In another recent report, the International Energy Agency (IEA) in its World Energy Investment Outlook 2014 estimates a cumulative investment of US\$22.4t in the global oil and gas sector between 2014 and 2035, equivalent to an average annual spend of more than US \$1t. IEA also provides a distribution of the regional cumulative investments by region with spending dominated by North America (particularly in US), Europe, and Asia Pacific. Table 2 shows the estimated regional cumulative investments between 2014 and 2035 (International Energy Agency, 2014).

Table 2. Estimated Regional Cumulative Oil and Gas Investment between 2014 and 2035 (International Energy Agency, 2014).

Region	Estimated Cumulative Oil and Gas Investment (in Trillion Dollars)
North America	5.8
Europe	4.6
Latin America	2.7
Africa	2.3
Asia-Pacific	4
Middle East	2.7
Inter-regional	0.4
Total	22.4

If current trends are an accurate indicator, mega-projects will continue to increase in number and size, which underlines their importance and criticality for all stakeholders involved. Despite another 20 years of experience with large projects, there has been little material progress in the control of very large projects (IPA, 2003). The SBC report (Procaccini, Lea-Cox, & Hoop, Challenges of E&P Megaproject Delivery, 2012) also measured performance of E&P projects; their findings show that there has been no improvement in the performance of mega-projects. According to the SBC report (See Figure 2) in 1997, 10 percent of the projects experienced large budget overruns, defined as more than 50 percent. The number has risen constantly with approximately 17 percent facing large budget overruns in 2005 and approximately 30 percent of projects facing large budget overruns in 2011. Organizations have not built up the capacity to deliver these mega-projects as per planned targets. The future will see more mega-projects, in fact, evolving to the more recent Giga-projects in Australia having costs in the tens of billions.

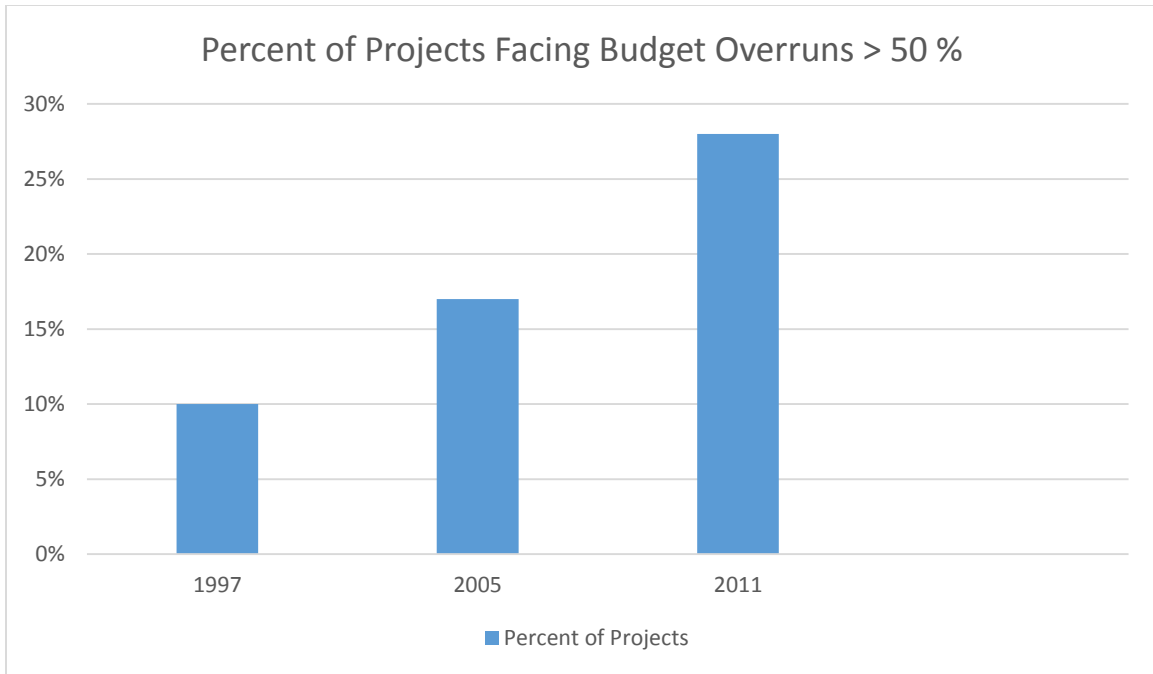


Figure 2. Degrading Project Performance in E&P Project (Procaccini, Lea-Cox, & Hoop, Challenges of E&P Megaproject Delivery, 2012)

Mega-project failure is not confined to any one industry type or to one part of the globe. Mega-projects like the Big Dig, the Euro Tunnel in the infrastructure industry, the Oil Sands projects in Canada, major product development projects like the Boeing 787 project in the Aerospace industry, the Large Hadron Collider (LHC) built by European Organization for Nuclear Research in the experimental science field are some of the well-known examples of failures. The recent study done by EY studied more than 300 oil and gas projects across the world. The study results show conclusive that poor performance on mega-projects are not restricted to one particular region but is widespread across continents. Table 3 shows some of the findings on mega-project cost and schedule overruns across continents from the research study. Despite dramatic failures in the past, mega-projects are still at the core of economic development of any country.

Table 3. EY Reported World Wide Mega-project Performance (EY, 2014)

Continent	Proportion of projects facing cost overrun	Proportion of projects facing schedule overrun	Average project budget overruns
North America	58%	55%	51%
Latin America	57%	71%	102%
Europe	53%	74%	57%
Africa	67%	82%	51%
Middle East	89%	87%	68%
Asia-Pacific	68%	80%	57%

From its data, IPA notes an interesting finding. Based on the metrics as defined by IPA, there is a wide performance chasm that develops between good and poor projects: good projects are genuinely excellent, but poor projects fail dramatically. Table 4 below shows a simple evaluation of successful vs. failed mega-projects to elucidate the sensitivity of mega-projects. If mega-projects start to fail on any account, the downward spiral causes failure for almost every outcome and in a dramatic way (Merrow E. W., 2011).

Table 4. Dramatic Failure- Comparison of failed and successful mega-projects on various fronts (Merrow E. W., 2011)

Performance Metric Index	Failed Projects	Successful Projects
Cost Index (Competitiveness)	1.3	1
Cost Growth (Predictability)	30 percent	0 percent
Execution Schedule Index (Competitiveness)	1.1	1
Execution Schedule Slip (Predictability)	30 percent	0 percent
Production (Predictability)	60 percent	100 percent

The sensitivity of mega-project to changes is a very key concept. Once approved, mega-projects are extremely sensitive to changes. It is important to comprehend and plan for challenges early on a mega-project. In the case of the Denver International Airport, the initially approved scope and schedule was based on the assumption that individual airlines would install their own baggage handling systems. Later, the airport's project management team changed their strategy. They realized that if an integrated system was to be built, they needed to take responsibility back from the individual airlines and run the project themselves. This change in strategy came a little more than two years prior to the airport's planned opening date. The timing of the decision was, in large part, the trigger behind the excessive schedule pressure the project was exposed to. The project was delayed by several years, and the baggage system was never successfully built and operated (Calleam Consulting Ltd, 2008).

3.4 Factors behind mega-projects successes and failure

The research focused on uncovering more of the reasons behind *both failure and success* on mega-projects than had been documented in previous publications. Most literature focused on failed mega-projects and discussed factors that led to failure on these mega-projects. Very few publications discussed *key success factors* on mega-projects.

3.4.1 FREQUENTLY OCCURRING CHALLENGES ON MEGA-PROJECTS

Many of the challenges that make mega-projects unique appear obvious, such as the requirement to manage numerous, concurrent, and complex activities while maintaining tough schedules and tight budgets. Other challenges are not so apparent or at least do not initially present themselves as challenging (Capka, 2004). Most of the present literature on mega-projects brings out broad project management areas where organizations failed to effectively plan and execute

mega-projects. Past publications from many sources were reviewed to identify factors that contribute to the success and failure of mega-projects. In the study conducted by Schlumberger Business Consulting (Procaccini, Lea-Cox, & Hoop, Challenges of E&P Megaproject Delivery, 2012) the authors interviewed several senior managers of E&P operators to identify the most common root causes of poor performance on the capital projects. They identified six main root causes, with people and organization being the most challenging factor, followed by governance. The least challenging factor was having defined project management processes. Table -5 shows below the six most pressing issues on capital projects and the percentage of operators that felt the area was a challenge:

Table 5. The Most Common Root Causes of Capital Project Issues (Procaccini, Lea-Cox, & Hoop, Challenges of E&P Megaproject Delivery, 2012)

Root Causes	Percentage of Operators (agree area was a challenge)
People and Organization	26%
Technical Challenges	21%
Governance	18%
External Stakeholders	14%
Contracting and Procurement	12%
Project Management Processes	9%

Some of the common challenges and risks identified from the literature that contribute towards failures on mega-projects include:

Inadequate front-end-planning

Front-End Planning is the most important phase, where the execution plans are set for a mega-project. It is critical to the success of a mega-project. Independent Project Analysis (IPA) refers to the phase

as Front-End Loading (FEL). In IPA's data on mega-projects, effective FEL (i.e., planning during the front end) improves cost and schedule predictability, and reduces operability problems.

A 3-to-5 percent investment on front-end planning is a large cost that organizations often are reluctant to put at the start of the project (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success*, 2011).

Unrealistic estimates

Merrow in his book includes aggressive unrealistic project schedules and unrealistic sanction estimates as two of seven deadly mistakes done on mega-projects. Many times mega-projects initial estimates are only based on business considerations and do not factor in execution and real site challenges. The need to deliver a mega-project quickly results in inadequate effort in defining basic data and defining project characteristics and requirements. Being so complex and tightly integrated, these workarounds never seem to work (Merrow E. W., 2011).

Some of the critical mistakes during the front-end phase documented in previous research include preparing overly optimistic estimates, lower contingency levels to decrease budget numbers, impractical aggressive schedules due to business pressure, and the inability to gauge present and future market conditions and a reluctance to pre-invest both money and time before authorization (Flyvbjerg, Bruzelius, & Rothengatter, 2003).

Jurisdictional risks

External market and political forces influence the progress of mega-projects. Given the value of the investments at stake, the impact of any major change in these forces can be severe on overall project economics, so much so that companies may consider delaying or even canceling projects (EY, 2014). Some of the key aspects to this area include: financial and supplier market uncertainty (EY, 2014); underestimated or ignored changes in exchange rates between currencies (EY, 2014) (Flyvbjerg, Bruzelius, & Rothengatter, 2003); underestimation of geological risks

(Flyvbjerg, Bruzelius, & Rothengatter, 2003); and civil and workforce disruption. A key success factor is to control and manage the influence of local politicians early on the project (Sue Dyer, 2005).

Unfair allocation of project value among key external stakeholders is another deadly mistake Merrow refers to in his book. Also, failure to include local informal and informal content can lead to dissatisfaction, causing frequent execution disruptions. These kinds of disputes can make the mega-project unmanageable and eventually end in complete failure (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success*, 2011).

Technical challenges

Using a new or unproven technology is a major challenge on mega-projects. Underestimation of a technological innovation's high risk factors, mainly due to the unproven nature of the new idea, presents a threat to performance (Flyvbjerg, Bruzelius, & Rothengatter, 2003). Delivering projects in harsh environments (e.g., ultra deep water and the Arctic) bring additional challenges. According to a Schlumberger Business Consulting study (Procaccini, Lea-Cox, & Hoop, *Challenges of E&P Megaproject Delivery*, 2012) where 30 senior management from 16 oil and gas operators were interviewed, the most common issues among operators were related to brownfield redevelopments. Uncertainties associated with brownfield redevelopment are often underestimated. Very few major oil and gas companies have sufficient scale and most independents and National Oil Companies rely on partnerships with specialists.

Ineffective interface management

Mega-projects are divided into many contract or scope packages, which are awarded to multiple contracting parties. Every contractor also had large numbers of interfaces and each

interface required the exchange of deliverables and information between contractors responsible for other scope packages.

Current methods of managing interfaces through spreadsheets and email do not provide the level of control or real-time up-to-date information required. Even the most sophisticated spreadsheet will not effectively document the distribution of information to support a project of this size. The project team, including external contractors, must use sophisticated tools and processes to monitor and control communication related to interfaces. Otherwise, information is lost, forgotten, or simply not documented or shared (Kelly Maloney, 2013).

Ineffective organizational structure

Mega-project organizations are inherently complex and diverse. They consist of members from various functions, nationalities, and cultural backgrounds. They are globally dispersed around the world. The Schlumberger Business Consulting (SBC) report (Procaccini, Lea-Cox, & Hoop, *Challenges of E&P Megaproject Delivery*, 2012) indicates that the dominant set of issues and the largest contributor to mega-project overruns stem from the category “organization and people.”

Inappropriate governance structures

Governance of mega-projects has become an emerging issue with the expansion of globalization. Research is desperately needed to develop enhanced government frameworks and hybrid models for governance that allow increased community participation and adherence to principles of distributive and procedural justice (Levitt, Henisz, & Settel, 2009). Mega-projects often are an alliance between multiple partners. Aligning them becomes challenging. The roles and responsibilities of the partners must be clearly defined with adequate risk allocation (Morrow E. W., *Industrial Megaprojects Concepts. Strategies, and Practices for Success*, 2011).

In his book Greiman (Greiman, 2013) writes that, on mega-projects, all roads lead to governance because the root cause of most problems is weak governance, nonexistence governance, or the wrong governance structure. For instance, The Big Dig's governance structure included federal oversight, an owner's board of directors, and a program manager led by the project's private joint venture consultant, among numerous decision making and approval authorities and several hundred teams that needed to be integrated and coordinated.

Joint ventures have become increasingly common across the industry, especially on complex projects in challenging environments. Governance agreements can be complex and delivery issues are often exacerbated by divergent investment rationale, project assessment criteria, and tolerance for project risks (EY, 2014).

Unfit project procurement strategy

Contracting and procurement is a fundamental driver of project value. Operators interviewed in a SBC study (Procaccini, Lea-Cox, & Hoop, Challenges of E&P Megaproject Delivery, 2012) faced increased challenges from a tight service market and lack of internal competency. According to the study, one major risk (especially on E &P projects) is not being able to adequately resource the technical and commercial skills needed, both at the central function level and in project teams.

The EY study (EY, 2014) lists poor contract management as one of the main challenges in project delivery. With inadequate capacity and experience with key contractors and vendors has led to poor quality of service on large projects. There is no "one size fits all" delivery method for every project. In selecting a project delivery system that is right for a project, owners should gauge the level of complexity and uniqueness of the project, and maintain an appropriate level of control (Yakowenko, 2004)

Another focus area of the literature review was to learn what factors differentiate mega-projects. The performance of projects degrades considerably as the size increases, according to IPA data about 2 out of 3 mega-projects as previously discussed fail to meet planned targets, double the failure rate of smaller projects (< 500 million) (Merrow E. W., *Why Large Projects Fail so often. Meagproject Failures: Understanding the Effect of Sizes*, April 20 2011). The benchmarking data of IPA bring out the following observation about practices when project size increases:

- Team integration is much poorer for mega-projects (55 percent) than for projects under \$750 million (74 percent).
- Personnel turnover increases on mega-projects.
- One mega-project team in five admits that they do not understand the business objectives versus one-in-ten for smaller projects.
- Mega-project teams are much more likely to report being confused about trade-offs among outcomes.
- FEL (Front-End Loading) completeness actually declines as projects size increases. Most FEL elements like labor availability, labor cost and productivity, local materials costs, plot plans and arrangements, permitting, and operational health and safety degrades as size increases.

3.4.2 BROAD STRATEGIES FOR SUCCESS ON MEGA-PROJECTS

Current literature provides guidance and recommendation on the mitigation of mega-project challenges. Some of the broad success strategies identified from the literature review are described below.

Strong front-end-planning

Strong front-end planning is the foundation to success on mega-projects. Organizations should devote adequate time and money to gather accurate basic technical data and include all key project functions on front-end planning teams to improve chances of success on the project (Merrow E. W., 2011). Improvements are needed in the front-end phase by including adequate information and more accurate predictability in estimates and project planning effort before construction execution.

Preparing realistic estimates

Mega-project teams often fail to include all challenges in project estimates. The project teams should include the impact of technology being used, geographic location challenges, resource constraints, possible inflation and escalations, productivity challenges, and local content challenges while preparing estimates to make project estimates a true reflection of the project scope (KPMG, 2013). With an awareness of optimism bias, project teams should practice greater transparency, hold independent project appraisal, and use benchmarking to compare projects with other similar projects having similar characteristics (Kardes, Ozturk, Cavusgil, & Cavusgil, 2013).

Early team building and alignment:

KPMG (KPMG, 2013) recently brought out a three-part series titled ***How to successfully deliver your mega-project***. The first part of the series focused on the importance of early planning and organizing. The study brought out certain best practices that include: forming project teams early; maintaining continuity of teams conducting planning; developing in-house skills; obtaining senior management buy-in; frequent meetings of the combined project teams; and assigning clear roles and responsibilities, among others. These practices can help mega-project organizations form a coherent project team with required alignment between the business side and the project side.

WisDOT (Whited & Hanna, March 2012) also recommend holding pre-construction planning and submittal workshops as a project management best practice for their infrastructure mega-projects indicating its primary importance for establishing schedule control.

Effective organizational structure:

In an article published by Schlumberger Business Consulting (Ghosh, Williams, Askew, & Mulgund, Summer 2012) lists the following as organizational success factors: alignment of organizations with project objectives; external stakeholder management that forms effective partnerships with impact groups; a simple horizontal, rather than vertical, leadership team; proactive risk assessment by leadership; pragmatism in governance with employee engagement;. Dynamic environments call for organizational agility. A program approach is important; organizations should look at mega-projects as a highly interrelated program of large projects (Sue Dyer, 2005).

Effective stakeholder communication

Stakeholder communication on mega-projects should include effective dialogue between project teams and other stakeholders like manpower, local actors, and other impact groups. Disputes are common on mega-projects; project teams should develop dispute boards and hold meetings to discuss project issues to better solve disputes on projects (Whited & Hanna, March 2012). Project teams should develop stakeholder communication plans that include formats of communications, address key interests of all stakeholders, discuss frequency of meetings and level of involvement of required personnel, and enable feedback from all stakeholders (KPMG, 2013).

Effective risk identification

Risk management should start early on the project, it is important to include all type of risks including; new technology risk, location risk, jurisdictional risk, political risk, security risk,

and human and materials resource availability risk while preparing early estimates. These risks will drive the contingency requirements and should reflect project characteristics (KPMG, 2013).

Collaborative working among partners

In increasing globalization where mega-projects are often done in partnerships, organizations should adopt a healthy spirit of collaboration. The focus should not only be on hard criterion (e.g., market position, technical risk, financial risk) but also on soft issues like managing culture, trust, and confidence and long-term objective alignment, among others (Kardes, Ozturk, Cavusgil, & Cavusgil, 2013).

Project fit contracting strategies

It is key to select the right contracting and delivery strategy early in the project. The strategy should be aligned with project objectives, in-house owner management capabilities, and project characteristics. It should also align with resources available, cost and quality expectations, and the overall risk appetite (KPMG, 2013). Strong pre-qualifications should be in place to choose the right experienced contractors for the project (EY, 2014). Finally, the project team should have the final authority to choose contractors; there should be no external influence from the business leadership side (Merrow E. W., Industrial Megaprojects Concepts. Strategies, and Practices for Success, 2011).

3.5 Conclusion

Through the literature review, we were able to determine the current state-of-art of delivery of mega-projects. The literature review helped us to gain a focused approach to the problem and decide a path forward that would not reinvent the wheel but complement the existing studies. Existing literature, though comprehensive, is mostly comprised of high-level broad descriptions of factors impacting mega-projects. The generic high-level descriptions provided insight into factors, but lacked the specificity needed to effectively plan for factors. The recommendations were too generic and seldom factor specific. Common areas identified from the literature that were the focus of further examination for mega-project success included: appropriate front-end-planning, realistic cost and schedule estimates, geopolitical risks, technical challenges, managing people, effective organizations, appropriate governance structures, clear and adaptable project management processes, mega-project fit contracting and procurement strategies, effective communications, and stakeholder management, among others.

At the end of the literature review, we concluded that the existing literature includes several lessons learned and generic recommendations, but there are two main gaps that require further examination:

- First, the present literature provides a list of factors impacting mega-projects, but there is no relative prioritization of these factors. It is key to provide project teams with some prioritization to help evaluate the factors on specific mega-projects.
- Second, the existing literature does not provide specific solutions to mitigate such factors.

The analysis of the gaps and needs after reviewing the present literature helped in establishing a better path forward. Based on these conclusions, the two main research hypotheses were:

1. There are factors that have higher occurrence and performance impacts on mega-projects.
2. These factors require changes in mega-project planning and execution to improve the chances of successful outcomes.

A series of data collection and analysis tasks were conducted to validate these hypotheses.

At the conclusion, using the research findings a methodology was developed to assess the critical impact factors and provide implementation recommendations for the front-end planning and execution phases.

CHAPTER 4- PRELIMINARY INTERVIEWS

4.1 Purpose and Objective

In parallel to the extensive literature review, from September 2013 to November 2013 the preliminary interviews were held with experienced industry professionals directly involved in the planning and execution of mega-projects. The primary purpose of the preliminary interviews was to understand and prioritize the contributing factors of mega-projects' good and poor performance and to define the focus of the subsequent research tasks. The preliminary interviews helped detail a future data collection and analysis plan.

4.2 Data Collection Methodology

Experts involved in the delivery of mega-projects were targeted for the preliminary interviews. Potential interviewees were identified from joint venture partners, owners, contractors, engineering consultants, and supplier organizations. These included the following: project managers, business managers, operations managers, construction litigation lawyers, and project planning consultants. To protect the interview participants and allow for honest feedback about failures on projects and company standard practices, the interview data was kept confidential. Only summaries were reported without naming any individual, company, or any data that would affect the confidentiality of the responses.

The interviews were conducted by telephone. Each interview was one-to-two hours long. In parallel to identifying interviewees, an interview guide was drafted and sent to the interviewees in advance to help interviewees prepare for the interviews. The interview guide, enclosed as Appendix B, consisted of nine open-ended questions that were designed to accomplish the following objectives:

- Learn lessons from successful and unsuccessful mega-projects
- Review mega-projects’ organizations and contracting strategies
- Identify specific challenges on the mega-projects
- Understand what the mega-projects did to mitigate these challenges
- Discuss what differentiates mega-projects from large-projects

4.3 Data Gathered

A total of 19 interviews were conducted with senior mega-project executives (e.g., project managers, project directors, and vice-president of construction) involved in either the business or the project side. Through the preliminary interviews, data was gathered regarding 20 mega-projects, 12 of them complete and eight ongoing at the time, having an average approved budget of approximately \$7 billion. The sanctioned schedule of the mega-projects varied from 2 years to 6 years. These included mega-projects from a variety of industries, including oil and gas, mining, energy, and petrochemicals. Of the 19 interviewees, 15 represented CII member organizations and four represented non-CII members. Table 6 below shows the project budget at approval of projects interviewed.

Table 6. Overall Project Budget at Approval of Interviewed Projects

Overall Project Budget at Approval	No of Projects
\$1 B- \$2.5 B	4
\$2.5 B- \$5 B	4
\$5 B- \$7.5 B	2
\$7.5 B- \$10 B	2
Above \$10 B	7
Total	20

The analysis showed that, out of the 12 completed mega-projects, five mega-projects had a cost overrun of more than 25 percent, with an average cost overrun of 57 percent. Also five mega-projects experienced a schedule delay of above 25 percent comparing to the sanctioned schedule.

4.4 Analysis and Findings

The preliminary interviews helped fulfill the primary objectives of identifying factors contributing to success and failure of mega-projects. The data collected through the interviews was analyzed to identify certain factors that impacted the majority of the mega-projects studied. After analyzing individual interview findings, it was found that though each mega-project is unique to some degree, there exist certain factors that occur more often on mega-projects. Individual interview summaries can be found in *CII Research Report 315-11*. The following are some of the consolidated findings:

4.4.1 DELIVERY AND CONTRACTING STRATEGIES ON MEGA-PROJECTS

The first few questions of the interviews focused on understanding the current delivery and contracting strategies adopted on mega-projects. Mega-projects studied during the preliminary interviews adopted a range of delivery strategies; lump sum, lump sum turnkey, cost reimbursable, time and material, or sometimes a cost reimbursable to begin that was negotiated to a lump sum later. The majority of the mega-projects were executed as EPC contracts (Engineering-Procurement-Construction), the only difference being the number of EPC contracts the mega-project was divided. Based on the type of facility and owner preferences, the scope of the mega-projects studied were divided anywhere from two to twenty major EPC packages. Each EPC contract, depending on the scope, was either lump sum or cost reimbursable; most interviewees

believed that having a mix of cost reimbursable and lump sum EPC on the same project caused more challenges.

The project management function on mega-projects studied was also contracted in a variety of ways, sometimes handled by in-house owner personnel, sometimes combined with the EPC contracts to form EPCm contracts, and sometimes a separate experienced firm was hired to manage the overall the management of the project. In only a few cases was the main EPC contractor also part of the planning process. On some mega-projects studied, owner organization had long-term collaboration with one or more major EPC contractors. In these cases, the EPC contractor was included in the pre-approval planning process and the project succeeded because of the early construction input in planning.

4.4.2 ORGANIZATION STRUCTURE ON MEGA-PROJECTS

In terms of the organization structure, some of the more established and experienced owner organizations had a more hands-on approach and were actively involved in project execution activities. On the other hand, there were also some owners that adopted a more hands off approach, especially after awarding turnkey projects.

The number of personnel on the team depended mostly upon the location and complexity level of the project. In remote locations with inadequate skilled resources, there were more expats on the team than local personnel, but most mega-project organizations felt that it was important to engage local skilled manpower. As expected, the number of the owner team staff depended mostly on the delivery and contracting strategy adopted on the project. Most interviewees felt that, on cost reimbursable contracts, projects required a much higher number of owner personnel assigned to the project for effective controls. Also, a strong owner team with sufficient skilled personnel was one of the success factors for the more successful mega-projects studied. On many occasions,

owner organizations that lacked experienced in-house resources supplemented by hiring consultants to manage and oversee the project from the owner side.

4.4.3 CONTRIBUTING FACTORS TO SUCCESS AND FAILURE ON MEGA-PROJECTS

The interviews focused on understanding key factors that contribute most to success and failure on mega-projects. The major portion of discussions with interviewees concentrated on understanding which factors led to success or failure on the project. During the analysis, it was evident that there are no magic factors that lead to failure or success. Rather, there are factors that some organizations successfully plan for, while some fail to consider them. The factors were not new but they had a profound impact on mega-projects, and because of the high degree of complexity on mega-projects, such projects are more sensitive to these particular factors. The following are some of the findings interviewees felt illustrate the biggest challenges for mega-projects.

Mega-projects suffered the most due to **inadequate basic data**. The scope definition in most cases was done hastily and without proper due diligence. Interviewees from mega-projects that failed to adequately define basic engineering data indicated that these mega-projects suffered all through project execution. Most success stories included project teams that allocated adequate resources and time for defining basic engineering data.

Inadequate definition of the basic engineering data sometimes led to making optimistic approximations that eventually led to **unrealistic baselines**. Most interviewees agreed that the sanctioned cost and schedule estimates on the projects were unrealistic and were often based on optimistic assumptions around project complexities. Some successful mega-projects either compensated the lack of adequate data definition with contingencies or delayed approval or spent more time defining basic project data.

Forming the right **core front-end planning (FEP)** team by including all functions and stakeholders during planning was an important aspect that contributed to the success and failures on mega-projects studied. Owners on successful projects had a strong front-end planning team with adequate input from various functions (execution, safety, quality, procurement and start-up). By including these inputs early, projects were able to realize potential critical risks on projects and plan effectively. On other side, most mega-projects that experienced poor performance lacked adequate representation from other cross functions in their core FEP teams.

Mega-projects require well-defined **governance structure**, roles, and responsibilities. On a few mega-projects that were undertaken as joint ventures, project teams faced numerous challenges coping with misalignment within partners because of an ineffective governance structure. On successful mega-projects, interviewees indicated that a clear and unambiguous responsibility matrix was a major contributing reason to the success on the project.

In addition to the direct sponsor partners, mega-project teams are comprised of various cross functions with a variety of stakeholders (local subcontractors, crafts, and suppliers). Interviewees stressed effective **team building and alignment** as a pre-requisite for a successful mega-project. If the project team lacked alignment, the mega-project was not successful. On some mega-projects, ineffective alignment was the main reason for underperformance on all aspects, including safety. Successful mega-projects had effective alignment among stakeholders and also between the business side and project execution side, which led to better decision-making.

Other challenges frequently faced on mega-projects studied were inadequate **skills and experience** within the owner project management teams. On these mega-projects, the owner was not able to effectively manage project execution and lacked effective project practices and procedures. Most successful mega-project owners laid adequate stress on forming a strong project

management team on the project. They either had strong in-house PM capabilities or hired consultants to complement in-house personnel.

All successful mega-projects had owners, contractors, suppliers, and subcontractors aligned and communicating freely with each other. A good **working relationship among the stakeholders** fostered effective communication within parties. This helped teams identify challenges and plan mitigation with buy-in from all stakeholders.

Most mega-project organizations had traditional **risks management** systems in place, but still indicated ineffective risk management as one of the key failure areas on projects. On many occasions project teams were able to identify risk, but they failed to evaluate accurately the consequential impacts of the risks. Inadequate contingency levels to manage risk was another reason behind ineffective risk management. Successful organizations started risk identification and mitigation early in the project and carried forward the risk mitigation through startup, monitoring critical risks closely throughout execution and allocating adequate contingencies to mitigate risks on projects.

Interviewees indicated **interface management** as a key issue on mega-projects. With the vast scope of work divided into numerous packages, there are increased chances of miscommunication and loss of information between the scope overlaps. Having strong interface management plan with experienced people managing the interfaces helped organizations mitigate the factor.

Change management and dispute resolution are key success factors on any projects, but on mega-projects they are critical areas for success. On mega-projects that underperformed, there were changes. Due to ineffective change management framework, these changes escalated into

large disputes between parties. The disputes led to significant schedule and cost overruns on the projects.

Most mega-projects are under constant scrutiny from the general public, regulatory bodies, local activist organizations, and state politicians. Nearly all mega-projects studied faced some form of **jurisdictional or regulatory challenge**. Those projects that were able to identify these challenges early and work in collaboration with the external stakeholders effectively were well prepared and faced few execution disruptions due to local conflict.

Mega-projects usually have a very complex **logistics network** with a high volume of equipment and resources being transported every day. Especially in **remote and unfamiliar locations**, mega-projects teams faced numerous challenges managing the complex logistics. Planning ahead and enlisting local contractors to overcome the local constraints were some of the mitigation measures adopted by project teams.

Mega-projects being executed in less developed or developing countries faced challenges around **safety management**. Poor safety standards of local subcontractors meant that extra effort was required from international owners/contractors to achieve high safety standards. A few of the mega-projects studied met their premised cost, schedule, and business objectives but failed to meet expected safety standards, which had a direct impact on organization reputation.

Another key aspect most mega-projects faced was **unavailability of skilled manpower**. This factor was sometimes aggravated by bans from local government on importing labor from different countries. Mega-project studies faced huge cost and schedule overruns due to low availability of local skilled manpower.

4.4.4 FACTORS THAT DIFFERENTIATE MEGA-PROJECTS

The last question of the interview focused on identifying factors that interviewees felt differentiated mega-projects from smaller projects. The following are some of the factors that most of the interviewees considered to be differentiating factors:

Mega-projects require better **defined front-end planning, which** requires more time and money. Teams need to define and fix plans before starting to mobilize. Mega-project organizations that fail to realize this are more prone to failure.

Mega-projects have a **more complex governance structure** with multiple partners and **globally dispersed teams**, which adds layers of complexity on mega-projects. Many organizations are conducting mega-projects in partnership for the first time and therefore lack experience in managing such partnerships, leading to convoluted governance structures.

Mega-projects also face **more jurisdictional and regulatory challenges**; this arises from the potential impact mega-project have on surrounding environment and societies.

Mega-projects have high complexities and require a **higher level of maturity of engineering and procurement** before mobilization. Most project teams do not appreciate the need for a mature level of project definition. Mega-projects without this are less successful. Mega-projects require adequately advanced engineering before mobilization and key materials should be procured and mobilized before construction begins.

Mega-projects are **more sensitive to changes in project execution plans**. To avoid late changes, project teams must obtain input from all major engineering and construction contractors and get buy-in from stakeholders on project execution plan.

Interviewees felt that mega-projects require a higher amount of skilled labor and are highly sensitive to the **unavailability of skilled craft**. This factor impacts mega-project performance,

increasing costs and causing delays, much more than with smaller projects. The problem of unavailability of skilled manpower is a global challenge. This lack of quality crafts and skilled supervision has a negative impact on productivity, quality, and progress of work, increasing the peak labor requirement and competitive market sourcing for extra craft to maintain progress, which increases project costs.

Due to the size and complexities of mega-projects, they require **more capable and experienced contractors**. In recent times, many engineering and construction contractors have faced high staff attrition. Most contractors do not have the ability to say no to work and therefore take on mega-projects for which that they are not capable, leading to poor performance.

4.5 Conclusion

Although there were numerous factors that occurred across the mega-projects analyzed, there were some specific factors that were more significant. Some of the more frequent and impactful factors identified were (not listed in any particular order):

- Unrealistic expectations concerning the local requirements and constraints
- Inadequate front-end definition
- Small number of staff assigned to the owner teams, leading to teams with insufficient personnel for proper oversight
- Lack of competent people
- Lack of a strong management team
- Lack of effective leadership, motivation, competency, and people skills within the management team

- High turnover of project personnel in the mega-project organization
- Lack of ability of the people involved to see the project as a whole
- Lack of true partnership among stakeholders
- Diverse systems and standards of involved parties
- Lack of an integrated project schedule
- Complex interfaces between stakeholders
- Lack of communications and hiding problems from senior management
- Lack of labor quality in remote location

Using the findings from the preliminary interviews and the review of past publications, a master list was prepared, consisting of more than 100 factors that contributed to poor performance on mega-projects. Through extended discussions and the knowledge of subject matter expertise on the team, the list of factors was analyzed, prioritized, and categorized, leading to a more focused and refined list of impact factors that occur more often and have a higher performance impact on mega-projects. A list of 34 impact factors in five categories was prepared that formed the basis of further data collection through surveys and case studies. Below is a short description of the impact factor categories. The list of impact factors can be found in Table 7.

Category A- Location and Technology: Four Impact Factors

This category consists of information about impact factors associated with mega-project location, jurisdiction, and technology.

Category B- Team, Organization, and Communications: Six Impact Factors

This category consists of information on about impact factors associated with team integration, organizational planning, and managing communication on a mega-project.

Category C- Planning and Execution Processes: Thirteen Impact Factors

This category consists of information about impact factors associated with framing and controlling mega-project planning and execution processes.

Category D- Governance and Stakeholders: Six Impact Factors

This category consists of information about impact factors associated with effective governance structure and stakeholder management on mega-projects.

Category E- Delivery Strategy: Five Impact Factors

This category consists of information about impact factors associated with selecting the right contracting strategy and managing contracts and procurements of a mega-project.

Table 7. List of Impact Factors

CATEGORY A - LOCATION AND TECHNOLOGY
Factor A1-New or Unproven Technology Factor A2-Logistics Challenges Factor A3-Jurisdictional Complexities Factor A4-Unavailability of Qualified Craftsmen
CATEGORY B - TEAM, ORGANIZATION, AND COMMUNICATIONS
Factor B1-Unplanned Changes in Key Personnel Factor B2-Ineffective Stakeholder Communication Factor B3-Multi-Location Challenges Factor B4-Inadequate Organization Planning and Staffing Factor B5-Ineffective Interface Management Factor B6-Inadequate Document Management Plan
CATEGORY C - PLANNING AND EXECUTION PROCESSES
Factor C1-Lack of Execution Input to FEP Factor C2-Optimism Bias Factor C3-Inadequate FEP Resources Factor C4-Inadequate Risk Assessment & Mitigation Factor C5-Inadequate Project Controls Systems Factor C6-Lack of Execution Plan Alignment Factor C7-Inadequate Integrated Schedule Factor C8-Regulatory & Environmental Delays Factor C9-Baseline Schedule Acceleration Factor C10-Quality Compromised for Schedule Factor C11-Ineffective Change Management Factor C12-Incomprehensive Risk Management Factor C13-Unfit Documents, Procedures, and Processes
CATEGORY D - GOVERNANCE AND STAKEHOLDERS
Factor D1-Unclear Definition of Roles, Responsibilities and Authority Factor D2-Inadequate Size, Skills, and Experience of Project Management Team Factor D3-Cultural Differences Across Stakeholders Factor D4 -Inadequate Owner Participation in Risk Management Factor D5-Misalignment Within Partner Organization Factor D6-Business Approach Differences Across Stakeholders
CATEGORY E - DELIVERY STRATEGY
Factor E1-Inappropriate Project Delivery Contracting Strategy Factor E2-Limited Capable Contractors Factor E3-Unclear Scope Definition in Contracts Factor E4-Unexpected Materials and / or Equipment Delays. Factor E5-Underperforming Contractor or Key Subcontractor

CHAPTER 5- SURVEY AND FOLLOW-UP INTERVIEWS

5.1 Purpose and Objectives

To gain further insights into the impact factors identified, a survey was conducted to gather additional data on the occurrence and impact levels of the impact factors on both mega-projects (defined here as projects having a sanctioned budget of above \$1 billion) and large projects (defined here as projects having a sanctioned budget greater than \$100 million and less than \$750 million). The survey helped in fulfill the following objectives:

- Verify the difference in occurrence and impact level of the impact factors on mega-projects and large-projects
- Identify impact factors that have a higher occurrence and performance impacts on mega-projects
- Identify impact factors that are more likely to occur with mega-projects
- Identify the most impactful factors on mega-project performance (cost, schedule, and production/business)

5.2 Data Collection Methodology

To fulfill these objectives, two survey forms were prepared: one for mega-projects and another for large-projects. The complete survey guide and forms are enclosed as Appendix D. The first two sections were the same in both survey forms (i.e., mega-projects and large-projects). In addition to these two sections, the mega-project survey form contained two additional sections. The survey forms consisted of following four sections:

Section I - General Information

This section gathered general information about the respondent, project, project sanctioned estimates, project performance, project's organizational structure, and project's contracting and delivery strategy.

Section II - Impact Factors Occurrence and Impact

This section of the survey focused on the impact factors, capturing whether the factor occurred on the specific project. It contained project-specific impact factor statements. On these statements, the survey respondents were asked to rate their level of agreement on a five-point Likert scale (Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, and Strongly Agree). If the survey respondent answered Agree or Strongly Agree it was inferred that the project faced the factor. The survey asked questions on the impacts on cost, schedule, and production/business performance. The impacts were recorded on a four-point Likert scale (No Impact, Minor Impact, Moderate Impact, and Serious Impact). Apart from the impact level questions, the survey also asked questions concerning whether the factor was identified upfront and whether it was identified in the risk register of the project. The impact factors were grouped within the five categories. When finishing a particular category of impact factors, survey respondents were also asked to mention any mitigation strategies adopted for impact factors faced within that category.

Section III - Other Factors

This section asked survey participants to list any other significant factor that the project might have faced apart from the impact factors included in Section II of the survey.

Section IV - Impact Factor Ranking

This section focused on identifying most impactful factors on the mega-project. Survey participants were asked to rank, from the list of impact factors faced on the mega-project, the top five most impactful factors on cost, schedule, and business performance.

5.3 Data Gathered

After finalizing the survey forms, potential survey respondents were identified and contacted to complete the survey. A total of 169 mega-project professionals were contacted in April 2014 to fill out the online survey. A total of 76 responses (45 percent response rate) were received by the end of August 2014. Each survey response was project specific. Data was gathered from 76 projects (41 mega-projects and 35 large-projects). Out of the 76 survey respondents, 61 were from CII member organizations and the other 15 respondents were from non-CII members.

5.3.1 CHARACTERISTICS OF PROJECTS SURVEYED

Table 8 presents the type of projects surveyed. Table 9 presents the approved budget of the projects surveyed. Figure 3 presents a synthesis of the results from the Table 8 and Table 9 to present a graphic showing distribution of the type of projects with the approved budgets. Table 10 also shows the schedule of the projects at approval.

Table 8. Type of Surveyed Projects

Project Type		
Type	Large-project	Mega-project
Oil Exploration and Production	1	12
Oil Refining	4	3
Mining	0	7
Metallurgical Refining	1	0
Power Generation	4	1
Chemical Manufacturing	2	1
Natural Gas Processing	4	9
Infrastructure	1	1
Commercial Building	0	1
Pharma/Bio Manufacturing	0	0
Heavy Industrial/Other Manufacturing	13	0
Others	4	6
Total	34	41

Table 9. Overall Budget at Sanction of Surveyed Projects

Overall Budget Approved at Sanction (including contingency)		
Large-project Total= 35	\$100 M- \$250 M	16
	\$250 M- \$500 M	10
	\$500 M- \$750 M	9
Mega- project Total= 41	\$1 B- \$2.5 B	21
	\$2.5 B- \$5 B	6
	\$5 B- \$7.5 B	3
	\$7.5 B- \$10 B	5
	Above \$10 B	6

Table 10. Project Duration at Sanction of Surveyed Projects

Overall Project Duration at Sanction		
	Large-projects	Mega-projects
Less than 1 year	0	0
1-2 years	13	1
2-3 years	16	8
3-5 years	3	21
5-7 years	2	7
Greater than 7 years	1	4
Total	35	41

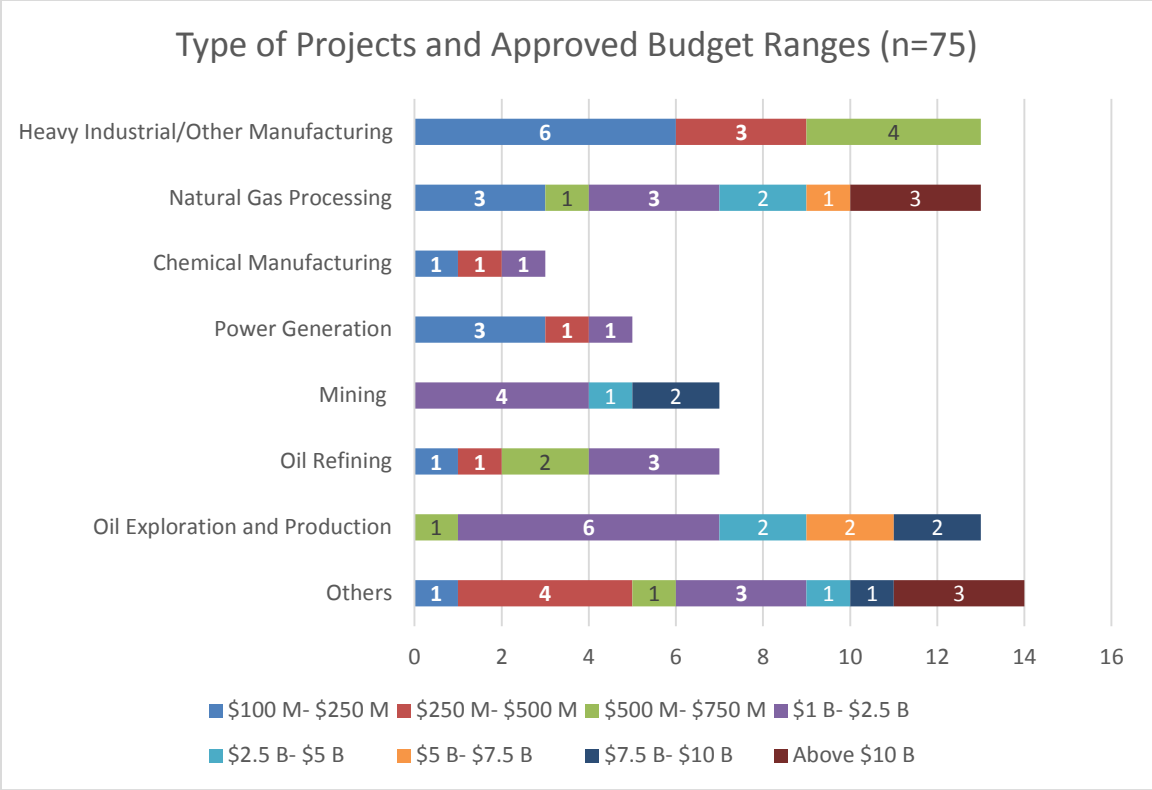


Figure 3. Survey Respondents - Types of Projects and Approved Budget Ranges

5.32 PERFORMANCE DATA

Table 11 through Table 14 present the cost, schedule, business, and safety performance data of the projects surveyed. Under each category of projects the percentage represents the percentage of total projects surveyed within that category.

Table 11. Cost Performance of Surveyed Projects

Cost Growth on the project? Cost Growth = {(Final Project Cost – Project Budget Approved at Sanction) x 100} / Project Budget Approved at Sanction		
	Large project (n=35)	Mega-project (n=41)
Within budget	29%	9%
1% to 10%	31%	20%
10% to 25%	23%	43%
25% to 50%	9%	14%
Above 50%	0%	6%
Project is ongoing	9%	26%
Percentage represents the percent of total projects within each category		

Table 12. Schedule Performance of Surveyed Projects

Schedule Delay on the project? Schedule Delay = Final Project Duration - Project Duration at Sanction (in months)		
	Large project (n=35)	Mega-project (n=41)
Within schedule	34%	23%
0-3 months	20%	6%
3-6 months	17%	14%
6-12 months	17%	31%
12-24 months	3%	9%
24-36 months	0%	6%
Project is ongoing	9%	23%
Percentage represents the percent of total projects within each category		

Table 13. Production/Business Performance of Surveyed Projects

Final facility production/business performance as per planned performance targets		
	Large project (n=34)	Mega-project (n=41)
-50% to -25%	3%	3%
-25% to Met plan	24%	21%
Met plan to +25%	53%	44%
+25% to +50%	0%	3%
Project is ongoing	21%	50%
Percentage represents the percent of total projects within each category		

Table 14. Safety Performance of Surveyed Projects

Safety performance satisfactory as per company standards		
	Large-project	Mega-project
Yes	31	30
No	4	10
Total	35	40

5.4 Data Analysis and Findings

Four main analyses were conducted on the survey data. The survey analysis was focused on verifying the higher occurrence and performance impacts of the impact factors identified.

5.4.1 ANALYSIS 1- OVERALL DIFFERENCE IN OCCURRENCE AND PERFORMANCE IMPACT LEVELS

The first analysis focused on verifying the overall difference in occurrence and impact levels of the 34 impact factors in the surveyed projects, which were divided into two categories: mega-projects (n=41) and large projects (n=35).

Difference in occurrence levels between large projects and mega-projects

To measure the overall difference in occurrence of the 34 impact factors, the number of impact factors faced on each project was calculated within both project categories. Survey respondents were provided project-specific impact factor statements and were asked to rate their level of agreement on the statements on a five-point Likert scale from Strongly Disagree to Strongly Agree. If a respondent responded with Agree or Strongly Agree, it was inferred that the project faced the particular impact factor.

The number of factors faced by each project in the two groups of projects (mega-projects and large-projects) was calculated using the criterion detailed above. Table 17 shows the number of factors faced by each mega-project and large project surveyed. A hypothesis test was then

conducted on the calculated data between the two groups (mega-project and large project). The null hypothesis was that mega-projects (MP) do not face a higher number of impact factors that that faced on large projects (LP). A confidence level of 90 percent was set to reject the null hypothesis and validate the hypothesis that mega-projects, on average, face a greater number of impact factors. The test gave a *statistically significant p value of 0.058 (detailed result in Table 15), indicating that the average number of impact factors faced on mega-projects is greater than the average number of impact factors faced on large projects.*

Table 15. Hypothesis Test Results for Overall Occurrence Comparison between MP and LP

Analysis:	Hypothesis Test	
	Number of Factors Faced by Each project	
Sample Summaries	Mega-project	Large-project
Sample Size	41	35
Sample Mean	10.36585366	7.914285714
Sample Std Dev	6.464348759	6.997358445
	Equal	Unequal
Hypothesis Test (Difference of Means)	Variances	Variances
Hypothesized Mean Difference	0	0
Alternative Hypothesis	> 0	> 0
Sample Mean Difference	2.451567944	2.451567944
Standard Error of Difference	1.545235254	1.555042871
Degrees of Freedom	74	70
t-Test Statistic	1.58653379	1.576527561
p-Value	0.058441234	0.059706604
Null Hypoth. at 10% Significance	Reject	Reject

Difference in performance impacts levels between large projects and mega-projects

To measure performance impact differences, the average impact of the 34 impact factors on cost, schedule, and business performance was calculated on each project in both categories of projects. If survey respondents indicated that the impact factor was faced on the project, they were asked to rate the level of impact the factor had on cost, schedule, and business performance of the

project using a four point Likert scale (No Impact, Minor Impact, Moderate Impact, and Serious Impact). For numerical calculations No Impact was given a rating of 0, Minor Impact a rating of 1, Moderate Impact a rating of 2, and Serious Impact a rating of 3. Also if a factor was not faced on the project it was inferred that it had no impact and was automatically given an impact rating of 0.

Using these numerical criteria, the average impact of all the 34 impact factors on cost, schedule, and production/business performance was calculated for each project in the two groups of projects (mega-projects and large-projects). Table 17 shows the average cost, schedule, production/business performance impact of the impact factors on each project within the two groups of project. A Hypothesis test was then conducted on the calculated data between the two groups (mega-project (MP) and large project (LP)). The null hypothesis formed was that mega-projects do not have higher performance impacts than that faced on large-projects. A confidence level of 90 percent was set to reject the null hypothesis and validate the hypothesis that performance impacts of the impact factors is greater on mega-projects than on large-projects. Through this analysis it was ascertained that the *average impact of the 34 impact factors on cost, schedule, and business performance of mega-projects is greater than that on large projects (p value (cost performance) = 0.054, p value (schedule performance) = 0.076, p value (production/business performance) = 0.073) (see Table 16).*

Table 16. Hypothesis Test Results for Performance Impact Comparison between MP & LP

Sample Summaries	Average Cost Performance Impact on Each Project		Average Schedule Performance Impact on Each Project		Average Production/Business Performance Impact on Each Project	
	Mega-project	Large project	Mega-project	Large project	Mega-project	Large project
Sample Size	41	35	41	35	41	35
Sample Mean	1.55	1.38	1.551	1.389	1.412	1.252
Sample Std Dev	0.50	0.45	0.500	0.468	0.502	0.439
Hypothesis Test (Difference of Means)	Equal Variance s	Unequal Variance s	Equal Variances	Unequal Variances	Equal Variances	Unequal Variances
Hypothesized Mean Difference	0	0	0	0	0	0
Alternative Hypothesis	> 0	> 0	> 0	> 0	> 0	> 0
Sample Mean Difference	0.178	0.178	0.162	0.162	0.160	0.160
Standard Error of Difference	0.110	0.109	0.112	0.111	0.109	0.108
Degrees of Freedom	74	73	74	73	74	73
t-Test Statistic	1.623	1.635	1.45	1.46	1.47	1.48
p-Value	0.054	0.053	0.08	0.07	0.07	0.07
Null Hypoth. at 10% Significance	Reject	Reject	Reject	Reject	Reject	Reject

Table 17. Data points of Overall Comparison of Occurrence and Impact between MP&NMP

Number of Impact Factors Faced				Average Impact on Cost Performance				Average Impact on Schedule Performance				Average Impact on Production/Business Performance			
MP1	23	NMP1	3	MP1	2.65	NMP1	1.12	MP1	2.62	NMP1	1.06	MP1	2.65	NMP1	1.00
MP2	17	NMP2	5	MP2	2.29	NMP2	1.18	MP2	2.32	NMP2	1.12	MP2	2.00	NMP2	1.06
MP3	22	NMP3	4	MP3	2.50	NMP3	1.24	MP3	2.35	NMP3	1.24	MP3	1.65	NMP3	1.24
MP4	10	NMP4	5	MP4	1.74	NMP4	1.12	MP4	1.74	NMP4	1.15	MP4	1.74	NMP4	1.09
MP5	1	NMP5	10	MP5	1.06	NMP5	1.56	MP5	1.06	NMP5	1.59	MP5	1.00	NMP5	1.29
MP6	8	NMP6	24	MP6	1.32	NMP6	2.79	MP6	1.32	NMP6	2.79	MP6	1.29	NMP6	2.74
MP7	1	NMP7	7	MP7	1.00	NMP7	1.21	MP7	1.00	NMP7	1.15	MP7	1.00	NMP7	1.03
MP8	12	NMP8	8	MP8	1.74	NMP8	1.26	MP8	1.74	NMP8	1.15	MP8	1.82	NMP8	1.00
MP9	15	NMP9	1	MP9	2.21	NMP9	1.03	MP9	2.03	NMP9	1.03	MP9	2.15	NMP9	1.00
MP10	1	NMP10	5	MP10	1.06	NMP10	1.18	MP10	1.03	NMP10	1.06	MP10	1.00	NMP10	1.00
MP11	17	NMP11	25	MP11	2.26	NMP11	2.47	MP11	2.38	NMP11	2.50	MP11	2.32	NMP11	2.50
MP12	14	NMP12	2	MP12	2.00	NMP12	1.03	MP12	2.03	NMP12	1.06	MP12	1.88	NMP12	1.03
MP13	8	NMP13	21	MP13	1.26	NMP13	2.06	MP13	1.24	NMP13	2.00	MP13	1.03	NMP13	1.91
MP14	9	NMP14	2	MP14	1.21	NMP14	1.06	MP14	1.09	NMP14	1.06	MP14	1.00	NMP14	1.00
MP15	17	NMP15	12	MP15	1.50	NMP15	1.79	MP15	1.68	NMP15	1.74	MP15	1.03	NMP15	1.12
MP16	6	NMP16	15	MP16	1.41	NMP16	1.85	MP16	1.44	NMP16	2.03	MP16	1.00	NMP16	1.71
MP17	4	NMP17	7	MP17	1.26	NMP17	1.24	MP17	1.26	NMP17	1.18	MP17	1.00	NMP17	1.15
MP18	8	NMP18	2	MP18	1.38	NMP18	1.09	MP18	1.44	NMP18	1.12	MP18	1.32	NMP18	1.00
MP19	14	NMP19	3	MP19	1.38	NMP19	1.18	MP19	1.21	NMP19	1.18	MP19	1.21	NMP19	1.21
MP20	0	NMP20	2	MP20	1.00	NMP20	1.09	MP20	1.00	NMP20	1.09	MP20	1.00	NMP20	1.00

Table 17 (Continued). Data points of Overall Comparison of Occurrence and Impact between MP&NMP

Number of Impact Factors Faced				Average Impact on Cost Performance				Average Impact on Schedule Performance				Average Impact on Production/Business Performance			
MP21	7	NMP21	7	MP21	1.32	NMP21	1.21	MP21	1.41	NMP21	1.15	MP21	1.00	NMP21	1.00
MP22	3	NMP22	3	MP22	1.06	NMP22	1.03	MP22	1.09	NMP22	1.00	MP22	1.00	NMP22	1.00
MP23	10	NMP23	6	MP23	1.35	NMP23	1.24	MP23	1.32	NMP23	1.35	MP23	1.26	NMP23	1.18
MP24	14	NMP24	1	MP24	1.85	NMP24	1.03	MP24	1.79	NMP24	1.03	MP24	1.88	NMP24	1.00
MP25	13	NMP25	9	MP25	2.06	NMP25	1.74	MP25	2.00	NMP25	1.76	MP25	1.71	NMP25	1.09
MP26	21	NMP26	3	MP26	2.50	NMP26	1.09	MP26	2.56	NMP26	1.03	MP26	2.41	NMP26	1.00
MP27	13	NMP27	13	MP27	1.29	NMP27	1.09	MP27	1.47	NMP27	1.62	MP27	1.26	NMP27	1.00
MP28	7	NMP28	16	MP28	1.26	NMP28	1.65	MP28	1.26	NMP28	1.65	MP28	1.18	NMP28	1.65
MP29	4	NMP29	14	MP29	1.12	NMP29	1.47	MP29	1.15	NMP29	1.59	MP29	1.06	NMP29	1.12
MP30	2	NMP30	23	MP30	1.09	NMP30	2.38	MP30	1.12	NMP30	2.44	MP30	1.03	NMP30	2.18
MP31	6	NMP31	3	MP31	1.24	NMP31	1.26	MP31	1.24	NMP31	1.26	MP31	1.24	NMP31	1.26
MP32	4	NMP32	2	MP32	1.21	NMP32	1.12	MP32	1.15	NMP32	1.06	MP32	1.18	NMP32	1.18
MP33	15	NMP33	1	MP33	1.50	NMP33	1.03	MP33	1.47	NMP33	1.06	MP33	1.47	NMP33	1.06
MP34	22	NMP34	10	MP34	2.85	NMP34	1.21	MP34	2.91	NMP34	1.21	MP34	2.85	NMP34	1.00
MP35	18	NMP35	3	MP35	1.71	NMP35	1.09	MP35	1.71	NMP35	1.15	MP35	1.50	NMP35	1.06
MP36	12			MP36	1.35			MP36	1.38			MP36	1.32		
MP37	10			MP37	1.47			MP37	1.38			MP37	1.29		
MP38	6			MP38	1.24			MP38	1.32			MP38	1.12		
MP39	4			MP39	1.06			MP39	1.00			MP39	1.03		
MP40	19			MP40	1.65			MP40	1.65			MP40	1.00		
MP41	8			MP41	1.29			MP41	1.24			MP41	1.03		

Through these results, the overall higher occurrence and performance impact levels of the 34 impact factors on mega-projects were statistically verified using the hypothesis tests. This analysis was helpful in validating the list of impact factors prepared and the first research hypothesis, that there exist factors that have high occurrence and performance impacts on mega-projects.

5.4.2 ANALYSIS 2- DIFFERENCE IN OCCURRENCE AND PERFORMANCE IMPACT OF EACH IMPACT FACTOR

Following the initial analysis on the two categories of projects, a second analysis was conducted comparing the occurrence and impact levels of each impact factor between mega-projects and large projects. The previous analysis was project specific and calculations were done for each project. This analysis focused on specific impact factors and calculations were performed for each impact factor, considering all projects within each category.

To compare the differences in occurrence of each impact factor between mega-projects and large-projects, the frequency of occurrence of impact factors was calculated on the two project categories. The frequency of occurrence represents the percentage of total projects in each category that faced the impact factor. The same criteria that was used in previous analysis was used for this analysis, inferring occurrence of the factor if survey respondents answered Agree or Strongly Agree to agreement level on factor statements. Using the criteria above, the number of projects facing the particular impact factor was calculated in each of the project categories and then divided it by the total number of projects in that category to get the percentage of total projects that faced the impact factor.

Frequency of Occurrence (within each category MP&LP)

= No of respondents that answered 'Agree' or 'Strongly Agree' / Total Number of Projects

The frequency of occurrence for each impact factor on mega-projects and large projects is shown in Table 18. Table 18 presents the consolidated results of the findings around occurrence and impact levels of each impact factor. The table shows how many projects faced the particular impact factor and also the distribution of the impacts the factor had on projects that faced the factor.

Table 18. Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor A1 - New or Unproven Technology								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	24%		40%		76%		60%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	20%	7%	10%	29%	40%	50%	30%	14%
Schedule	10%	7%	30%	43%	30%	29%	30%	21%
Production	30%	29%	20%	14%	10%	21%	40%	36%
Factor A2 - Logistics Challenges								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	49%		26%		51%		74%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	20%	33%	25%	67%	35%	0%	20%	0%
Schedule	20%	56%	40%	33%	20%	0%	20%	0%
Production	45%	100%	25%	13%	15%	0%	15%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor A3 - Jurisdictional Complexities								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	34%		20%		66%		80%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	7%	14%	43%	86%	36%	0%	14%	0%
Schedule	15%	29%	31%	71%	31%	0%	23%	0%
Production	36%	71%	21%	29%	29%	0%	14%	0%
Factor A4 - Unavailability of Qualified Craftsmen								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	46%		34%		54%		66%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	5%	8%	32%	33%	37%	50%	26%	8%
Schedule	0%	0%	42%	25%	26%	50%	32%	25%
Production	37%	42%	32%	33%	16%	8%	16%	17%
Factor B1 - Unplanned Changes in Key Personnel								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	59%		43%		41%		57%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	21%	33%	38%	27%	33%	33%	8%	0%
Schedule	25%	14%	33%	64%	25%	21%	17%	0%
Production	29%	79%	42%	7%	21%	14%	8%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor B2 - Ineffective Stakeholder Communication								
OCCURRENCE	FACED				DID NOT FACE			
	MP	LP	MP	LP	MP	LP	MP	LP
	29%		23%		71%		77%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	8%	13%	42%	38%	17%	38%	33%	13%
Schedule	8%	0%	25%	38%	33%	50%	33%	13%
Production	33%	13%	8%	25%	25%	25%	33%	13%
Factor B3 - Multi-Location Challenges								
OCCURRENCE	FACED				DID NOT FACE			
	MP	LP	MP	LP	MP	LP	MP	LP
	49%		29%		51%		71%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	15%	20%	60%	60%	20%	20%	5%	0%
Schedule	20%	10%	55%	60%	15%	20%	10%	10%
Production	30%	40%	55%	30%	10%	20%	5%	0%
Factor B4 - Inadequate Organization Planning and Staffing								
OCCURRENCE	FACED				DID NOT FACE			
	MP	LP	MP	LP	MP	LP	MP	LP
	37%		26%		63%		74%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	7%	0%	27%	56%	33%	33%	33%	11%
Schedule	13%	0%	13%	11%	33%	78%	40%	11%
Production	20%	11%	27%	33%	33%	22%	20%	11%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor B5 - Ineffective Interface Management								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	22%		11%		78%		89%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	11%	25%	22%	25%	44%	50%	22%	0%
Schedule	11%	0%	22%	50%	33%	50%	33%	0%
Production	22%	25%	22%	25%	22%	25%	33%	0%
Factor B6 - Inadequate Document Management Plan								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	17%		20%		83%		80%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	29%	71%	29%	29%	43%	0%
Schedule	0%	29%	29%	29%	29%	43%	43%	0%
Production	14%	29%	29%	43%	57%	29%	0%	0%
Factor C10 - Quality Compromised for Schedule								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	10%		6%		90%		94%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	25%	0%	25%	50%	25%	0%	25%	50%
Schedule	25%	0%	25%	50%	25%	0%	25%	50%
Production	0%	50%	25%	0%	50%	0%	25%	50%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor C11 - Ineffective Change Management								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	29%		17%		71%		83%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	25%	17%	33%	50%	42%	33%
Schedule	8%	0%	17%	33%	50%	33%	25%	33%
Production	33%	0%	8%	17%	17%	50%	42%	33%
Factor C12 - Incomprehensive Risk Management								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	20%		17%		80%		83%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	25%	50%	63%	33%	13%	17%
Schedule	0%	0%	25%	50%	63%	33%	13%	17%
Production	13%	0%	38%	0%	38%	50%	13%	33%
Factor C13 - Unfit Documents, Procedures, and Processes								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	7%		14%		93%		86%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	67%	20%	33%	80%	0%	0%
Schedule	0%	20%	67%	20%	33%	60%	0%	0%
Production	33%	20%	67%	0%	0%	60%	0%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor C1 - Lack of Execution Input to FEP								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	17%		15%		83%		85%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	14%	0%	0%	33%	86%	67%
Schedule	0%	0%	14%	0%	0%	33%	86%	67%
Production	0%	17%	14%	17%	0%	17%	86%	50%
Factor C2 - Optimism Bias								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	59%		46%		41%		54%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	17%	25%	33%	44%	50%	31%
Schedule	8%	6%	8%	31%	46%	38%	38%	25%
Production	17%	44%	42%	13%	8%	25%	33%	19%
Factor C3 - Inadequate FEP Resources								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	29%		23%		71%		77%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	33%	25%	17%	50%	50%	25%
Schedule	8%	0%	17%	38%	33%	38%	42%	25%
Production	33%	25%	25%	25%	8%	25%	33%	25%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor C4 - Inadequate Risk Assessment & Mitigation								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	27%		26%		73%		74%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	11%	27%	22%	18%	44%	55%	11%
Schedule	0%	13%	36%	13%	27%	63%	36%	13%
Production	9%	13%	45%	25%	27%	38%	18%	25%
Factor C5 - Inadequate Project Controls Systems								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	5%		23%		95%		77%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	13%	50%	13%	0%	38%	50%	38%
Schedule	0%	0%	50%	0%	0%	50%	50%	50%
Production	0%	38%	50%	13%	0%	25%	50%	25%
Factor C6 - Lack of Execution Plan Alignment								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	24%		11%		76%		89%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	30%	25%	40%	75%	30%	0%
Schedule	0%	0%	22%	0%	33%	100%	44%	0%
Production	30%	25%	30%	0%	10%	75%	30%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor C7 - Inadequate Integrated Schedule								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	24%		20%		76%		80%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	14%	22%	29%	22%	43%	56%	14%
Schedule	0%	0%	22%	29%	22%	43%	56%	29%
Production	0%	29%	20%	43%	30%	14%	50%	14%
Factor C8 - Regulatory & Environmental Delays								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	24%		20%		76%		80%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	10%	14%	40%	43%	20%	14%	30%	29%
Schedule	0%	14%	30%	0%	40%	57%	30%	29%
Production	50%	71%	20%	14%	20%	0%	10%	14%
Factor C9 - Baseline Schedule Acceleration								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	24%		23%		76%		77%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	10%	0%	30%	50%	40%	38%	20%	13%
Schedule	0%	0%	40%	25%	30%	63%	30%	13%
Production	30%	25%	40%	50%	30%	13%	0%	13%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor D1 - Unclear definition of Roles, Responsibilities and Authority								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	20%		31%		80%		69%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	9%	50%	36%	0%	18%	50%	36%
Schedule	0%	9%	50%	27%	13%	36%	38%	27%
Production	13%	27%	38%	27%	25%	27%	25%	9%
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	48%		26%		53%		74%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	22%	32%	22%	42%	44%	26%	11%
Schedule	5%	11%	32%	22%	32%	56%	32%	11%
Production	16%	33%	37%	11%	26%	33%	21%	11%
Factor D3 - Cultural Differences Across Stakeholders								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	41%		11%		59%		89%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	18%	0%	65%	25%	18%	75%	0%	0%
Schedule	18%	25%	59%	25%	24%	50%	0%	0%
Production	44%	50%	38%	0%	13%	50%	6%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor D4 - Inadequate Owner Participation in Risk Management								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	22%		11%		78%		89%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	33%	25%	33%	25%	33%	50%
Schedule	0%	0%	33%	25%	44%	50%	22%	25%
Production	22%	0%	22%	0%	44%	25%	11%	50%
Factor D5 - Misalignment Within Partner Organization								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	37%		23%		63%		77%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	40%	13%	33%	63%	27%	25%
Schedule	7%	0%	27%	25%	40%	38%	27%	38%
Production	27%	25%	27%	50%	27%	25%	20%	0%
Factor D6 - Business Approach Differences Across Stakeholders								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	29%		14%		71%		86%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	8%	20%	50%	40%	25%	20%	17%	20%
Schedule	0%	40%	58%	20%	17%	20%	25%	20%
Production	42%	60%	25%	20%	17%	20%	17%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor E1 - Inappropriate Project Delivery Contracting Strategy								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	23%		13%		78%		87%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	22%	0%	11%	20%	67%	80%
Schedule	0%	0%	22%	0%	11%	20%	67%	80%
Production	22%	0%	33%	20%	11%	40%	33%	40%
Factor E2 - Limited Capable Contractors								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	49%		37%		51%		63%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	5%	31%	40%	31%	40%	31%	15%	8%
Schedule	15%	31%	15%	38%	45%	23%	25%	8%
Production	40%	77%	30%	15%	20%	8%	10%	0%
Factor E3 - Unclear Scope Definition in Contracts								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	17%		17%		83%		83%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	14%	0%	29%	83%	57%	17%
Schedule	14%	0%	0%	0%	57%	83%	29%	17%
Production	14%	33%	14%	33%	29%	33%	43%	0%

Table 18. (Continued) Consolidated Result for Occurrence and Impact Levels of Impact Factors on MP and LP

Factor E4 - Unexpected materials and / or equipment delays.								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	41%		37%		59%		63%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	6%	8%	35%	62%	29%	23%	29%	8%
Schedule	12%	0%	18%	54%	41%	31%	29%	15%
Production	41%	38%	35%	46%	6%	15%	18%	0%
Factor E5 - Underperforming Contractor or Key Subcontractor								
OCCURRENCE	FACED				DID NOT FACE			
	MP		LP		MP		LP	
	46%		34%		54%		66%	
IMPACT (on projects that faced the factor)	NO		MINOR		MODERATE		SERIOUS	
	MP	LP	MP	LP	MP	LP	MP	LP
Cost	0%	0%	32%	25%	32%	50%	37%	25%
Schedule	0%	17%	32%	17%	32%	25%	37%	42%
Production	16%	33%	42%	25%	11%	17%	32%	25%

To compare numerically the difference in performance impact levels of each impact factor between mega-projects and large projects, an average performance impact rating was calculated for each factor. The numerical rating criterion is the same as used in previous analysis, giving No Impact a rating of 0, Minor Impact a rating of 1, Moderate Impact a rating of 2, and Serious Impact a rating of 3. Also, if a factor was not faced on the project it was inferred that it had no impact and was automatically given an impact rating of 0.

The average performance (cost, schedule, and business) impact rating for an impact factor was calculated by averaging the performance impact rating for that impact factor on all the projects within each category. For example to calculate the average cost impact value of an impact factor

on mega-projects, the cost performance impact ratings for all the 41 mega-project surveyed was averaged for the impact factor in question.

Average Performance Impact (Mega – project)

$$= \frac{\sum \text{Numerical value of impact responses for each response (n = 41)}}{\text{Total number of projects}}$$

Average Cost Impact (Large – project)

$$= \frac{\sum \text{Numerical value of impact responses for each response (n = 35)}}{\text{Total number of projects}}$$

The same approach was followed to calculate the average schedule and production/business impact ratings for each impact factor. Table 19(a) through Table 19(e) shows the percentage differences in occurrence and average performance impact of the impact factors between mega-projects(MP) (n=41) and large projects(LP) (n=35). A positive percentage (highlighted in gray) represents higher occurrence/impact on mega-projects than on large projects and a negative percentage represents the reverse.

Table 19a. Impact Factor Difference between MP & LP (Category A)

Category A - Location and Technology				
Impact Factors	Occurrence	Average Impact		
		Cost	Schedule	Business
Factor A1-New or Unproven Technology	-39%	-36%	-33%	-41%
Factor A2-Logistics Challenges	90%	341%	697%	1607%
Factor A3-Jurisdictional Complexities	71%	213%	259%	626%
Factor A4-Unavailability of Qualified Craftsmen	35%	57%	28%	49%

Table 19b. Impact Factor Difference between MP & LP (Category B)

Category B - Team, Organization, and Communications				
Impact Factors	Occurrence	Average Impact		
		Cost	Schedule	Business
Factor B1 - Unplanned Changes in Key Personnel	37%	89%	82%	344%
Factor B2 - Ineffective Stakeholder Communication	28%	49%	40%	80%
Factor B3 - Multi-Location Challenges	71%	96%	51%	120%
Factor B4 - Inadequate Organization Planning and Staffing	42%	77%	42%	96%
Factor B5 - Ineffective Interface Management	92%	173%	142%	327%
Factor B6 - Inadequate Document Management Plan	-15%	42%	60%	22%

Table 19c. Impact Factor Difference between MP & LP (Category C)

Category C - Planning and Execution Processes				
Impact Factors	Occurrence	Average Impact		
		Cost	Schedule	Business
Factor C1 - Lack of Execution Input to FEP	0%	1%	1%	35%
Factor C2 - Optimism Bias	28%	42%	47%	71%
Factor C3 - Inadequate FEP Resources	28%	39%	42%	21%
Factor C4 - Inadequate Risk Assessment & Mitigation	4%	64%	34%	4%
Factor C5 - Inadequate Project Controls Systems	-79%	-79%	-83%	-69%
Factor C6 - Lack of Execution Plan Alignment	113%	144%	113%	99%
Factor C7 - Inadequate Integrated Schedule	22%	63%	28%	145%
Factor C8 - Regulatory & Environmental Delays	22%	32%	22%	92%
Factor C9 - Baseline Schedule Acceleration	7%	12%	8%	-5%
Factor C10 - Quality Compromised for Schedule	71%	28%	28%	128%
Factor C11 - Ineffective Change Management	71%	71%	64%	31%
Factor C12 - Incomprehensive Risk Management	14%	28%	28%	-15%
Factor C13 - Unfit Documents, Procedures, and Processes	-49%	-62%	-51%	-72%

Table 19d. Impact Factor Difference between MP & LP (Category D)

Category D - Governance and Stakeholders				
Impact Factors	Occurrence	Average Impact		
		Cost	Schedule	Business
Factor D1 - Unclear definition of Roles, Responsibilities and Authority	-38%	-32%	-36%	-8%
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	80%	143%	105%	148%
Factor D3 - Cultural Differences Across Stakeholders	263%	107%	207%	177%
Factor D4 - Inadequate Owner Participation in Risk Management	92%	71%	81%	39%
Factor D5 - Misalignment Within Partner Organization	60%	41%	41%	124%
Factor D6 - Business Approach Differences Across Stakeholders	105%	120%	185%	270%

Table 19e. Impact Factor Difference between MP & LP (Category E)

Category E - Delivery Strategy				
Impact Factors	Occurrence	Average Impact		
		Cost	Schedule	Business
Factor E1 - Inappropriate Project Delivery Contracting Strategy	54%	34%	34%	9%
Factor E2 - Limited Capable Contractors	31%	88%	120%	327%
Factor E3 - Unclear Scope Definition in Contracts	0%	12%	-8%	99%
Factor E4 - Unexpected materials and / or equipment delays.	12%	56%	30%	45%
Factor E5 - Underperforming Contractor or Key Subcontractor	35%	39%	45%	60%

The results show that 30 out of the 34 impact factors either have a higher occurrence or higher performance impacts on mega-projects. These results represent the factors identified as having higher occurrence or performance impacts on mega-projects. Following this analysis, the next analyses focused on identifying key factors among the impact factors that make mega-project more prone to failure.

5.4.3 ANALYSIS 3- MEGA-PROJECT DIFFERENTIATING UNIQUE FACTORS

For the third analysis, impact factors were identified that may be more unique to mega-projects. The analysis focused on finding if there were any impact factors that have a statistically significant higher occurrence or performance impact levels on mega-projects. A statistically significant higher occurrence or impact level difference on mega-projects for any impact factor was inferred as a measure of uniqueness of the impact factor. To conduct this analysis, based on the nature of the data gathered the Man Whitney U test was selected to test statistically the difference in responses for each impact factor in both categories of project. The Mann-Whitney U test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. The data gathered in the survey is based on Likert scale responses, which are ordinal in nature and are not normally distributed. The test was conducted in SPSS, a statistical package tool from IBM. Some of the important elements of the test include:

- The two independent groups are mega-projects and large-projects.
- The 34 factors and their respective occurrence levels and impacts on the cost performance, schedule performance, and business performance are the dependent variables in the analyses.
- In group 1 (mega-projects) there are 41 respondents and in group 2 (large projects) there are 35 respondents.
- Null Hypothesis: There exists no difference in occurrence and impact levels of the impact factors between mega-projects and large projects.
- Alternate Hypothesis: Impact factors have a higher occurrence and larger performance impact on mega-projects than on large projects.

- Confidence Interval: A confidence interval of 90 percent was selected; in other words, a p value less than 0.1 indicates a statistically significant difference in occurrence and impact levels of the factor between the two categories of project.

Table 20 shows the impact factors and their corresponding p values, as attained from the Man Whitney U Test for difference occurrence and impact levels between the two sets of projects. The test identified 11 factors (lettered in red) to have a statistically significant (p value less than 0.1) higher occurrence or performance impacts on mega-projects.

Table 20. Mega-project Differentiating Unique Factors

Impact Factor Name	p values of difference between MP and LP			
	Occurrence	Cost	Schedule	Business
Factor C1 - Lack of Execution Input to FEP	.681	.968	.968	.693
Factor C2 - Optimism Bias	.362	.165	.186	.066
Factor E1 - Inappropriate Project Delivery Contracting Strategy	1.000	.431	.431	.767
Factor C3 - Inadequate FEP Resources	.610	.636	.721	.769
Factor A1 - New or Unproven Technology	.051	.143	.192	.241
Factor B6 - Inadequate Document Management Plan	.345	.908	.663	.912
Factor C4 - Inadequate Risk Assessment & Mitigation	.987	.397	.493	.731
Factor C5 - Inadequate Project Controls Systems	.098	.042	.020	.158
Factor C6 - Lack of Execution Plan Alignment	.132	.136	.206	.279
Factor C7 - Inadequate Integrated Schedule	.625	.509	.753	.210
Factor C8 - Regulatory & Environmental Delays	.399	.594	.510	.339
Factor B1 - Unplanned Changes in Key Personnel	.400	.068	.198	.002
Factor B4 - Inadequate Organization Planning and Staffing	.824	.289	.441	.190
Factor B2 - Ineffective Stakeholder Communication	.667	.458	.592	.470
Factor D1 - Unclear definition of Roles, Responsibilities and Authority	.649	.362	.338	.769

Table 20. (Continued) Mega-project Differentiating Unique Factors

Impact Factor Name	p values of difference between MP and LP			
	Occurrence	Cost	Schedule	Business
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	.040	.017	.052	.023
Factor A4 - Unavailability of Qualified Craftsmen	.049	.213	.362	.350
Factor B3 - Multi-Location Challenges	.034	.055	.169	.038
Factor C9 - Baseline Schedule Acceleration	.921	.994	.960	1.000
Factor C10 - Quality Compromised for Schedule	.785	.780	.780	.244
Factor C11 - Ineffective Change Management	.657	.221	.306	.717
Factor C12 - Incomprehensive Risk Management	.206	.740	.740	.857
Factor C13 - Unfit Documents, Procedures, and Processes	.724	.295	.506	.474
Factor B5 - Ineffective Interface Management	.666	.165	.286	.116
Factor A3 - Jurisdictional Complexities	.024	.053	.073	.037
Factor D3 - Cultural Differences Across Stakeholders	.001	.038	.020	.057
Factor D4 - Inadequate Owner Participation in Risk Management	.708	.249	.239	.333
Factor D5 - Misalignment Within Partner Organization	.218	.263	.322	.238
Factor D6 - Business Approach Differences Across Stakeholders	.050	.102	.030	.123
Factor E2 - Limited Capable Contractors	.134	.066	.073	.022
Factor E3 - Unclear Scope Definition in Contracts	.335	.930	.805	.594
Factor A2 - Logistics Challenges	.027	.013	.002	.004
Factor E4 - Unexpected materials and / or equipment delays.	.562	.417	.699	.779
Factor E5 - Underperforming Contractor or Key Subcontractor	.088	.284	.180	.159

5.4.4 ANALYSIS 4- MOST IMPACTFUL FACTORS ON MEGA-PROJECTS

The last analysis focused on determining the most impactful factors on mega-projects.

Using the rankings provided by the survey respondents, an impact ranking score was established

for each factor. For every impact factor, the rankings from each mega-project survey respondent were consolidated to calculate the impact ranking score. The ranks were given the following weights: a weight of 5 to a rank of 1, a weight of 4 to rank of 2, a weight of 3 to rank 3, a weight of 2 to rank 4, and a weight of 1 to rank 5. If a factor was not among those ranked by the respondent, it was given a weight of 0. Using these assigned weights for each impact factor, the impact rank score was calculated by adding all the weighted ranks from the 41 mega-project responses.

Impact Rank Score (Cost, Schedule, & Business)

$$= \frac{\sum \text{No of rank no. 1} \times 5 + \text{No of rank no. 2} \times 4 + \text{No of rank no. 3} \times 3 + \text{No of rank no. 4} \times 2 + \text{No of rank no. 5} \times 1}{\text{Total number of projects } (n = 41)}$$

First, the most impactful factors on cost, schedule, and production/business performance on mega-projects were identified based on the individual ranking score. Nearly half of the impact factors contributed approximately 80 percent of the cumulative impact score for each of the cost, schedule, and business impact ranking score. Table 21 through Table 23 shows results for the three impact ranking scores and the impact factors that have the most impact on the cost, schedule, and business performance of mega-projects.

Table 21. Mega-project Factors having Most Impact on Cost Performance

Impact Factor name	Cost Impact Ranking Score	Percentage of Cumulative Impact Score
Factor C2 - Optimism Bias	39	10%
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	37	10%
Factor E5 - Underperforming Contractor or Key Subcontractor	37	10%
Factor A4 - Unavailability of Qualified Craftsmen	33	8%
Factor A2 - Logistics Challenges	29	7%
Factor E4 - Unexpected materials and / or equipment delays	24	6%
Factor E2 - Limited Capable Contractors	23	6%
Factor C8 - Regulatory & Environmental Delays	16	4%
Factor C6 - Lack of Execution Plan Alignment	13	3%
Factor A3 - Jurisdictional Complexities	13	3%
Factor C3 - Inadequate FEP Resources	12	3%
Factor C1 - Lack of Execution Input to FEP	11	3%
Factor C7 - Inadequate Integrated Schedule	11	3%
Factor C9 - Baseline Schedule Acceleration	11	3%

Table 22. Mega-project Factors Having Most Impact on Schedule Performance

Impact Factor name	Schedule Impact Ranking Score	Percentage of Cumulative Impact Score
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	35	9%
Factor C2 - Optimism Bias	33	9%
Factor A4 - Unavailability of Qualified Craftsmen	33	9%
Factor E5 - Underperforming Contractor or Key Subcontractor	32	8%
Factor E4 - Unexpected materials and / or equipment delays.	29	8%
Factor C8 - Regulatory & Environmental Delays	24	6%
Factor E2 - Limited Capable Contractors	22	6%
Factor A2 - Logistics Challenges	19	5%
Factor B4 - Inadequate Organization Planning and Staffing	15	4%
Factor B2 - Ineffective Stakeholder Communication	13	3%
Factor C9 - Baseline Schedule Acceleration	13	3%
Factor C11 - Ineffective Change Management	12	3%
Factor D5 - Misalignment Within Partner Organization	12	3%
Factor C7 - Inadequate Integrated Schedule	11	3%

Table 23. Mega-project Factors Having Most Impact on Business Performance

Impact Factor name	Business Impact Ranking Score	Percentage of Cumulative Impact Score
Factor C1 - Lack of Execution Input to FEP	24	10%
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	22	9%
Factor E5 - Underperforming Contractor or Key Subcontractor	21	8%
Factor A3 - Jurisdictional Complexities	16	6%
Factor B2 - Ineffective Stakeholder Communication	14	6%
Factor A2 - Logistics Challenges	13	5%
Factor C2 - Optimism Bias	12	5%
Factor D4 - Inadequate Owner Participation in Risk Management	12	5%
Factor A4 - Unavailability of Qualified Craftsmen	11	4%
Factor C7 - Inadequate Integrated Schedule	10	4%
Factor D5 - Misalignment Within Partner Organization	10	4%
Factor A1 - New or Unproven Technology	9	4%
Factor D1 - Unclear definition of Roles, Responsibilities, and Authority	9	4%
Factor C8 - Regulatory & Environmental Delays	8	3%
Factor C9 - Baseline Schedule Acceleration	8	3%

Then, we combined these three performance criteria by summing individual rank scores of impact factors on the cost, schedule, and production/business performance to get a combined impact rank score. Analyzing the impact ranking scores, we identified in total 16 factors that contributed approximately 80 percent of the total impact ranking scores. These 16 impact factors

are shown in Table 24 with their respective contribution (in percentage) to the total impact ranking score.

Table 24. Mega-project Most Impactful Factors

Impact Factor Name	Combined Impact Ranking Score	Percentage of Cumulative Impact Score
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	94	9%
Factor E5 - Underperforming Contractor or Key Subcontractor	90	9%
Factor C2 - Optimism Bias	84	8%
Factor A4 - Unavailability of Qualified Craftsmen	77	8%
Factor A2 - Logistics Challenges	61	6%
Factor E4 - Unexpected materials and / or equipment delays.	58	6%
Factor C8 - Regulatory & Environmental Delays	48	5%
Factor E2 - Limited Capable Contractors	48	5%
Factor C1 - Lack of Execution Input to FEP	45	4%
Factor A3 - Jurisdictional Complexities	38	4%
Factor B2 - Ineffective Stakeholder Communication	35	3%
Factor C7 - Inadequate Integrated Schedule	32	3%
Factor C9 - Baseline Schedule Acceleration	32	3%
Factor D5 - Misalignment Within Partner Organization	30	3%
Factor C3 - Inadequate FEP Resources	28	3%
Factor C6 - Lack of Execution Plan Alignment	25	2%

Total Ranking Impact Score= 1022

Concluding the survey analysis, follow-up interviews were conducted to understand the results and learn more about the most impactful and unique factors. The interviews clarified the occurrence and impact of some of the factors. In all, five follow up interviews were conducted. The interviews were 30 to 45 minutes long and conducted over the phone. This provided a starting point for in-depth case studies to understand why some factors have significant impacts and what can be done to mitigate the factors. The detailed summaries of the follow-up interviews are enclosed in *CII Research Report 315-11*.

CHAPTER 6- CASE STUDIES

6.1 Purpose and Objective

After conducting the survey and follow up interviews, the next step was to conduct case studies to learn more in-depth information around the impact factor occurrence and impact on mega-project performance. The main objectives of the case studies were:

- To gain in-depth understanding on the occurrence and influence of the selected impact factors
- To identify mitigation strategies, if any adopted on mega-projects to mitigate the impact of these factors
- To understand what could have been done in hindsight to mitigate the impact of these factors

6.2 Data Collection Methodology

The case projects were selected from the projects that had participated in the survey. As part of the mega-project survey, the participants were asked if they would be interested in future research activities and 29 respondents agreed to be contacted for participation. Based on the final cost, schedule, and business performance, the projects were analyzed in order to choose a project shortlist for conducting case studies. Based on existing characterizations of mega-project failure (Merrow E. W., *Industrial Megaprojects Concepts, Strategies, and Practices for Success, 2011*), for the purpose of these case studies unsuccessful mega-projects were defined as those that experienced poor performance; that is, had *either* cost growth greater than 25 percent *or* schedule delays greater than 25 percent *or* did not meet business targets. Out of these 29 mega-projects, 11

completed mega-projects were shortlisted to be contacted for conducting case studies. These 11 mega-projects were a mix of successful and unsuccessful projects.

In parallel to selection of the potential case study projects, a detailed reference case study interview questionnaire was prepared for the case study interviews. The case study interview questionnaire was designed to facilitate an open conversation with the interviewee. The main aim was to enable the interviewee to tell a story of how the impact factor occurred and impacted the mega-project and what was done or what could have been done to mitigate the factor. Following selecting potential case projects and interview guide preparation, the 11 mega-project representatives were contacted for participation in the study.

Case study interviews were telephone interviews that lasted between one-and-a-half to two hours long. During the interviews the interviewees were asked a series of open-ended questions surrounding impact factors. If the project was impacted by a particular factor, the questions focused on why and how the factor impacted project performance. If the factor did not impact the project, the questions focused on what practice or strategy was adopted that mitigated it.

6.3 Data Gathered

In all, seven case studies were conducted, including five unsuccessful mega-projects and two successful mega-projects. One of the key project team members was interviewed for each case study. Table 25 provides a brief overview of key characteristics of the case mega-projects.

Table 25. Case Study Project- General Characteristics

S. No.	Project Type	Project Location	Overall Project Budget	Cost Growth	Overall Project Duration	Schedule Delay	Business Performance
Case Project 1	Oil Exploration and Production	Asia	\$1 B- \$2.5 B	10% to 25%	3-5 years	24-36 months	Met plan to +25%
Case Project 2	Infrastructure	Middle East	\$1 B- \$2.5 B	10% to 25%	2-3 years	6-12 months	-25% to Met plan
Case Project 3	Chemical Manufacturing	North America	\$1 B- \$2.5 B	10% to 25%	2-3 years	6-12 months	Met plan to +25%
Case Project 4	Mining	Oceania (Including Australia)	\$1 B- \$2.5 B	Above 50%	3-5 years	6-12 months	-50% to -25%
Case Project 5	Natural Gas Processing	Middle East	Above \$10 B	10% to 25%	3-5 years	12-24 months	Met plan to +25%
Case Project 6	Natural Gas	Africa	\$2.5 B- \$5 B	1% to 10%	5-7 years	12-24 months	Met plan to +25%
Case Project 7	Power Generation	Africa	Above \$10 B	1% to 10%	5-7 years	6-12 months	Met plan to +25%

6.4 Analysis and Findings

The case studies helped to learn in-depth about the impact factors and how they manifest and negatively impact mega-projects. The information from the case studies was used to draft real case examples for each impact factors that are explained in the next chapter of the thesis.

Learning from the case projects also included identifying some probable causes and potential outcomes of each impact factor. The combined results were used to provide impact factor descriptions, which are explained in the next chapter of the report. The complete summary of each

case interview can be found in *CII Research Report 315-11*. The following are some key impact factors and a summary of the findings around the impact factors from the case studies:

6.4.1 CATEGORY A- LOCATION AND TECHNOLOGY

Factor A2 - Logistics Challenges

Organizations involved in mega-projects often venture into challenging and unfamiliar locations. Unfamiliar and remote locations present a host of related issues that impact mega-projects. The availability of existing infrastructure and logistics and transportation requirements are key factors that impact mega-projects. Challenges in managing logistics in remote or unfamiliar locations were common discussion points with interviewees. Mega-project planning teams often failed to accurately assess the complexity of remote sites with a large volume of equipment/craft. Logistics challenges included underestimating cost and schedule impacts of transporting materials in unfamiliar and/or remote locations, lack of understanding of resource availability, no or poor quality existing infrastructure, partial assessment of local fabrication capabilities, and disruptions due to weather (e.g., cold regions, wet seasons, hurricanes, loop currents, etc.). Not including these logistics challenges during planning of the mega-project in all cases led to mismanagement of logistics on a mega-project.

Factor A3 - Jurisdictional Complexities

Understanding jurisdictional complexities was another important planning aspect on mega-projects. Interviewees felt that mega-project planning need to accurately assess all jurisdictional complexities and take early steps to include all formal and informal local content in project planning. Mega-projects studies suffered due to unfamiliarity with the regional tax regulations; incomplete examination of applicable import/export requirements; lack of a thorough review of

local laws, including local content/permitting requirements; ignoring political influences/stability; overlooking informal local content requirements; dependence upon the host government to provide required infrastructure additions; and, in some cases, corruption within the host government. Interviewees stressed the need to identify and plan for permits early in project planning and to deploy experienced, expert personnel to handle regulatory requirements. Incomplete and poorly drafted permit applications often led to regulatory authorities imposing delays on projects.

Factor A4 - Unavailability of Qualified Craftsmen

Most mega-projects studied faced numerous challenges related to the project location. Availability of quality local crafts is a crucial planning aspect that has often been ignored. Increasingly, host governments are restricting mass importation of crafts. This has led to a serious shortage of available skilled crafts. Most projects failed to meet the peak craft requirements, which led to direct schedule delays. Interviewees felt that inaccurate assumptions made about craft availability and inadequate assessments of craft availability in an unfamiliar location during planning led to unfeasible targets, leading to eventually failure. Many mega-projects studied were located in areas where many mega-projects were being executed simultaneously. These led to a mismatch between the high demand and inadequate supply of local skilled workforce. The resulting hot market situation meant continuous escalation in wage rates, leading to cost growth.

Many mega-projects also failed to accurately assess the training costs required to train the local workforce. Those interviewed advised that planning teams should assess and recognize location factors early and incorporate them into project plans to mitigate their impact. On successful mega-projects, sponsor organizations established early training programs to improve

local craft productivity and ensure availability of local skilled craft. On a particular successful mega-project, the sponsor organization worked with the local government in establishing training schools locally. All key contractors and large equipment suppliers were contractually bound to hold training programs with the local workforce to strengthen local skilled workforce. The mega-project was successful in meeting project objectives and also had a very positive effect on the local community and was considered a huge success from every aspect.

6.4.2 CATEGORY B- TEAM, ORGANIZATION, AND COMMUNICATIONS

Factor B1 - Unplanned Changes in Key Personnel

Project teams should plan for and manage personnel turnover during mega-projects, as some continue for more than 10 years from inception to completion. Most interviewees reported that frequent changes in key leadership positions, such as project director or project manager, had negative impacts on project schedules. These unplanned changes are either a result of personality conflicts between team members, health issues, sudden retirement, or simply project manager burnout. The unplanned changes in key personnel led to knowledge loss and lack of team cohesion. When key personnel change, the entire team has to realign, which slows down the project. Organizations fail to plan for such complexities and though it is difficult to quantify the impacts the personnel changes have, it was evident from the interviews that it can lead to serious complications leading to poor performance on mega-projects. On successful mega-projects, special emphasis was given to succession planning. For all key project roles there were multiples deputies deployed to smooth the transition when there was a change in the leadership.

Factor B2 - Ineffective Stakeholder Communication

Another challenge for most mega-projects was maintaining effective communications across stakeholders and project team members. Multiple stakeholders, cross-functional teams, and

globally dispersed teams increase the chances of miscommunications. Diverse stakeholders have different perceptions. Different cultures and different languages present additional challenges and require special attention for maintaining effective communications

Most successful organizations formed dedicated teams at the start of the project to manage communications. Communication or integration teams are designed to keep every stakeholder informed. Stakeholders on mega-projects, both internal and external, have very different expectations and perspectives of project success. For successful integration of these diverse expectations, it becomes critical to maintain continuous clear communications across project teams and other external stakeholders. Projects that failed to recognize these complexities suffered misalignment and increased errors. Ineffective communication was a root cause of failure for some of the mega-projects.

Factor B3 - Multi-Location Challenges

Interviewees felt that, with mega-projects now being conducted simultaneously with multiple teams located worldwide, there was an increased potential of errors due to different terminologies, standards, and procedures. With team members from diverse cultures speaking different languages, mega-project teams faced challenges in forming integrated teams. There were increased instances of miscommunications due to inadequate face-to-face interactions within different functions on projects. Most mega-projects had design completed by multiple offices; this led to more issues around the integration of the design done at multiple offices. Such issues require more face-to-face communications and better communication frameworks between globally dispersed teams.

Most mega-projects studies had globally dispersed teams. Very few were able to successfully mitigate the factor. On a successful mega-project, there were three different locations

where detailed engineering was being completed. To improve alignment between the dispersed teams at the start of the detailed engineering phase, teams from all locations were invited to the company headquarters for a week to have effective team-building and alignment. This helped different teams understand expectations better and the project faced fewer problems in subsequent communications between the dispersed teams.

6.4.3 CATEGORY C-PLANNING AND EXECUTION PROCESSES

Factor C1 - Lack of Execution Input to FEP

Most interviewees felt that planning is done with haste and fails to comprehensively consider all of the complexities of execution, procurement, and start-up. Favorable business conditions and the urgency to get to the market often influenced owners to skip key aspects of planning. When project risks and challenges are not effectively defined, the outcome can be serious cost and schedule overruns. Haste and urgency can result in inadequate representation and input of key functions during planning. Missing input from the execution side often led to late changes that made projects more susceptible to failure. Interviewees felt that mega-projects are unique in characteristics and require planning considerations specific to project characteristics. Planning done only from business perspective while failing to effectively consider complexity around execution, procurement, and logistics suffer from poor performance. Some interviewees felt that the company procedures did not allow for early involvement of the constructor, which led to late construction input. Having experienced full-time execution personnel as part of the core front-end planning was key to have a comprehensive complete front-end definition.

Factor C2 - Optimism Bias

When probed about unrealistic estimates on mega-projects, most interviewees felt that sanctioned estimates were often unrealistic and were based on optimistic assumptions about

project conditions. Planning teams are usually under business pressure to reduce cost and schedule numbers to make mega-projects more financially feasible. There were many cases where estimates were arbitrarily cut down by higher management for business reasons, but scope was never reduced in proportion, which led to unfeasible sanctioned cost and schedule estimates on the project. Reverse cases also existed, where scope and production capacity was increased for more financial feasibility without rigorous assessment that lead to serious complications later on the project. Another aspect of unfeasible cost and schedule estimates were optimistic and aggressive bids from the main contractors. In many cases, especially on lump-sum contracts, the main contractor knowingly underbid the job to get established in the market. Project teams were never able to meet the aggressive bids agreed by sales teams. Eventually, contractors started seeking change orders that had huge negative effect on overall project progress. Optimistic assumptions, brought on by lack of front-end planning, combined with business pressure to lower costs and schedule numbers that make mega-projects appear more financially feasible are additional reasons for unrealistic estimates.

Factor C3 - Inadequate FEP Resources

All interviewees felt that effective **front-end planning** is one of the most important steps for success. Most mega-projects studied suffered from inadequate project scope definition or from inaccurate or incomplete basic technical data. Most of the mega-projects failed to completely assess the complexities attached with the mega-project. The lack of definition of basic data on the project led to serious consequences during the project, eventually leading to failure.

It was evident from case studies that mega-project planning require large investments both money and time. In some cases, inexperienced owners were not inclined to invest adequately on

the initial planning of mega-projects. The lack of in-house resources and the high cost of accruing accurate basic data lead to inappropriate definition of project process and plans eventually leading to poor performance on mega-projects.

Factor C6 - Lack of Execution Plan Alignment

Interviewees felt that execution plans often lack adequate input from all stakeholders. On mega-projects, execution plans lay the foundation for future collaboration. Planning teams often failed to include input from contractors, key subcontractors, and suppliers while framing execution plans. This arose mostly due to ineffective communication, improper implementation of alignment best practices, and inadequate updating of the execution plan. A lack of alignment on the execution plans eventually led to changes on projects eventually leading to disruptive disagreements, unaligned or conflicting team objectives, resource imbalance due to inadequate definition of project execution plan or out of sequence milestone completion.

Factor C7 - Inadequate Integrated Schedule

Interviews felt that, with mega-projects divided into multiple scopes and packages, an integrated schedule is often missing. An integrated master schedule is key for establishing a strong baseline and for effective cost and time control. On mega-projects, project teams often fail to assess impact or delay in one scope to overall project. Because individual packages are strongly interlinked, a delay in one effects all. A major cause of this was the tendency to work in silos with a lack of “birds eye view” planning. Often there is no one party responsible for integrating the whole project and interface deliverables. Are poorly defined The lack of an integrated schedule on mega-projects leads to differing objectives and delaying interfaces, lack of understanding of the project milestone requirements, resource imbalance and a lack of accountability because there is no strong baseline the project management can use to measure progress.

Factor C8 - Regulatory & Environmental Delays

Many mega-projects studied faced delays in getting required permits, which sometimes led to a complete halt in execution. Some mega-projects teams failed to understand the environmentally sensitive nature of mega-projects and the constant public attention to their development and execution. Mega-projects teams often failed to identify environmentally sensitive areas within project limits or identify all the required regulatory execution permits, which led to throwing schedules out of sequence. Another key reason cited by interviewees was that permit application are often improperly filled out, which led to application rejection. Project execution suffered as time was lost while re-applying for permits. There were also instances when changes to projects that were not communicated back to the permit agency led to the project begin halted by local regulatory bodies. These delays not only generate huge losses, in terms of loss of direct man-hours, but it is difficult to ramp down and ramp up progress after temporary halts.

Factor C9 - Baseline Schedule Acceleration

Urgency to get to the market or pressure to recover a lost schedule are two reasons for baseline schedule acceleration after approval of mega-projects studies. According to interviewees, project teams failed to realize that accelerating or compressing the schedule for a mega-project Execution Phase (Post-Approval) can cause a significant ripple effect through the existing engineering, procurement, construction, and start-up schedules. The complexities involved on the mega-projects made it extremely difficult to regain control of the overall project schedule.

6.4.4 CATEGORY D - GOVERNANCE AND STAKEHOLDERS

Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team

Interviewees from both owners and contractors stressed the need to assign skilled personnel with experience leading mega-projects. Adequate size, skills and experience of the project

management team was felt by all interviewees the key for effective planning and execution of mega-projects. Key functions on the project teams were often manned by inexperienced personnel who lacked skills specific to their roles. These mega-projects faced ineffective decision-making and the project team lacked the ability to effectively control the project. Remote locations and hot market conditions have made staffing and retaining skilled experience personnel a challenge for almost all organizations. Successful organizations are now offering higher wages and continuation bonuses to retain skilled personnel. On a successful mega-project in a remote location, the owner organization came up with a novel salary scheme to retain skilled personnel on the project. The organization was reluctant to increase the basic salary on the projects so it introduced special allowances and bonuses to increase the salaries of project personnel without increasing the basic salaries. Based on the salary structure, they were able to attract and retain skilled and experienced personnel to relocate to the project.

Factor D3 - Cultural Differences across Stakeholders

Mega-projects have an impact on a wide variety of stakeholders. In addition to the host government and active sponsors on the project, there is a growing influence on and from communities, locals, and other community groups. Most mega-project studied had owner partners, contractors, team members, or craft workers from diverse cultures and different nationalities. Stakeholders on these mega-projects had different working styles, perceptions, and expectations. These issues cause misalignment. Interviewees indicated that organizations are becoming more aware of cultural differences, not only within partners, but also across stakeholders. They are beginning to invest in strategies to manage cultural issues that arise when people having different languages, beliefs, and working styles work together. All mega-project that failed to deal with

these cultural issues faced numerous consequences that impacted all aspects of project performance, including safety.

On one mega-project studied, an international contractor faced numerous challenges due to differing tolerance to low safety standards. Local subcontractors did not have a culture of maintaining high safety standards, which led to increased safety exposure for the contractor. Delays were caused due to frequent work stoppages because of safety concerns. In contrast, on a successful mega-project the owner organizations realized the challenges of misalignment due to differing cultural views. They hired a consultant early in the project to facilitate alignment between the expats and locals working on the project team. According to the interviewee, this was a major reason for success on the project.

Factor D5 - Misalignment within Partner Organization

Many interviews felt that as more mega-projects are undertaken as joint ventures, both from owner and contractor sides, there is an increase in convoluted governance where work and responsibilities are poorly defined. Often, individual organizations work together for the first time on a mega-project. This requires effective partnering practices, with well-defined responsibility matrices for cohesive team effort. In oil and gas projects, independent oil companies increasingly form joint ventures with host country national oil companies. Aligning partners is a major challenge, due to differences in working styles, cultures, and business objectives.

Factor D6 - Business Approach Differences across Stakeholders

Mega-projects studied were often a combined effort of partners working together. Partners were often aligned on short-term goal of meeting project output goals, but differed on larger business objectives. Interviewees felt that differing business objectives was a unique differentiating factor on mega-projects complementing the survey findings. Differing business

priorities often manifested into continuous disputes on the project, leading to complete misalignment between partners. Ineffective role definition for partners in joint venture organizations was a key reason for conflicts that arose due to opposing business objectives.

6.4.5 CATEGORY E- DELIVERY STRATEGY

Factor E2 - Limited Capable Contractors

Mega-projects conducted in foreign countries must work with host governments' requirements to utilize local craft resources. This creates a challenge to obtain sufficient expert contractors/subcontractors. Most owners interviewed felt that, with unfamiliar locations and complex regulatory environments, owners require experienced, capable local contractors/subcontractors. Mega-projects have an extensive magnitude of scope of work that requires major contractors with established processes and systems. Local contractors often lacked experience with similarly sized projects. They were unable to scale up to match project scale. There are an insufficient number of qualified major contractors. In some cases, there were many competing local projects that increased the difficulty of obtaining limited capable contractors. Most mega-projects that faced such situations eventually hired under-qualified contractors, which affected project success.

Factor E4 - Unexpected materials and / or equipment delays.

Materials management was another key area stressed by interviewees, as large volumes of equipment and materials are often subject to delivery delays. Mega-projects involve complex procurement cycles. Aggressive schedules magnify sensitivity to materials delays. Some of the causes indicated by interviewees that lead to equipment delays were: unavailability of material/equipment locally, out-of-sync engineering, procurement delays, a poor execution plan, lack of procurement input in front-end planning, challenges in transportation and logistics, and

poor warehousing and storage conditions. In addition to the loss of direct man-hours and decreased productivity, delays in key large equipment led to huge inventories of associated materials that could not be executed due to delay. Successful mega-projects had experienced personnel capable of proactively adjusting project schedules to work around material or equipment delays.

Factor E5 - Underperforming Contractor or Key Subcontractor

Many interviewees emphasized the importance of clear, unambiguous contracts and collaborative effort between owners and contractors as a key requirement of success for **contracting and delivery strategy**. Mega-projects conducted in foreign countries must work with host governments' requirements to utilize local craft resources, which creates the challenge to obtain expert contractors/subcontractors. Most mega-project studied involved huge investments that required contractors to carry extreme financial risks over a long period of time. This made contractors or key sub-contractors vulnerable to financial failures on projects. Most failures occurred when a local contractor or sub-contractor failed to perform and meet expectations, due to lack of sufficient resources and experience. On some mega-projects, poor prequalification processes were a major reason for choosing an inexperienced and under-resourced contractors/fabricators. On some occasions, contractors/sub-contractors committed to multiple contracts and underperforming due to the lack of required resources to manage all the contracts at once. Interviewees felt that an underperforming contractor not only caused direct schedule delays, but also eventually led to poor quality of work that increased cost in rework or recovery of lost schedule.

6.4.6 CASE STUDIES OUTSIDE CAPITAL PROJECTS INDUSTRY

In addition to the case studies on construction mega-projects, case studies were also conducted on mega-projects in other industries outside capital projects industry to learn how

impact factors occurred, how they affected projects, and what was done to mitigate the impacts. The mega-projects studied included aerospace projects (Airbus A380 and Boeing 747) and a science project (National Ignition Facility, United States nuclear fusion project). Below are some examples of common impact factors that were also faced outside capital projects industry.

Category A - Location and Technology

Mega-projects outside capital projects industries are usually undertaken to exploit a new or unproven technologies. There are many similarities in the challenges faced by projects within and outside capital projects industry. The Airbus 380 aircraft development project used a host of new technologies on the project. The wiring system was one of the most complex ever tried in the industry. The plan was to design wiring systems of different parts of the aircraft simultaneously and then integrate the individual designs at a central location (Toulouse). However, when the team started integrating the design they ran into numerous challenges. The wiring system was too complex, and the separate parts of the design were not perfectly compatible with each other, so that the integration was not possible. Eventually, the wiring system had to be redesigned, which delayed the project for months. At one point, more than 1,100 German engineers were temporarily housed at the Toulouse production facility as they worked to rectify the problems (Callear Consulting Ltd., 2013).

Category B - Team, Organization, and Communications

Outside capital projects industry mega-projects sometimes involve more complex stakeholder interactions. Aircraft manufacturing mega-projects involve a very intricate supply chain networks. Failure to effectively integrate different suppliers and continuous monitoring led to eventual failure. The Boeing 787 Dreamliner project involved a complex supply chain network. Boeing underestimated the risks of the cultural and language differences and the physical distances

involved in the lengthy supply chain. Boeing had very limited on-site involvement with its suppliers and relied more on virtual communications. Boeing had subcontractors responsible for managing the oversight and integration between different suppliers. But the subcontracts failed to maintain effective communication across the supply chain network. This led to serious flaws in the design. Many other risks associated with this approach materialized on the project, significantly delaying the project. Boeing later had to send out hundreds of its engineers to the sites of various tier-1, tier-2, or tier-3 suppliers worldwide to solve various technical problems. These technical issues were the root cause of the delay in the 787's development. Ultimately, Boeing had to redesign the entire aircraft subassembly process that took months, further delaying the project (Denning, May/June 2013).

Category C - Planning and Execution Processes

Mega-projects within and outside capital projects industry face the challenge of unrealistic cost and schedule estimates. The two prime reasons, in both categories of projects, is the inadequate definition of assumptions while preparing estimates and the business pressure to lower costs and schedule numbers. The National Ignition Facility (NIF) project's initial estimates did not take into consideration two critical aspects: (1) the complexities associated with assembling and installing the complex and new technology and (2) the cost of building major laser components. The managers did not properly identify the full scope of the NIF effort and had greatly underestimated the project's engineering complexities. NIF managers lacked adequate project management capabilities and, in particular, had no systems engineering focus within the NIF management hierarchy (United States General Accounting Office Report to the Committee on Science, August, 2000).

The schedule for The Airbus 380 project was unrealistic and failed to factor in the level of complexity on the project. The management evidently failed to understand the criticality in the project logistics and the complexity in different software usage. The complexity of operating from different locations without a unifying Project Management Office (PMO) caused the overlooking of key critical issues. The underestimating of risks and the race to meet the aggressive schedule caused serious design flaws that resulted in later rework resulting in huge delays in the delivery of the A380 aircraft (Calleam Consulting Ltd., 2013).

Category D - Governance and Stakeholders

Like in the capital projects industry, most mega-projects in other industries are also undertaken as partnership among different major players. The project is an example of an aircraft development project undertaken by Airbus. Airbus is a consortium of existing companies having facilities scattered at sixteen sites in four European countries including France, Germany, Britain, and Spain. During the development of Airbus 380, to integrate the consortium a new administrative structure was put in place, relocating top managers from each of the sixteen sites to one location. Management succeeded in moving executives to a central location in Toulouse, but failed to move the culture off dead center. There was a lack of shared beliefs and values. The relocated managers at headquarters remained loyal to their former constituents. The company was plagued with a “convoluted management structure” that repeatedly suffered from slowed decision-making (Calleam Consulting Ltd., 2013).

CHAPTER 7 - APPLICATION AND IMPLEMENTATION

To fulfill the final objective of the research effort, an Implementation Resource (IR) was produced to help project teams better assess and prepare for the impact factors. The Implementation Resource (IR 315-2) Mega-Project Assessment of Criticality Tool (MPACT), an easy-to-use Microsoft Excel- based tool, produces a synthesis of all the research findings to produce a targeted knowledge structure around the Impact factors. The targeted knowledge structure includes impact factor descriptions, real case examples, industry findings, and recommendations. The information collected around each impact factor represents the findings from various data collection efforts done, including literature review. The MS Excel-based tool uses an interactive assessment methodology that enable teams to review several aspects of the impact factor before assessing its criticality specific to the mega-project. IR 315-2 provides the following flexible functions to the project teams using MS Excel platform:

- Assess which impact factors are relevant for their project
- Assign project-specific criticality assessments
- Incorporate project team comments
- Access real project case examples and recommendations
- Generate customized reports

MPACT is designed to complement and not to replace any existing processes of an organization. The output can supplement other project planning and execution processes (e.g., risk assessments) of an organization. MPACT is most effectively used in conjunction with other traditional scope definition tools and practices. MPACT compliments CII's Project Definition Rating Index (PDRI) tool assessment by bringing key elements of governance, team alignment, change management, and stakeholder management into the planning stage of the project. It extends

the critical impact factor assessment to the Execution Phase, which is out of the scope of PDRI. In developing this tool, the research has gone beyond the previous generic cause assessments and now provides project teams the means to:

- Raise awareness of the impact factors
- Highlight the importance of the impact factors on mega-projects
- Stimulate thinking on these mega-project impact factors and implement mitigation recommendations so as to improve their odds of mega-project success.

7.1 Benefits of IR 315-2

The Implementation Resource has been designed to be used on any scale and type of mega-project. The tool has a simple interactive user interface enabling easy usage by project teams. The following are some of the key benefits of the tool:

- The tool provides a list of 34 impact factors that are more impactful on mega-projects and need to be planned and mitigated by project teams. The impact factors are mega-project specific and enables project teams to consider key aspects early in the planning stage.
- The tool also provides a prioritization of the 34 impact factors through color-coded industry survey findings. The industry survey findings comprise occurrence and performance impact levels of each impact factor will provide project teams with an idea of how the factor had impacted other mega-projects as a reference.
- The tool presents in-depth information on impact factors, including factor descriptions and real case examples, to help project teams understand the impact factor. This enables

project teams gain a more holistic perspective toward the impact factor and helps team members accurately assess criticality of the factor on the project.

- The tool provides guidance and recommendations to mitigate the impacts of these factors. These form the starting point of detailed mitigation planning of the factors on the project.
- The tool provides customized reports that should become live project documents and be used as reference documents for risk mitigation planning. The reports highlight factors most critical on the project and will help project team members identify and focus on areas of high criticality on the specific mega-project.

7.2 Structure of IR 315-2 MPACT

MPACT was designed in a way to gain input from project teams around criticality of Impact Factors by providing necessary information and to provide output reports capturing the assessment findings for further use in detailed mega-project planning and execution processes. The IR structure (as shown in Figure 4) is divided into five categories. Each category comprises a group of Impact Factors. The project team can assess each category by reviewing the in-depth information provided for each Impact Factor to better judge the criticality of the factor on the specific mega-project. The IR model consists of three main sections:

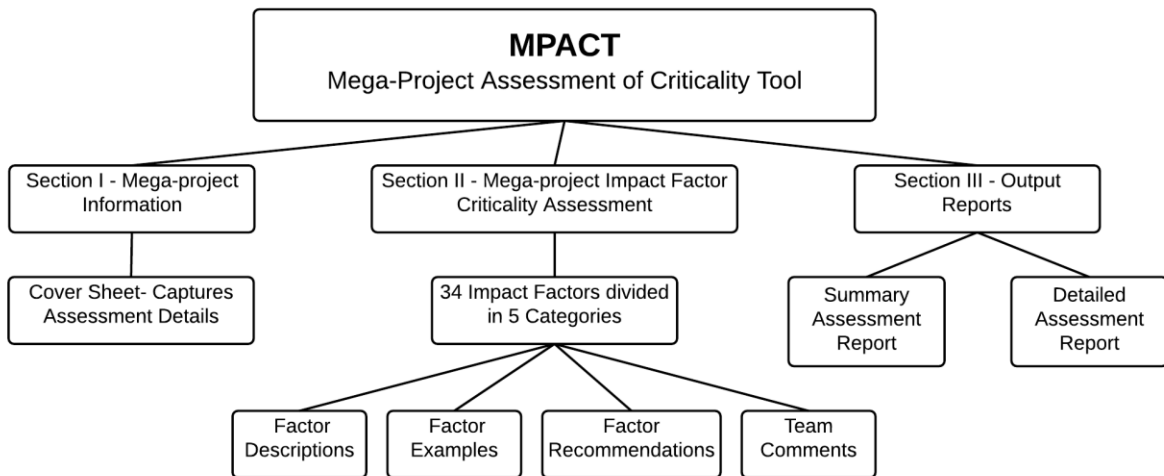


Figure 4. Structure of MPACT

7.3.1 SECTION I - MEGA-PROJECT INFORMATION

This section deals with capturing information around the mega-project and some assessment details. Figure 5 shows a screen shot of the Cover Sheet dashboard of IR 315-2

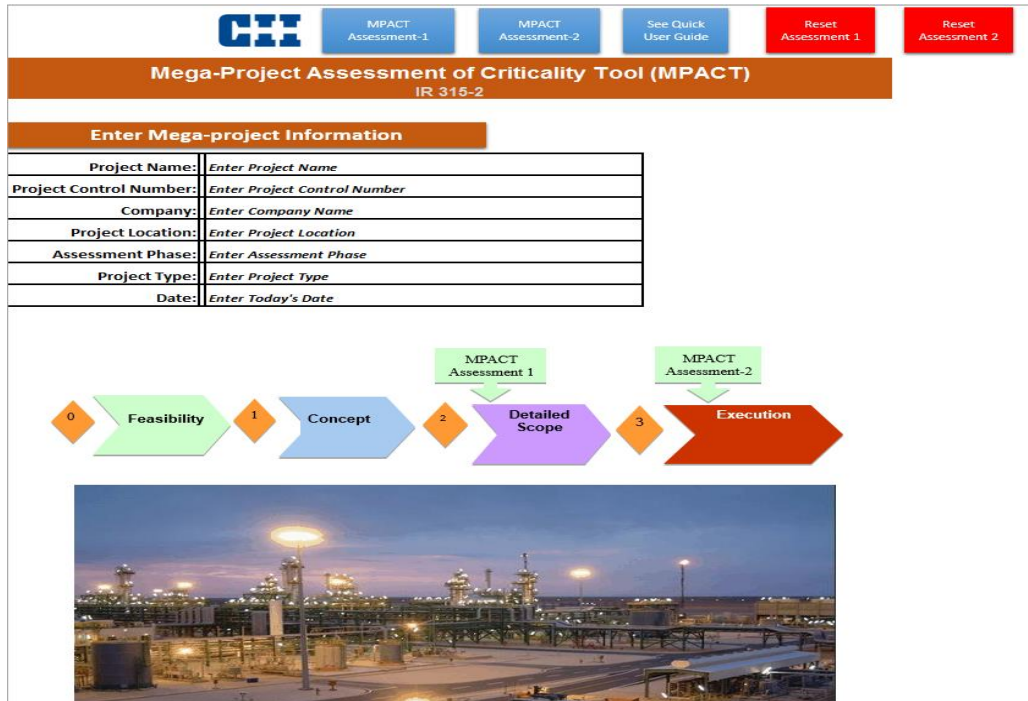


Figure 5. IR 315-2 Cover Sheet Dashboard

7.3.2 SECTION II - MEGA-PROJECT IMPACT FACTOR CRITICALITY ASSESSMENT

This section is the core of the IR model and forms the input assessment part of the IR. It contains 34 impact factors categorized in five categories. Each Impact Factor name is a short 4-to-8-word phrase that highlights the key issue for that Impact Factor. The section focuses on capturing the criticality of each Impact Factor. During assessment, the project teams can enter criticality of each factor on a 3-point scale; Low Criticality, Moderate Criticality, and High Criticality, with an option to mark Not Applicable if the Impact Factor is not related to the project. These criticality ratings are captured in output reports with other associated information. The tool also provides the ability to conduct multiple assessments within the same file. To assist in the judgment of criticality of an Impact Factor the IR provides associated in-depth knowledge, which is broken into four key components:

1. Factor Description:

Each Impact Factor has an associated factor description with an in-depth explanation of the importance, probable causes, and potential outcomes of each impact factor. Importance is listed, in bullet point format, of why the impact factor is important in context of mega-projects. Probable causes gives information on how the factor may occur and what can lead to occurrence of the factor. The potential outcomes illustrate the range of outcomes and how mega-projects can be impacted if teams fail to address the Impact Factor. The descriptions provide necessary related information to the factor to help project teams assess that factor in its entirety. The factor description for each impact factor is detailed in Appendix H.

2. Industry Findings:

The industry findings provide a measure of the occurrence and impact of the Impact factors on mega-projects; they represent the survey findings from the research. Project teams can use these results in reference to judge criticality of the Impact factors on the mega-project being assessed.

For each factor, the IR provides the following consolidated survey findings from the survey:

- **PERCENTAGE FREQUENCY OF OCCURRENCE:** This represents the percentage of total number of mega-projects surveyed that faced the factor.
- **AVERAGE IMPACT ON COST PERFORMANCE:** This represents, on a scale of 3, the average impact of the factor on the cost performance of the mega-projects surveyed that faced the factor.

- **AVERAGE IMPACT ON SCHEDULE PERFORMANCE:** This represents, on a scale of 3, the average impact of the factor on the schedule performance of the mega-projects surveyed that faced the factor.
- **AVERAGE IMPACT ON BUSINESS PERFORMANCE:** This represents, on a scale of 3, the average impact of the factor on the business performance of the mega-projects surveyed that faced the factor.

The findings were color coded to depict prioritization of the impact factors. For prioritizing the frequency of occurrence, the distribution of frequency of occurrence as measured from the survey of all the 34 impact factors was divided into three groups. The 0 to 33rd percentile distribution values are depicted in *green representing the Impact factors that have a low frequency of occurrence*. The 33rd to 66th percentile distribution values are depicted in *yellow representing moderate frequency of occurrence and distribution values above the 66th percentile are depicted in red representing high frequency of occurrence*.

For the average performance impacts, Impact factors having *minor performance impact (average impact value between 0 and 1) were coded green*. Similarly, impact factors having *moderate performance impact (average impact value between 1 and 2) were coded yellow* and Impact factors having *serious performance impact (average impact value between 1 and 2) were coded red*. Table 26 shows the survey results with color-coded prioritization.

Table 26. Survey Research Findings

Impact Factor Name	Mega-project Impact Factor Survey Findings			
	Frequency of Occurrence	Cost Impact	Schedule Impact	Business Impact
Factor A1 - New or Unproven Technology	24%	1.8	1.8	1.6
Factor A2 - Logistics Challenges	49%	1.6	1.4	1.0
Factor A3 - Jurisdictional Complexities	34%	1.6	1.6	1.2
Factor A4 - Unavailability of Qualified Craftsmen	46%	1.8	1.9	1.1
Factor B1 - Unplanned Changes in Key Personnel	59%	1.3	1.3	1.1
Factor B2 - Ineffective Stakeholder Communication	29%	1.8	1.9	1.6
Factor B3 - Multi-Location Challenges	49%	1.2	1.2	0.9
Factor B4 - Inadequate Organization Planning and Staffing	37%	1.9	2.0	1.5
Factor B5 - Ineffective Interface Management	22%	1.8	1.9	1.7
Factor B6 - Inadequate Document Management Plan	17%	2.1	2.1	1.4
Factor C1 - Lack of Execution Input to FEP	17%	2.7	2.7	2.7
Factor C2 - Optimism Bias	59%	2.3	2.1	1.6
Factor C3 - Inadequate FEP Resources	29%	2.2	2.1	1.4
Factor C4 - Inadequate Risk Assessment & Mitigation	27%	2.3	2.0	1.5
Factor C5 - Inadequate Project Controls Systems	5%	2.0	2.0	2.0
Factor C6 - Lack of Execution Plan Alignment	24%	2.0	2.2	1.4
Factor C7 - Inadequate Integrated Schedule	24%	2.3	2.3	2.3
Factor C8 - Regulatory & Environmental Delays	24%	1.7	2.0	0.9
Factor C9 - Baseline Schedule Acceleration	24%	1.7	1.9	1.0
Factor C10 - Quality Compromised for Schedule	10%	1.5	1.5	2.0
Factor C11 - Ineffective Change Management	29%	2.2	1.9	1.7
Factor C12 - Incomprehensive Risk Management	20%	1.9	1.9	1.5

Table 26. (Continued) Survey Research Findings

Impact Factor Name	Mega-project Impact Factor Survey Findings			
	Frequency of Occurrence	Cost Impact	Schedule Impact	Business Impact
Factor C13 - Unfit Documents, Procedures, and Processes	7%	1.3	1.3	0.7
Factor D1 - Unclear definition of Roles, Responsibilities and Authority	20%	2.0	1.9	1.6
Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team	46%	1.9	1.9	1.5
Factor D3 - Cultural Differences Across Stakeholders	41%	1.0	1.1	0.8
Factor D4 - Inadequate Owner Participation in Risk Management	22%	2.0	1.9	1.4
Factor D5 - Misalignment Within Partner Organization	37%	1.9	1.9	1.4
Factor D6 - Business Approach Differences Across Stakeholders	29%	1.5	1.7	1.1
Factor E1 - Inappropriate Project Delivery Contracting Strategy	22%	2.4	2.4	1.6
Factor E2 - Limited Capable Contractors	49%	1.7	1.8	1.0
Factor E3 - Unclear Scope Definition in Contracts	17%	2.4	2.0	2.0
Factor E4 - Unexpected materials and / or equipment delays.	41%	1.8	1.9	1.0
Factor E5 - Underperforming Contractor or Key Subcontractor	46%	2.1	2.1	1.6

3. Examples:

The IR provides real case examples of impact factor occurrence, impact, and mitigation of Impact factors on mega-projects to help project teams gain a better perspective on the factors. Each Impact Factor has one or more factor examples from different mega-projects gathered from both construction industry and outside construction industries. The factor examples provide a short description of how the Impact Factor occurred and impacted a particular mega-project. Examples also provide a brief discussion

on mitigation strategies, if any that were adopted by the specific mega-project. In total 135 real case examples were drafted for the 34 impact factors using the findings from the data collection effort and also from the background review. Figure 6 shows a snapshot of some factor examples as seen in the IR 315-2. For more details and all factor examples refer to IR 315-2 Mega-project Assessment of Criticality Tool.

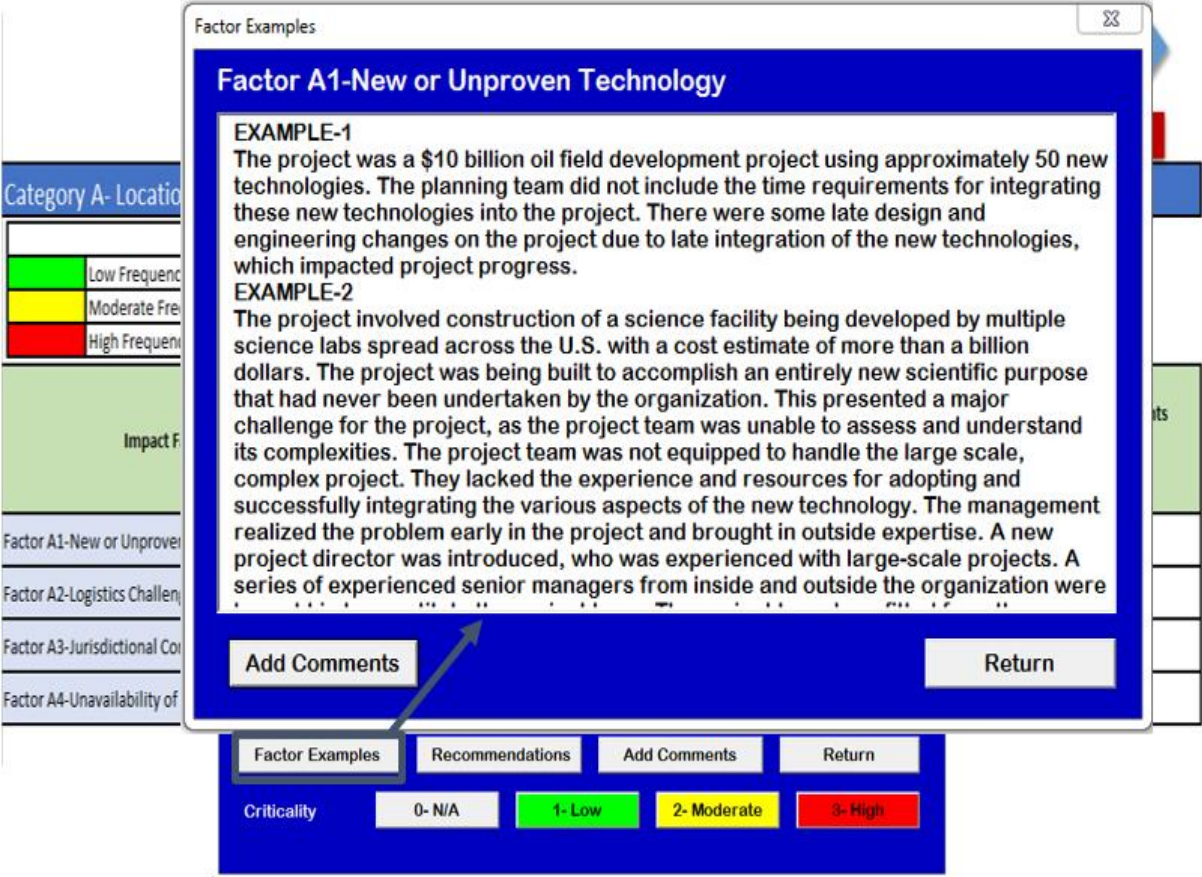


Figure 6. Factor Example Window Screenshot

4. Recommendations:

Using case study analysis and extended discussion with subject matter experts, recommendations were drafted for each Impact Factor. Recommendations summarized steps that should be taken both Front-End Planning Phase (Pre-Approval), Execution

Phase (Post-Approval), and throughout project duration to effectively plan for an impact factor. These recommendations provide a starting point of detailed mitigation planning on the Impact factors. The recommendations for each impact factor are listed in the final chapter of the report. Figure 7 shows a screenshot of some factor recommendations as seen in the IR 315-2. For more details and all factor examples refer to IR 315-2 Mega-project Assessment of Criticality Tool. The detailed recommendations are included in Chapter 8 of the report.



Figure 7. Factor Recommendations Window Screenshot

7.3.3 SECTION III - OUTPUT REPORTS

The reports are a collection of all the information around the Impact Factors, project team's comments, and the criticality, as assessed. The tool provides a summary of the assessment listing

all the impact factors with their respective criticality ratings. The tool also provides the following two more technical reports detailing assessment details:

- **Summary Technical Report:** The summary organizes the results of the assessment in order of criticality, delineating the factor descriptions, recommendations, and team comments.
- **Detailed Technical Report:** The report structure is similar to the Summary Technical Report but includes factor examples.

7.3 Application of Tool

7.2.1 TIMING OF ASSESSMENT

For effective assessment and control, IR 315-2 should be used at least twice during the front-end planning phase and execution phase. The first assessment should be done in the beginning of the front-end planning detailed scope phase. The second assessment should be conducted in the beginning of the execution phase. IR 315-2 complements the Project Definition Rating Index (PDRI) during the Front-End Planning Phase by addressing scope issues that are critical to mega-projects. In addition, it extends the critical impact factor assessment to the Execution Phase, which is out of the scope of PDRI. The assessment should include all stakeholders. Assessment-2 should be done when all the key contractors, suppliers and subcontractors have been involved on the project. Figure 8 illustrates the timing of the assessments.

However, on many mega-projects where the time frame from Assessment 1 (beginning of the front-end planning detailed scope phase) and Assessment 2 (beginning of the execution phase) is more than one year we recommend doing the assessment either every 6-to-9 months. It is important that project teams do regular assessments to account for changing project conditions.

This helps project teams keep constant control over the critical impact factors. Also if a significant change occurs on the project, then another assessment should be done to ascertain critical impact factors post change on the project.

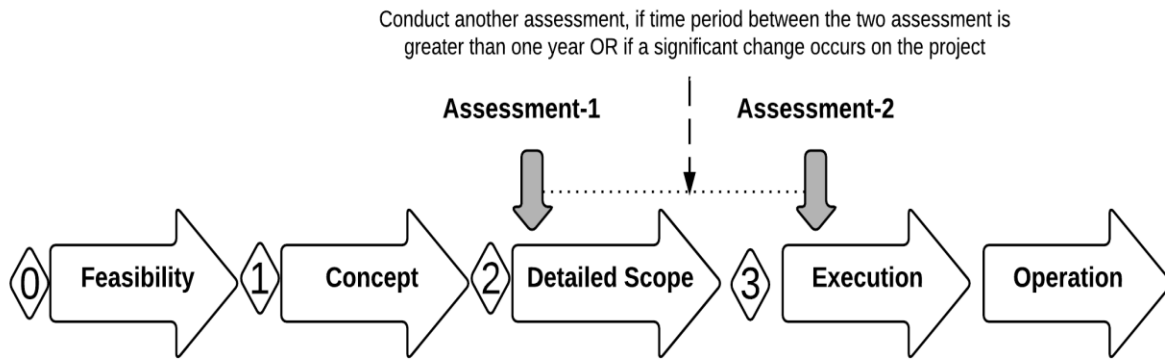


Figure 8. Timing of Assessment

7.2.2 SUGGESTED PROCESS OF USE

The impact factor assessment should be done using a two-phase facilitated assessment. The following is the recommended **assessment methodology for using the CII IR 315-2 MPACT** to enable project teams assess the criticality of the impact factors identified in the research:

Assessment 1 - Start of Front-End Planning Detailed Scope Phase

Step 1: The owner organization should appoint an experienced facilitator.

Step 2: Identify a list of key project team members involved in the planning and execution of the project.

Step 3: The facilitator should arrange and complete one-on-one sessions with key project team members identified in Step 2.

- Sessions should have the facilitator review each of the impact factors with the stakeholder.

- Each stakeholder should provide a criticality rating for each impact factor complete with notes.
- It is expected that each session will take 1 to 2 hours.

Step 4: The facilitator should consolidate the criticality ratings and notes into one overall file.

Step 5: The facilitator arranges for all the stakeholders to meet together and do a group assessment.

- The purpose of the meeting is to discuss the consolidated criticality ratings and notes.
- Consensus needs to be reached among the stakeholders for the overall group criticality rating for each Impact Factor.
- It is expected that this meeting will take at least half a day or more depending on the size and complexity of the project.
- If Step 3 is skipped, the meeting in Step 5 should be split into half day meetings over two or three days.

Assessment #2 - Start of Execution Phase

Step 6: Ideally, the same facilitator will be used for this phase.

Step 7: Review the list of key stakeholders and add or modify the list as required.

Step 8: Repeat Steps 3 to 5 above.

CHAPTER 8- CONCLUSION AND RECOMMENDATIONS

The main contributions of the research include:

- **Identified 34 impact factors**, grouped in five categories that have higher occurrence and performance impacts on mega-projects.
- **Prioritized the factors**, using the findings from the industry survey conducted on 76 large and mega-projects
- **Developed a methodology to assess the criticality of these impact factors** designed to assist project teams to assess factors that may be critical to their project and to provide a library of lessons learned from completed mega-projects

Included in the assessment methodology are recommendations that project teams should adopt to manage or mitigate the impact of each of the factors during the front-end planning and execution phases of the mega-project. Below are some key mitigation steps for the five impact factor categories. The factor-specific recommendations around the 34 impact factors are enclosed as Appendix I:

8.1 CATEGORY A - LOCATION AND TECHNOLOGY

1. When using a new or unproven technology, conduct a **pilot test and plan for scale-up requirements** and limitations. Project teams need to allocate sufficient time and resources to plan and execute the integration of new or unproven technologies.
2. Managing formal and informal local constraints and requirements is a key planning aspect for mega-projects. It is recommended that a **location assessment team** be formed early to analyze the project location's taxes, laws, and import/export requirements. Organizations should plan to work with local associates to verify jurisdictional challenges and begin communications with local government agencies and other external stakeholders. These

should be done early so that the input can be taken into consideration during the planning and execution project phases.

3. The project team should **thoroughly assess transportation and logistics challenges, as well as craft quality and availability at project location. These aspects should be factored into project plans and estimates.** Planners should consider resource availability and associated cost and schedule implications before defining the baselines. **Adequate contingency should be incorporated in the plan to manage logistics — and alternate plans should be prepared to deal with eventual shortages of skilled labor.**
4. **Training programs** involving local resources should start early. Training cost should be included in initial budgets.

8.2 CATEGORY B - TEAM, ORGANIZATION AND COMMUNICATION

1. Complex and diverse mega-project teams are often overwhelmed by ineffective communications. It is recommended that **early and continuous alignment activities be adopted to reduce communication gaps and to ensure communication flows.**
2. It is important to **build trust and transparency between project team members and stakeholders. These should include all levels of the involved organizations. Frequent, and effective steering team meetings** for key management personnel and stakeholders can help with this goal.
3. **Experienced individuals should manage the key interfaces. An effective interface management plan, with all key interfaces identified and integrated into the project execution plan,** should be implemented.
4. With globally dispersed teams, it is recommended to **prepare and implement terminology usage guidelines and standardized procedures** across multiple project team locations.

5. Mega-project organizations should **consider measures to address attrition of personnel**, which is typical for long duration mega-projects. **Mentoring programs** should be established to help train future project leaders.

8.3 CATEGORY C - PLANNING AND EXECUTION PROCESSES

1. Many mega-projects suffer poor performance due to ineffective front-end planning. Incomplete definitions of basic technical data, business focused planning, lack of execution input, and overly optimistic assumptions can be mitigated with **thorough and complete front-end planning**.
2. The front-end planning process should include **auditable procedures to ensure early engagement of key business and project personnel, as well as accuracy of cost and schedule baselines**. To prevent an optimistic attitude bias on mega-projects, organizations need **experienced personnel leading project planning and execution, with estimates benchmarked against industry standards and best practices**.

8.4 CATEGORY D - GOVERNANCE AND STAKEHOLDERS

1. Mega-project organizations are typically large and complex, with multiple parties coming together. Organizations should continuously **conduct team-building sessions during front-end planning**. These meetings should **include all levels of the team and be facilitated**.
2. A well-defined **responsibility matrix should contain detailed roles, responsibilities, and authorities for each role** and should be prepared with **agreement of the entire team**. Owners, as well as contractors, should understand the skill levels needed to effectively perform each role and budget appropriately.

3. To prevent misalignment on business objectives, organizations should **define partner roles at the time of joint venture formation** and follow the lead partner philosophies in their respective roles.
4. To manage the cultural differences, project teams should understand the political landscape and **try and meet with key players in advance of the project**. It is important to **engage non-governmental organizations** during the front-end planning process in order to gain their support and understanding.

8.5 CATEGORY E - DELIVERY STRATEGY

1. Mega-project success requires owners and contractors to work together. **Contracts should include well-defined scopes, with clearly stated expectations and roles, well-established baselines, and clear interfaces to avoid scope overlap.**
2. When selecting contractors, organizations should have **strong pre-qualification processes in place to evaluate the capability of the contractor, sub-contractor, and/or supplier before making the award.**
3. Organizations executing mega-projects should assist inexperienced local contractors where necessary (e.g., execution planning, advance work packaging, creation of safety and quality plans, staffing, commissioning).

APPENDICES

Appendix A: Team Roster

Current Members

Carlos Caldas, UT-Austin
Ubaldo T. Ciminieri, Technip
Robin Duszynski, Wood Group Mustang
Ashish Gupta, UT-Austin
Steven Heise, eProject Management
Terence Henn, American Transmission
Mark Howard, Emerson process Management
Howard Irwin, FHR – Koch Industries
Jeff Knight, ConocoPhillips
David Luchtefeld, Black & Veatch
Samara Merrighi, Vale
Steve Owen, Southern Company
Dean Poillucci, Skanska (*Co-Vice Chair*)
Mike Pratt, Bechtel
Ronnie Stephens, The Williams Companies (*Chair*)
David Taylor, Emerson Process Management (*Co-Vice Chair*)
Mauricio Villegas, IHI E&C International Co.
John White, Department of Energy
Ward Witherspoon, ConocoPhillips

Past Members

Larry Doskoch, Teck Resources
Stephanie Gordon, Ontario Power Generation
Robin Mikaelsson, Bentley Systems
David Miller, Kvaerner
Brad Warn, Black & Veatch

Appendix B: Preliminary Interview Guide

CII RT 315 Successful Delivery of Mega-projects

Preliminary Interviews – Plan

An Introduction to CII (Construction Industry Institute)

The Construction Industry Institute, based at The University of Texas at Austin, is a consortium of more than 100 leading owner, engineering-contractor, and supplier firms from both the public and private arenas. These organizations have joined together to enhance the business effectiveness and sustainability of the capital facility life cycle through CII research, related initiatives, and industry alliances. A learning organization with a wealth of knowledge and information, CII is unique in the engineering and construction industry.

Overview of the RT 315 Research Project

Mega-projects are very important not only to the capital projects industry stakeholders involved in their delivery, but also to the societies, economies, and environments impacted by them. There are many mega-projects currently being executed around the world, and there are many more being planned. The successful delivery of these mega-projects represents both a challenge and an opportunity.

Despite their importance, recent studies conducted by Independent Project Analysis (IPA) based on the analysis of more than 300 mega-projects concluded that 65 percent of the mega-projects haven't achieved their performance objectives established at sanction. The performance was even worse in the oil and gas sector, where 78 percent of the mega-projects failed. Mega-projects are complex and problematic. They tend to be frail by sheer size, with failures tending to be dramatic. These observations suggest that, while mega-projects may be more sensitive to practices used than other projects, their very size and complexity makes their deployment of best practices more difficult and less successful. The Construction Owners Association of Alberta (COAA) and many others have also studied this issue and come to similar conclusions.

There are very few studies that provide guidance on the effective planning and execution of mega-projects. It is important to verify if some Construction Industry Institute (CII) practices are more difficult to implement on mega-projects, or if there are certain practices in need of modification to suit mega-projects. Conversely, it is important to identify other practices that may be critical to the success of mega-projects. Other research has suggested that mega-projects produce a culture of optimism. If this is the case, it is important to investigate how unrealistic expectations with regard to capital costs, execution schedule, project benefits, and impacts can be avoided. In this regard, previous studies highlighted the importance of the project shaping phase and the alignment between the business planning team and the project management team.

For all the reasons mentioned above, there is a clear need to identify what sorts of changes in project development and execution are needed to ensure that mega-projects are successful. This research project will address this need. In the context of capital projects, the specific research objectives are:

Describe the current-state-of-the-art on the delivery of mega-projects. This includes the identification of existing practices and tools developed by CII, COAA, IPA, and others to plan and execute projects and the verification of their applicability, scalability, and adaptability to mega-projects.

Prioritize the primary contributing factors of good and bad performance that impact the delivery of mega-projects.

Identify changes in shaping, planning, or execution practices to address the primary contributing factors and improve performance.

Develop tools to support proactive mega-project planning and execution.

For the purpose of this project, the research team has defined mega-projects as projects with total installed cost of more than \$1 billion dollars, having one or more of the following complexity criteria:

- Significant number of stakeholders.
- Large number of interfaces.
- Challenging project location.
- Inadequate supply of resources.
- Unfamiliar technology.
- Difficult regulatory constraints.
- Extensive infrastructure requirements.
- Geographically dispersed team.
- Political, economic, environmental, and social influence.
- Mega-projects from different locations will be considered. While the findings may be applicable to all sectors, the focus will be on industrial projects.

Preliminary Interviews

Methodology: 1-hour phone interviews.

Purpose: Understand and prioritize the contributing factors of mega-projects' good and poor performance and to define the focus of the subsequent research tasks. These interviews will be conducted during the first three months of the research project. After these initial interviews, the research team will detail the data collection and analysis plan.

Target: Experts involved in the delivery of mega-projects will be the targets for these interviews. In other words, individuals that are better positioned to answer the questions below. Potential interviewees will be identified from joint venture partners, owners, contractors, engineering consultants, and supplier organizations. These may include the following: project managers, business managers, operations managers, construction litigation lawyers, and project planning consultants, among others.

Confidentiality Statement: To protect the confidentiality of the interviewees, the interviews will be conducted by an academic representative on the team. Also all the information gathered as part of this project will be treated in strictest confidence and kept under conditions of security at The

University of Texas at Austin. Specific individuals, jobs, and organizations will **not** be named in the project report in any way.

Benefits for Interviewee: The CII RT-315 team highly appreciates the time given by individuals for the interview. The interview will help the team carry forward the research. As a token of appreciation all the interviewees will receive the final **research report** at the end of the research.

Questions:

Describe the mega-project and its objectives. Comment on its organization/contracting.

Do you think the project was successful? Why?

Please comment on the project performance (e.g., cost, time, changes, safety, quality, final product, business). Explain.

What is your opinion on the original cost estimate, schedule, and benefits? Explain.

What was different in this project that contributed to its success or failure?

Tell me about your success stories.

What were the main challenges in this project? What was done to mitigate them? Please explain.

What would you have done differently?

What makes a mega-project usually less successful than a regular project?

Appendix C: Survey Guide and Forms

CII RT 315 Successful Delivery of Mega-projects

Data Collection Plan – Phase 2- Mega-projects

An Introduction to the Construction Industry Institute (CII)

The Construction Industry Institute, based at The University of Texas at Austin, is a consortium of more than 100 leading owner, engineering-contractor, and supplier firms from both the public and private arenas across global industry. These organizations have joined together to enhance the business effectiveness and sustainability of the capital facility life cycle through CII research, related initiatives, and industry alliances. A learning organization with a wealth of knowledge and information, CII is unique in the engineering and construction industry.

Overview of the CII RT 315 Research Project

Mega-projects are very important not only to the capital projects industry stakeholders involved in their delivery, but also to the societies, economies, and environments impacted by them. There are many mega-projects currently being executed around the world, and there are many more being planned. The successful delivery of these mega-projects represents both a challenge and an opportunity.

Despite their importance, recent studies conducted by Independent Project Analysis (IPA) based on the analysis of more than 300 mega-projects concluded that 65 percent of the mega-projects haven't achieved their performance objectives established at sanction. The performance was even worse in the oil and gas sector, where 78 percent of the mega-projects failed. Mega-projects are complex and problematic. They tend to be fragile by sheer size, with failures tending to be dramatic. These observations suggest that, while mega-projects may be more sensitive to practices used than other projects, their very size and complexity makes their deployment of best practices more difficult and less successful. The Construction Owners Association of Alberta (COAA) and many others have also studied this factor and come to similar conclusions.

There are very few studies that provide guidance on the effective planning and execution of mega-projects. It is important to verify if some CII practices are more difficult to implement on mega-projects, or if there are certain practices in need of modification to suit mega-projects. Conversely, it is important to identify other practices that may be critical to the success of mega-projects. Other research has suggested that mega-projects produce a culture of optimism. If this is the case, it is important to investigate how unrealistic expectations with regard to capital costs, execution schedule, project benefits, and impacts can be avoided. In this regard, previous studies highlighted the importance of the project shaping phase and the alignment between the business planning team and the project management team.

For all the reasons mentioned above, there is a clear need to identify what sorts of changes in project development and execution are needed to increase the probability of having successful mega-projects. Mega-projects from different geographic and geopolitical locations will be considered. While the findings may be applicable to all sectors, the focus will be on industrial projects.

Data Collection Methodology

Format: Survey and follow up interviews. The survey can be completed online via the link sent to you by email. It will take approximately 30 to 40 minutes to complete. The online version has the option to save, stop, and start the survey from the last page completed. You can close the browser and return to the last answered page using the same survey link you have received. A paper version is also enclosed for your reference while completing the online survey. We appreciate if you want to fill the survey for more than one project, once you have completed the survey from one project and the response has been recorded you can use the same link to fill out the survey for another project.

Purpose: This data collection phase consists of an assessment of 34 factors. These factors were identified in the previous phases of this research. The primary purpose is to gather data on the frequency, importance, and impact that these factors have, or have had, on your project. The same factors will be presented to participants from ‘**mega-projects**’ and ‘**large projects**’ to assess the differences in importance and impacts of these factors on the two categories.

Target: Experts involved in the delivery of projects will be the target for the surveys and follow up interviews. In other words, individuals that are better positioned to answer the questions in the enclosed data collection instrument.

Confidentiality Statement: In regard with protecting the confidentiality of the research data, the data will be accessible only to the academic representatives on the team. Also all the information gathered as part of this project will be treated in strictest confidence and kept under conditions of security at The University of Texas at Austin. Specific individuals, projects, and organizations will **not** be named in the research reports.

Benefits for Participants: The CII RT-315 team highly appreciates the time given by individuals for the data collection effort. The data will help the team carry forward the research and contribute to the development of the capital projects industry. As a token of appreciation all the participants will receive the final **research report** at the end of the research project.

Data Collection Instrument

PART 1 - GENERAL INFORMATION

Your Name: _____

Your Company Name (Optional): _____

Your Company Type:

- | | |
|-------------------------------------|--|
| <input type="checkbox"/> Owner | <input type="checkbox"/> Consultant |
| <input type="checkbox"/> Contractor | <input type="checkbox"/> Subcontractor |
| <input type="checkbox"/> Supplier | <input type="checkbox"/> Other |

Your Position: _____

Your years of Experience in Industry: _____

Your Role on the Project: _____

Project Name (Optional): _____

Project Owner Company Name (Optional): _____

What is the Project Type?

- | | |
|---|--|
| <input type="checkbox"/> Oil Exploration and Production | <input type="checkbox"/> Infrastructure |
| <input type="checkbox"/> Oil Refining | <input type="checkbox"/> Commercial Building |
| <input type="checkbox"/> Mining | <input type="checkbox"/> Pharma/Bio Manufacturing |
| <input type="checkbox"/> Metallurgical Refining | <input type="checkbox"/> Heavy Industrial/Other
Manufacturing |
| <input type="checkbox"/> Power Generation | <input type="checkbox"/> Other |
| <input type="checkbox"/> Chemical Manufacturing | |
| <input type="checkbox"/> Natural Gas Processing | |

What is the Project Location?

- | | |
|--|--|
| <input type="checkbox"/> Asia | <input type="checkbox"/> Africa |
| <input type="checkbox"/> North America | <input type="checkbox"/> Other Location (Mention Below-
Optional) |
| <input type="checkbox"/> South America | _____ |
| <input type="checkbox"/> Oceania (Including Australia) | |
| <input type="checkbox"/> Europe | |

What was the Overall Project Budget Approved at Sanction? (Including contingency)

- | | |
|--|---------------------------------------|
| <input type="checkbox"/> \$1B-\$2.5B | <input type="checkbox"/> \$7.5B-\$10B |
| <input type="checkbox"/> \$2.5B – \$5B | <input type="checkbox"/> ABOVE \$10B |
| <input type="checkbox"/> \$5B-\$7.5B | |

What is / was the Cost Growth on the project?

Cost Growth = $\frac{\text{Final Project Cost} - \text{Project Budget Approved at Sanction}}{\text{Project Budget Approved at Sanction}} \times 100$

- | | |
|---|---|
| <input type="checkbox"/> Within Budget (<=0%) | <input type="checkbox"/> 25-50 % |
| <input type="checkbox"/> 1-10 % | <input type="checkbox"/> Above 50 % |
| <input type="checkbox"/> 10-25 % | <input type="checkbox"/> Project is Ongoing |

What is / was the Overall Project Duration at Sanction?

- Less than 1 year
- 1-2 years
- 2-3 years
- 3-5 years
- 5-7 years
- Greater than 7 years

What is / was the Schedule Delay on the project?

Schedule Delay = Final Project Duration –Project Duration at Sanction

- Within schedule
- 0-3 months
- 3-6 months
- 6-12 months
- 12-24 months
- 24-36 months
- Above 36 months
- Project is ongoing

Is / was the safety performance satisfactory as per company standards?

- Yes
- No

What was the Total Recordable Incidents Reported (TRIR) on the project? (Optional)

What was the DART (“Days Away, Restricted, and Transferred”) on the project? (Optional)

Is / was the final facility Production/Business performance as per planned performance targets?

- 50% to -25%
- 25% to Met plan
- Met plan to +25%
- +25% to +50%
- Project is ongoing

What is / was the predominant project delivery strategy?

- Design-Bid-Build
- Design-Build (or EPC)
- Multiple Design-Build
- Construction Manager–at-Risk
- Fast Track
- Turnkey

What is / was the predominant contracting strategy?

- Lump sum
- Cost Reimbursable
- Target price
- Unit Rates
- Guaranteed Maximum Price

What was the Number of Prime Contractors?

What was the actual Percentage Engineering Complete at the Start of Site Infrastructure Construction?

- Less than 10%
- 10-25%
- 25-50%
- 50%-75%
- Above 75%

What was the actual Percentage of Engineering Complete at the Start of Plant Facility Construction?

- | | |
|--|------------------------------------|
| <input type="checkbox"/> Less than 10% | <input type="checkbox"/> 50%-75% |
| <input type="checkbox"/> 10-25% | <input type="checkbox"/> Above 75% |
| <input type="checkbox"/> 25-50% | |

PART 2- FACTORS

CATEGORY A – Location and Technology

Factor A1 - The project is / was using a new or unproven technology.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- Cost performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Schedule performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Production/Business performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact

Factor A2 - The project is / was remotely located presenting challenges of transporting materials and human resources to site.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor A3 - The project has / had jurisdictional complexities (permitting, environmental and regulatory).

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor A4 - The project has / had an unavailability of quality skilled trades.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact

- Moderate impact
 Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

CATEGORY A (WRAP-UP) - What changes in project planning and/or execution were/are being implemented to address the factors listed in this category to ensure the success of the project?

CATEGORY B-PROJECT ORGANIZATION, RESOURCING, AND COMMUNICATION

Factor B1 - The project is having / had unplanned changes in key project personnel.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B2 - The project has / had ineffective management and communication across the project team and stakeholders.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B3 - The project has / had communication challenges (location, time zone, language) due to multiple engineering, construction, pre-assembly, and/or construction locations.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B4 - The project has/had inadequate organizational planning and staffing.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B5 - The project has / had ineffective interface management.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B6 - The project does not / did not have an established robust universal document management plan.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

CATEGORY B (WRAP-UP) - What changes in project planning and/or execution were /are being implemented to address the factors listed in this category to ensure the success of the project?

CATEGORY C- PLANNING AND EXECUTION PROCESSES

Factor C1 - The FEP team is / was too “business focused” and does / did not receive sufficient input from the execution team leading to inadequate definition of project requirements.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C2 - The project team is / was overly optimistic leading to unrealistic cost and schedule at project sanction.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor C3 - The owner does not / did not fully understand the benefits of adequate investment of funds and resources to support front-end planning.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor C4 - The project lacks / lacked a comprehensive and rigorous risk assessment and mitigation planning.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C5 - The project has / had an inadequate project controls system.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C6 - The project stakeholders lack / lacked agreement on the project execution plan.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C7 - The project lacks / lacked an integrated schedule covering the entire scope from FEP through initial operations.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C8 - The project execution is being / was impacted due to delay in obtaining regulatory and environmental approvals.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C9 - The project baseline schedule is being / was modified post sanction to fast track the project.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C10 - The project execution team sacrificed / is sacrificing quality to meet aggressive schedule.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C11 - The project is failing / failed to provide a framework and resources to effectively manage change.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C12 - The project has / had a lack of comprehensive risk management.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C13 - The project documents, procedures, and processes are / were not fit-for-purpose.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

CATEGORY C (WRAP-UP) - What changes in project planning and/or execution were/are being implemented to address the factors listed in this category to ensure the success of the project?

CATEGORY D- GOVERNANCE AND STAKEHOLDERS

Factor D1 - The project has / had a lack of clear definition of roles, responsibilities and authority for all owner and project personnel.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D2 - The project has / had a lack of personnel and / or skills and experience in the project management team (both owner and contractor team).

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D3 - The project stakeholders have / had cultural differences.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D4 - The project owner is failing / failed to communicate the identified risks and work on cooperative mitigation plans with all stakeholders.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D5 - The project owner JV and / or contractor JV organization is lacking / lacked focus or alignment.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D6 - The project stakeholders have / had differences in business approach.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

CATEGORY D (WRAP-UP) - What changes in project planning and/or execution were/are being implemented to address the factors listed in this category to ensure the success of the project?

CATEGORY E - DELIVERY STRATEGY

Factor E1 - The project requirements are / were not aligned with the project delivery and contracting strategies.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E2 - There are / were limited number of capable major contractors to execute this type of project.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E3 - The project scope is / was ambiguous with inadequately defined contracts.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E4 - The project has / had unexpected materials and / or equipment delays.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E5 - The project contractor or key subcontractor is failing / failed to meet expectations during execution.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- Cost performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Schedule performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Production/Business performance of the project?

<input type="checkbox"/> No impact	
<input type="checkbox"/> Minor impact	
<input type="checkbox"/> Moderate impact	
<input type="checkbox"/> Serious impact	

CATEGORY E (WRAP-UP) - What changes in project planning and/or execution were/are being implemented to address the factors listed in this category to ensure the success of the project?

PART 3 - OTHER FACTORS

Were/Are there any other significant factors that the project faced not mentioned Part 2 of the survey? If so, please list them and describe the changes in project planning and/or execution that were/are being implemented to address these factors to ensure the success of the project

PART 4 - FACTOR RANKING

Please enter the factor name or code name in the space provided in front of the rank under each category.

For Example: If in your opinion *Factor A3-“Contracting strategy is not aligned with the project requirements”* is a factor which has the highest contribution in impacting the cost of the project enter *A3* or the factor name (*Contracting strategy is not aligned with the project requirements*) in the space provided in front of Rank 1 under cost impact. Similarly for factors that have a schedule impact and production impact.

Rank the Top 5 factors that impacted/are impacting the COST performance of the project

RANK 1

RANK 2

RANK 3

RANK 4

RANK 5

Rank the Top 5 factors that impacted/are impacting the project SCHEDULE performance of the project

RANK 1

RANK 2

RANK-3

RANK4

RANK 5

Rank the Top 5 factors that impacted/are impacting the PRODUCTION / BUSINESS performance of the project

RANK 1-

RANK 2

RANK 3

RANK 4

RANK 5

Thank You for taking out time to complete the survey.

If needed, can we contact you for any clarifications based on your response to the survey questions?

YES

NO

If yes, please provide a phone number for us to contact you. Thank You.

Phone Number: _____

CII RT 315 Successful Delivery of Mega-projects

Data Collection Plan – Phase 2- Large-projects

An Introduction to the Construction Industry Institute (CII)

The Construction Industry Institute, based at The University of Texas at Austin, is a consortium of more than 100 leading owner, engineering-contractor, and supplier firms from both the public and private arenas across global industry. These organizations have joined together to enhance the business effectiveness and sustainability of the capital facility life cycle through CII research, related initiatives, and industry alliances. A learning organization with a wealth of knowledge and information, CII is unique in the engineering and construction industry.

Overview of the CII RT 315 Research Project

Mega-projects are very important not only to the capital projects industry stakeholders involved in their delivery, but also to the societies, economies, and environments impacted by them. There are many mega-projects currently being executed around the world, and there are many more being planned. The successful delivery of these mega-projects represents both a challenge and an opportunity.

Despite their importance, recent studies conducted by Independent Project Analysis (IPA) based on the analysis of more than 300 mega-projects concluded that 65 percent of the mega-projects haven't achieved their performance objectives established at sanction. The performance was even worse in the oil and gas sector, where 78 percent of the mega-projects failed. Mega-projects are complex and problematic. They tend to be fragile by sheer size, with failures tending to be dramatic. These observations suggest that, while mega-projects may be more sensitive to practices used than other projects, their very size and complexity makes their deployment of best practices more difficult and less successful. The Construction Owners Association of Alberta (COAA) and many others have also studied this factor and come to similar conclusions.

There are very few studies that provide guidance on the effective planning and execution of mega-projects. It is important to verify if some CII practices are more difficult to implement on mega-projects, or if there are certain practices in need of modification to suit mega-projects. Conversely, it is important to identify other practices that may be critical to the success of mega-projects. Other research has suggested that mega-projects produce a culture of optimism. If this is the case, it is important to investigate how unrealistic expectations with regard to capital costs, execution schedule, project benefits, and impacts can be avoided. In this regard, previous studies highlighted the importance of the project shaping phase and the alignment between the business planning team and the project management team.

For all the reasons mentioned above, there is a clear need to identify what sorts of changes in project development and execution are needed to increase the probability of having successful mega-projects. Mega-projects from different geographic and geopolitical locations will be considered. While the findings may be applicable to all sectors, the focus will be on industrial projects.

Data Collection Methodology

Format: Survey and follow up interviews. The survey can be completed online via the link sent to you by email. It will take approximately 15 to 20 minutes to complete. The online version has the option to save, stop, and start the survey from the last page completed. You can close the browser and return to the last answered page using the same survey link you have received. A paper version is also enclosed for your reference while completing the online survey. We appreciate if you want to fill the survey for more than one project, once you have completed the survey from one project and the response has been recorded you can use the same link to fill out the survey for another project.

Purpose: This data collection phase consists of an assessment of 34 factors. These factors were identified in the previous phases of this research. The primary purpose is to gather data on the frequency, importance, and impact that these factors have, or have had, on your project. The same factors will be presented to participants from ‘*mega-projects*’ and ‘*non mega-projects*’ to assess the differences in importance and impacts of these factors on the two categories.

Target: Experts involved in the delivery of projects will be the target for the surveys and follow up interviews. In other words, individuals that are better positioned to answer the questions in the enclosed data collection instrument.

Confidentiality Statement: In regard with protecting the confidentiality of the research data, the data will be accessible only to the academic representatives on the team. Also all the information gathered as part of this project will be treated in strictest confidence and kept under conditions of security at The University of Texas at Austin. Specific individuals, projects, and organizations will **not** be named in the research reports.

Benefits for Participants: The CII RT-315 team highly appreciates the time given by individuals for the data collection effort. The data will help the team carry forward the research and contribute to the development of the capital projects industry. As a token of appreciation all the participants will receive the final **research report** at the end of the research project.

Data Collection Instrument: Large Projects

PART 1- GENERAL INFORMATION

Your Name: _____

Your Company Name (Optional): _____

Your Company Type:

- | | |
|-------------------------------------|--|
| <input type="checkbox"/> Owner | <input type="checkbox"/> Consultant |
| <input type="checkbox"/> Contractor | <input type="checkbox"/> Subcontractor |
| <input type="checkbox"/> Supplier | <input type="checkbox"/> Other |

Your Position: _____

Your years of Experience in Industry: _____

Your Role on the Project: _____

Project Name (Optional): _____

Project Owner Company Name (Optional): _____

What is the Project Type?

- | | |
|---|---|
| <input type="checkbox"/> Oil Exploration and Production | <input type="checkbox"/> Infrastructure |
| <input type="checkbox"/> Oil Refining | <input type="checkbox"/> Commercial Building |
| <input type="checkbox"/> Mining | <input type="checkbox"/> Pharma/Bio Manufacturing |
| <input type="checkbox"/> Metallurgical Refining | <input type="checkbox"/> Heavy Industrial/Other Manufacturing |
| <input type="checkbox"/> Power Generation | <input type="checkbox"/> Other |
| <input type="checkbox"/> Chemical Manufacturing | |
| <input type="checkbox"/> Natural Gas Processing | |

What is the Project Location?

- | | |
|--|--|
| <input type="checkbox"/> Asia | <input type="checkbox"/> Africa |
| <input type="checkbox"/> North America | <input type="checkbox"/> Other Location (Mention Below-Optional) |
| <input type="checkbox"/> South America | _____ |
| <input type="checkbox"/> Oceania (Including Australia) | |
| <input type="checkbox"/> Europe | |

What was the Overall Project Budget Approved at Sanction? (Including contingency)

- | | |
|--|---------------------------------------|
| <input type="checkbox"/> \$1B-\$2.5B | <input type="checkbox"/> \$7.5B-\$10B |
| <input type="checkbox"/> \$2.5B – \$5B | <input type="checkbox"/> ABOVE \$10B |
| <input type="checkbox"/> \$5B-\$7.5B | |

What is / was the Cost Growth on the project?

$$\text{Cost Growth} = \frac{(\text{Final Project Cost} - \text{Project Budget Approved at Sanction}) \times 100}{\text{Project Budget Approved at Sanction}}$$

- | | |
|---|---|
| <input type="checkbox"/> Within Budget (<=0%) | <input type="checkbox"/> 25-50 % |
| <input type="checkbox"/> 1-10 % | <input type="checkbox"/> Above 50 % |
| <input type="checkbox"/> 10-25 % | <input type="checkbox"/> Project is Ongoing |

What is / was the Overall Project Duration at Sanction?

- Less than 1 year
- 1-2 years
- 2-3 years
- 3-5 years
- 5-7 years
- Greater than 7 years

What is / was the Schedule Delay on the project?

Schedule Delay = Final Project Duration –Project Duration at Sanction

- Within schedule
- 0-3 months
- 3-6 months
- 6-12 months
- 12-24 months
- 24-36 months
- Above 36 months
- Project is ongoing

Is / was the safety performance satisfactory as per company standards?

- Yes
- No

What was the Total Recordable Incidents Reported (TRIR) on the project? (Optional)

What was the DART (“Days Away, Restricted, and Transferred”) on the project? (Optional)

Is / was the final facility Production/Business performance as per planned performance targets?

- 50% to -25%
- 25% to Met plan
- Met plan to +25%
- +25% to +50%
- Project is ongoing

What is / was the predominant project delivery strategy?

- Design-Bid-Build
- Design-Build (or EPC)
- Multiple Design-Build
- Construction Manager–at-Risk
- Fast Track
- Turnkey

What is / was the predominant contracting strategy?

- Lump sum
- Cost Reimbursable
- Target price
- Unit Rates
- Guaranteed Maximum Price

What was the Number of Prime Contractors?

What was the actual Percentage Engineering Complete at the Start of Site Infrastructure Construction?

- Less than 10%
- 10-25%
- 25-50%
- 50%-75%

- Above 75%

What was the actual Percentage Engineering Complete at the Start of Plant Facility Construction?

- Less than 10%
- 10-25%
- 25-50%
- 50%-75%
- Above 75%

PART 2 - FACTORS

CATEGORY A – LOCATION AND TECHNOLOGY

Factor A1 - The project is / was using a new or unproven technology.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor A2 - The project is / was remotely located presenting challenges of transporting materials and human resources to site.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact

- Moderate impact
- Serious impact
- Schedule performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact

Factor A3 - The project has / had jurisdictional complexities (permitting, environmental and regulatory).

- Strongly disagree
- Agree
- Disagree
- Strongly agree
- Neither agree or disagree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact

Factor A4 - The project has / had an unavailability of quality skilled trades.

- Strongly disagree
- Agree
- Disagree
- Strongly agree
- Neither agree or disagree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact

- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

CATEGORY B: PROJECT ORGANIZATION, RESOURCING, AND COMMUNICATION

Factor B1 - The project is having / had unplanned changes in key project personnel.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor B2 - The project has / had ineffective management and communication across the project team and stakeholders.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact

- Moderate impact
- Serious impact
- Schedule performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact

Factor B3 - The project has / had communication challenges (location, time zone, language) due to multiple engineering, construction, pre-assembly, and/or construction locations.

- Strongly disagree
- Agree
- Disagree
- Strongly agree
- Neither agree or disagree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Moderate impact
 - Minor impact
 - Serious impact

Factor B4 - The project has/had inadequate organizational planning and staffing.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B5 - The project has / had ineffective interface management.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor B6 - The project does not / did not have an established robust universal document management plan.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

CATEGORY C: PLANNING AND EXECUTION PROCESSES

Factor C1 - The FEP team is / was too “business focused” and does / did not receive sufficient input from the execution team leading to inadequate definition of project requirements.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C2 - The project team is / was overly optimistic leading to unrealistic cost and schedule at project sanction.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C3 - The owner does not / did not fully understand the benefits of adequate investment of funds and resources to support front-end planning.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C4 - The project lacks / lacked a comprehensive and rigorous risk assessment and mitigation planning.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor C5 - The project has / had an inadequate project controls system.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor C6 - The project stakeholders lack / lacked agreement on the project execution plan.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C7 - The project lacks / lacked an integrated schedule covering the entire scope from FEP through initial operations.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C8 - The project execution is being / was impacted due to delay in obtaining regulatory and environmental approvals.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C9 - The project baseline schedule is being / was modified post sanction to fast track the project.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C10 - The project execution team sacrificed / is sacrificing quality to meet aggressive schedule.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C11 - The project is failing / failed to provide a framework and resources to effectively manage change.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C12 - The project has / had a lack of comprehensive risk management.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor C13 - The project documents, procedures, and processes are / were not fit-for-purpose.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

CATEGORY D: GOVERNANCE AND STAKEHOLDERS

Factor D1 - The project has / had a lack of clear definition of roles, responsibilities and authority for all owner and project personnel.

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor D2 - The project has / had a lack of personnel and / or skills and experience in the project management team (both owner and contractor team).

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

This factor was identified upfront in the risk register?

- Yes
- No

There is / was a mitigation plan for this factor?

- Yes
- No

What is / was the impact of this factor on?

- Cost performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Schedule performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact
- Production/Business performance of the project?
 - No impact
 - Minor impact
 - Moderate impact
 - Serious impact

Factor D3 - The project stakeholders have / had cultural differences.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D4 - The project owner is failing / failed to communicate the identified risks and work on cooperative mitigation plans with all stakeholders.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D5 - The project owner JV and / or contractor JV organization is lacking / lacked focus or alignment.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor D6 - The project stakeholders have / had differences in business approach.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

CATEGORY E: DELIVERY STRATEGY

Factor E1 - The project requirements are / were not aligned with the project delivery and contracting strategies.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E2 - There are / were limited number of capable major contractors to execute this type of project.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | |
|---|--|
| <ul style="list-style-type: none">• Cost performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Schedule performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact• Production/Business performance of the project?<ul style="list-style-type: none"><input type="checkbox"/> No impact<input type="checkbox"/> Minor impact | <ul style="list-style-type: none"><input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact<input type="checkbox"/> Moderate impact<input type="checkbox"/> Serious impact |
|---|--|

Factor E3 - The project scope is / was ambiguous with inadequately defined contracts.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | | |
|---|--|--|
| • Cost performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |
| • Schedule performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |
| • Production/Business performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |

Factor E4 - The project has / had unexpected materials and / or equipment delays.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- | | | |
|---|--|--|
| • Cost performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |
| • Schedule performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |
| • Production/Business performance of the project? | | |
| <input type="checkbox"/> No impact | <input type="checkbox"/> Moderate impact | |
| <input type="checkbox"/> Minor impact | <input type="checkbox"/> Serious impact | |

Factor E5 - The project contractor or key subcontractor is failing / failed to meet expectations during execution.

- | | |
|--|---|
| <input type="checkbox"/> Strongly disagree | <input type="checkbox"/> Agree |
| <input type="checkbox"/> Disagree | <input type="checkbox"/> Strongly agree |
| <input type="checkbox"/> Neither agree or disagree | |

This factor was identified upfront in the risk register?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

There is / was a mitigation plan for this factor?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

What is / was the impact of this factor on?

- Cost performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Schedule performance of the project?

<input type="checkbox"/> No impact	<input type="checkbox"/> Moderate impact
<input type="checkbox"/> Minor impact	<input type="checkbox"/> Serious impact
- Production/Business performance of the project?

<input type="checkbox"/> No impact	
<input type="checkbox"/> Minor impact	
<input type="checkbox"/> Moderate impact	
<input type="checkbox"/> Serious impact	

Appendix D: Quick User Guide for Using IR 315-2

The section provides with a quick overview of the navigation aspect of IR 315-2. IR 315-2 is an Excel based tool that can be used with versions MS Excel 2010 and better. The tool contains several tabs and has the capability to store two assessments within same file. Below is a step-by-step navigation overview of IR 315-2.

Step 1: Open the Microsoft Excel file for the Mega-Project Assessment of Criticality Tool (MPACT)

Step 2: Enable macros if Microsoft Excel posts a message asking if you would like to do so.

Step 3: Once you open the file and enable the macros. Fill out the information on the “Cover Sheet” Page, which includes the project name and information, the date, etc. A snapshot of the cover sheet is shown in Figure 3.

The screenshot displays the MPACT software interface. At the top, there is a navigation bar with the CH logo, buttons for 'MPACT Assessment-1', 'MPACT Assessment-2', 'See Quick User Guide', 'Reset Assessment 1', and 'Reset Assessment 2'. Below this is a title bar for 'Mega-Project Assessment of Criticality Tool (MPACT) IR 315-2'. A section titled 'Enter Mega-project Information' contains a form with the following fields:

Project Name:	Enter Project Name
Project Control Number:	Enter Project Control Number
Company:	Enter Company Name
Project Location:	Enter Project Location
Assessment Phase:	Enter Assessment Phase
Project Type:	Enter Project Type
Date:	Enter Today's Date

Below the form is a process flow diagram with four stages: 0 Feasibility (green), 1 Concept (blue), 2 Detailed Scope (purple), and 3 Execution (red). Above the 'Detailed Scope' and 'Execution' stages are buttons for 'MPACT Assessment 1' and 'MPACT Assessment-2' respectively. Red arrows point from these buttons to the 'MPACT Assessment-1' and 'MPACT Assessment-2' buttons in the top navigation bar. Text annotations state: 'To start new assessment click 'MPACT Assessment-1'' and 'To start the second assessment click 'MPACT Assessment-2''. At the bottom of the interface is a photograph of an industrial facility at night.

Figure 9. MPACT Cover Sheet Snapshot

Step 4: After filling out the project information, if you are conducting the assessment for the first time, Click “MPACT Assessment-1”. If this is the second assessment, click "MPACT Assessment-2," as shown in Figure 3.

Step 5: After clicking on the “MPACT Assessment” button, a dialog box will appear on your screen as per Figure 4. This dialog box is the control screen for rating the criticality

of the impact factors, for recording comments for each factor and to review the mega-project data collected by the RT315 research team.

Step 6: Click on "Factor Examples" or "Factor Recommendations" button to open the respective information. For recording team discussion comments, assessment justification or any other notes, click "Add Comments" and record necessary comments in the dialog box. To assess the criticality, click the "Low", "Moderate" or "High" criticality from the dialog box. Note that this will automatically advance you to the next impact factor.

If you close the Factor Description window, double click on the impact factor name to reopen further information on the impact factor. Note that you can also assess the criticality for each impact factor and you can enter comments directly on the Excel sheet without using the dialog box system.

Category A- Location and Technology

Legend					
Low Frequency of Occurrence/ Minor Impact (average impact value between 0 & 1)					
Moderate Frequency of Occurrence/ Moderate Impact (average impact value b/w 1 & 2)					
High Frequency of Occurrence/ Serious Impact (average impact value between 2 & 3)					
Impact Factor Name	Mega-project Impact Factor Survey Findings				
	Frequency of Occurrence	Cost Impact	Schedule Impact	Production Impact	
Factor A1-New or Unproven Technology	24%	1.8	1.8	1.6	
Factor A2-Logistics Challenges	49%	1.0	1.4	1.0	Double Click
Factor A3-Jurisdictional Complexities	34%	1.6	1.6	1.2	
Factor A4-Unavailability of Qualified Craftsmen	46%	1.8	1.9	1.1	

Factor Description

Factor A1-New or Unproven Technology

- o Importance
 - More sensitive to challenges using new/unproven technologies
 - Directly impacts production performance as well as cost/schedule
- o Probable Causes
 - Lack of familiarity with the new project execution methodology or tool
 - Reluctance to make large investment up front to develop/mature new technology
 - Lack of information required about the new technology
 - Inadequate experience and resources on team
- o Potential Outcomes
 - Challenges in integrating multiple technologies
 - Late design and engineering changes
 - Occurrence of scale-up problems

Factor Examples Recommendations Add Comments Return

Criticality 0- N/A **1- Low** 2- Moderate 3- High

More information on impact factor examples and recommendations

Record Team Justification/Comments during assessment

Assess Criticality Assessment by clicking on required buttons

Figure 10. MPACT Input Assessment Sheet Snapshot

Step 7: Once a category is complete, use the next buttons at the top of the page to move to the next category. Repeat Step 5 for each of the five categories.

Step 8: When reaching the last category (Category E) page, click the “Go to Results” button. This will take you to the results page (snapshot shown in Figure 5) where the criticality of all the impact factors are displayed.

Generate Summary Report Generate Detailed Report Print Refresh Assessment Home Save

MPACT- ASSESSMENT 1 SUMMARY

Project Name:

Project Control Number:

Company:

Project Location:

Project Type:

Date:

Assessment Summary-1	
3- High Criticality	
Factor A3-Jurisdictional Complexities	Generate Detailed or Summary Reports
Factor B3-Multi-Location Challenges	
Factor C12-Incomprehensive Risk Management	
Factor C4-Inadequate Risk Assessment & Mitigation	
Factor C7-Inadequate Integrated Schedule	
Factor C9-Baseline Schedule Acceleration	
Factor D3-Cultural Differences Across Stakeholders	
Factor D6-Business Approach Differences Across Stakeholders	
Factor E4-Unexpected materials and / or equipment delays.	
2- Moderate Criticality	
Factor A1-New or Unproven Technology	
Factor A2-Logistics Challenges	
Factor B2-Ineffective Stakeholder Communication	
Factor B4-Inadequate Organization Planning and Staffing	
Factor B6-Inadequate Document Management Plan	
Factor C11-Ineffective Change Management	
Factor C3-Inadequate FEP Resources	
Factor C6-Lack of Execution Plan Alignment	
Factor C8-Regulatory & Environmental Delays	
Factor D2-Inadequate Size, Skills, and Experience of Project Management Team	
Factor D5-Misalignment Within Partner Organization	

Figure 11. MPACT Assessment Result Sheet Snapshot

Step-9: On the Results page, you will see an assessment summary. You have the option to print the assessment summary by clicking the Print button (as shown in Figure 5).

Step-10: There are two options on the results page. You can generate a summary report or a more detailed report. Summary report provides information on impact factor description,

its recommendations and the team comments with the criticality assessment done. The detailed report provides the factor examples for each impact factor (as shown in Figure 5).

Step-11: On the report page (snapshot shown in Figure 6), you can either print or save the file as per your convenience.

MPACT
IR 315-2
Summary Report

Project Name:Enter Project Name
Project Control Number:Enter Project Control Number
Company:Enter Company Name
Project Location:Enter Project Location
Project Type:Enter Project Type
Assessment Phase:Enter Assessment Phase
Date:Enter Today's Date

Impact Factor Information	Assessed Impact Factor Criticality
Factor A3-Jurisdictional Complexities	High Criticality

Factor Description

- o Importance
 - Inadequate understanding of permitting and regulatory environment
 - Inadequate understanding of potential enforcement (i.e., requirements change post sanction)
- o Probable Causes
 - Unfamiliar tax regulations
 - Incomplete examination of applicable import/export requirements
 - Lack of a thorough review of local laws, including local content/permitting requirements
 - Ignoring political influences/stability
 - Overlooking informal local content requirements
 - Dependence upon host government to provide required infrastructure addition
 - Corruption in host government
- o Potential Outcomes
 - Increased chances of disruptions in later stages
 - Procedure or policy decisions with negative project impact from the host government
 - Delays and cost overruns to obtain permits during execution

Factor Recommendations

- o Pre-Sanction:
 - Send a team early to assess the project location's taxes, laws, and import/export requirements.
 - Work with local contacts to better define the jurisdictional challenges.

Figure 12. MPACT Assessment Summary Report Snapshot

Appendix E: Impact Factor Descriptions

Category A- Location and Technology

This category consists of information about impact factors associated with mega-project *location, jurisdiction, and technology*. An understanding of this category and its challenges will help project teams anticipate and mitigate the impact factors and their related issues.

Factor A1 - New or Unproven Technology

Factor Description

- Importance
 - Projects are sensitive to challenges of using new/unproven technologies.
 - Issues can directly impact production performance as well as cost/schedule.
- Probable Causes
 - Lack of familiarity with the new project execution methodology or tool
 - Reluctance to make large investment up front to develop/mature new technology
 - Lack of information required about the new technology
 - Inadequate experience and resources on team
- Potential Outcomes
 - Challenges in integrating multiple technologies
 - Late design and engineering changes
 - Occurrence of scale-up problems

Factor A2 - Logistics Challenges

Factor Description

- Importance
 - Complexity of remote sites with large volume of equipment/craft
 - Availability of infrastructure to support project requirements
- Probable Causes
 - Underestimating cost and schedule impacts of transporting materials in unfamiliar and/or remote locations
 - Lack of understanding of resource availability
 - No or poor quality existing infrastructure
 - Partial assessment of local fabrication capabilities
 - Disruptions due to weather (e.g., cold regions, wet seasons, hurricanes, loop currents, etc.)
- Potential Outcomes
 - Inadequately sized worker camps
 - Frequent changes in procurement and logistic plans
 - Challenges in managing the overall complex logistic network

Factor A3 - Jurisdictional Complexities

Factor Description

- Importance
 - Time required to obtain permits can be significant.
 - Changes and lack of compliance can impact execution.
- Probable Causes
 - Unfamiliar tax regulations
 - Incomplete examination of applicable import/export requirements
 - Lack of a thorough review of local laws, including local content/permitting requirements
 - Ignoring political influences/stability
 - Overlooking informal local content requirements
 - Dependence upon host government to provide required infrastructure addition
 - Corruption in host government
- Potential Outcomes
 - Increased chances of disruptions in later stages
 - Procedure or policy decisions with negative project impact
 - Delays and cost overruns to obtain permits

Factor A4 - Unavailability of Qualified Craftsmen

Factor Description

- Importance
 - Location potentially limits availability of qualified workforce
 - Unfamiliarity with location makes resource assessment harder
- Probable Causes
 - High demand or low supply of local skilled workforce
 - Restriction on mass importation of labor
 - Increased demands in labor market
 - Escalating wage rates
 - Union requirements
- Potential Outcomes
 - Unskilled local workers
 - High training cost
 - Low productivity and quality
 - Increased need for higher cost expats

Category B - Team, Organization, and Communications

This category consists of information on about impact factors associated with *team integration, organizational planning, and managing communication* on a mega-project. An understanding of this category and its challenges will help project teams anticipate and mitigate the impact factors and their related issues.

Factor B1 - Unplanned Changes in Key Personnel

Factor Description

- Importance
 - Longer project durations increase exposure to turnover.
 - Continuous turnover impacts team integration and alignment.
- Probable Causes
 - High personnel turnover
 - Project Manager (PM) burnout
 - Sudden retirement of key leaders
 - Lack of succession planning
 - Health issues
- Potential Outcomes
 - Lack of team cohesion (i.e., personality conflicts)
 - Knowledge loss
 - Time loss due to realignment of project team after changes

Factor B2 - Ineffective Stakeholder Communication

Factor Description

- Importance
 - Large number of stakeholders (JV partners, contractor, subcontractor, supplier, etc.) and functions (engineering, management, finance, human resources, operations, etc.) involved on mega-projects
 - More complex and geographically dispersed teams
- Probable Causes
 - Different communication styles
 - Inexperience in handling communications with large number of stakeholders
- Potential Outcomes
 - Lack of information flows (up-down, sideways, across phases)
 - Problems are not communicated to higher management
 - Mistrust between project team members

- Hampers the coordinated effort to meet project objectives

Factor B3 - Multi-Location Challenges

Factor Description

- Importance
 - Communication challenges: locations, time zones, languages, cultures
 - Rapid Globalization
- Probable Causes
 - Differences in cultures
 - Different time zones
 - Different terminologies
 - Different standards and procedures
 - Different languages
 - Lack of trust in sharing information
- Potential Outcomes
 - Increased potential for errors in work conducted in multiple locations
 - Problems in integrating work conducted in multiple locations
 - Increase in cost of maintaining proper oversight at remote locations
 - Increases the complexity and challenges of having integrated coherent teams

Factor B4 - Inadequate Organization Planning and Staffing

Factor Description

- Importance
 - Experience, size, and timing of formation of mega-project team impacts integration and quality of execution
- Probable Causes
 - Significant changes from the front-end planning team to the execution team
 - Poor human resources management
 - Lack of in-house depth and breadth of technical expertise
 - Staffing problem due to remote location
- Potential Outcomes
 - Outsourcing of key project functions
 - Missing key function representation on important decisions
 - Ineffective project management team

Factor B5 - Ineffective Interface Management

Factor Description

- Importance
 - Increased number of interface points on mega-projects
 - Need for collaboration and timely exchange of information
 - Rapid advancement of information technology
- Probable Causes
 - Inadequate owner participation in interface management
 - Lack of interface management processes and procedures
 - Lack of experienced personnel conducting interface management
 - Late implementation of interface management
- Potential Outcomes
 - Opportunities for miscommunications and misunderstandings
 - Inefficient information exchange
 - Incomplete execution of scope
 - Overlooking scope overlaps at interfaces

Factor B6 - Inadequate Document Management Plan

Factor Description

- Importance
 - Globally dispersed teams require easy access to accurate data
 - Increase volume of documents and interfaces/accesses
- Probable Causes
 - Inadequate expertise level of system users
 - Ineffective processes to drive document management
 - Inadequate definition of related tools and practices
 - Third party or contractor lack access to owner's document control system or document repository
- Potential Outcomes
 - Lack of integration with business and projects systems
 - Insufficient access to vital information
 - Improper version control of documents
 - Inaccuracies in document sharing
 - Lack of interoperability of IT systems
 - Lack of concise and accurate data hampers proactive decision making

Category C - Planning and Execution Processes

This category consists of information about impact factors associated with *framing and controlling* mega-project planning and execution processes. An understanding of this category and its challenges will help project teams anticipate the challenges and mitigate the impact factors and their related issues.

Factor C1 - Lack of Execution Input to FEP

Factor Description

- Importance
 - Timely execution input is the key to success on mega-projects.
 - Late execution input has minimal *or no* benefit.
- Probable Causes
 - No fulltime execution personnel on front-end planning (FEP) team
 - Late contractor involvement due to company procedures
- Potential Outcomes
 - Undefined and/or unclear expectations and requirements
 - Ineffective constructability studies
 - Late changes due to execution limitations

Factor C2 - Optimism Bias

Factor Description

- Importance
 - There is a tendency towards an overly optimistic attitude
 - It is critical to have realistic cost and schedule baselines
 - Early and accurate definition of scope prevents late changes
- Probable Causes
 - Lack of rigor in the estimating and scope definition process (i.e., documentation, assumptions, risk identification)
 - Overly optimistic assumptions
 - Inexperienced personnel in key project definition roles
 - Irrational management pressure to reduce cost and schedule estimates
- Potential Outcomes
 - Unrealistic cost and schedule estimates
 - Inadequate risk identification and mitigation
 - Inadequate definition of assumptions and basic technical data
 - Inadequate project contingency

Factor C3 - Inadequate Front-end Planning (FEP) Resources

Factor Description

- Importance
 - Long periods of time are required to comprehensively define the technical data.
 - Large investments are required for effective front-end planning (FEP).
- Probable Causes
 - Urgency to get products to market
 - Lack of in-house resources to conduct effective front-end planning
 - High cost of gathering reliable technical data
 - Inexperienced owners who do not understand the benefit of FEP
- Potential Outcomes
 - Misalignment between the business and project teams
 - Premature project start
 - Inappropriate definition of project processes and plans
 - Inaccurate definition of basic data

Factor C4 - Inadequate Risk Assessment and Mitigation

Factor Description

- Importance
 - Execution surprises are difficult to manage on mega-projects.
 - Front-end planning risk assessment and mitigation planning forms the basis for risk management and control for future project phases.
- Probable Causes
 - Not enough resources allocated for risk assessment
 - Lack of experience and skills in risk management team
- Potential Outcomes
 - Risk mitigation not incorporated into the project plan
 - Arbitrary cuts in risk contingencies by management
 - Unrealistic contingencies in cost and schedule
 - Inadequate “What if?” scenario planning
 - Lack of risk-impact assessment on the project schedule

Factor C5 - Inadequate Project Controls Systems

Factor Description

- Importance
 - Complexities of vast scope, multiple contracts, long schedules, and multiple stakeholders require strong project controls
 - Critical to forecast and predict risks to prevent a downward spiral on mega-projects
- Probable Causes
 - System not adequate for handling large number of contract packages
 - Inexperienced project controls team
 - Understaffed project controls team
- Potential Outcomes
 - Inability to track progress, identify trends and take pro-active decisions.
 - Lack of integrated project control reporting
 - Schedule delay and cost escalation getting out of control
 - Lack of effective scope control and change management processes

Factor C6 - Lack of Execution Plan Alignment

Factor Description

- Importance
 - Input from all stakeholders is important for coherent execution plans.
 - Mega-projects are highly sensitive to late changes in execution plans.
- Probable Causes
 - Ineffective communication
 - Improper implementation of alignment best practices
 - Inadequate updating of the execution plan
- Potential Outcomes
 - Late project changes
 - Disruptive disagreements
 - Unaligned or conflicting team objectives
 - Resource imbalance due to inadequate definition of project execution plan
 - Milestone completion out of preferred sequence

Factor C7 - Inadequate Integrated Schedule

Factor Description

- Importance
 - Individual contract packages are interlinked, delay in one affects all
 - Important for effective project controls
 - Master schedule required for a strong baseline for overall progress measurement

- Probable Causes
 - Lack of definition on interface deliverables
 - No responsible party to integrate the whole project
 - Lack of emphasis on integrating individual scope packages
- Potential Outcomes
 - Lack of understanding of the project milestone requirements
 - Schedule extension due to no agreed baseline to hold parties accountable
 - Resource imbalance due to lack of an integrated schedule
 - Different objectives and delaying interfaces
 - Improper consideration of schedule impact factors, such as weather changes or environmental approvals

Factor C8 - Regulatory and Environmental Delays

Factor Description

- Importance
 - Very difficult to ramp down and ramp up progress after temporary halts
 - Project halts, resulting in significant losses and schedule delays
- Probable Causes
 - Did not identify environmentally sensitive areas within project limits
 - Overloaded regulatory bodies
 - Public apprehension/intervention against project
 - Not identifying all required permits
 - Permit application improperly filled out, or changes to project that are not communicated back to permit agency
 - Not identifying schedule related permit restrictions, such as road-ban restrictions
- Potential Outcomes
 - Halt in project execution
 - Throw engineering and procurement out of sequence
 - Loss of direct man-hours and decreased productivity

Factor C9 - Baseline Schedule Acceleration

Factor Description

- Importance
 - Accelerating or compressing the schedule for a Mega-project post sanction can cause a significant ripple effect through the existing engineering, procurement, construction and start-up schedules.

- Complexities involved in a Mega-project may make it extremely difficult to regain control of the overall project schedule.
- Probable Causes
 - Urgency to get to market
 - Recovery of lost schedule
 - Need to fast track the project
- Potential Outcomes
 - Incomplete engineering, leading to late changes
 - Delay in equipment delivery
 - Increased overtime
 - Commissioning and start-up receiving completed work out of sequence
 - Inefficiencies due to work face congestion and/or conflicts
 - Inefficient craft deployment for schedule recovery

Factor C10 - Quality Compromised for Schedule

Factor Description

- Importance
 - Comprising quality to gain schedule efficiencies may have negative impacts on the operational capabilities or could result in other long-term consequences.
- Probable Causes
 - Pressure to meet aggressive schedule
 - Lack of resources for quality assurance and planning
 - Quality not a priority objective on project
- Potential Outcomes
 - Issues in commissioning and startup
 - Increased safety exposure
 - Greater potential for higher rework
 - Increased errors in drawings
 - Out of sequence procurement
 - Increased number of change orders

Factor C11 - Ineffective Change Management

Factor Description

- Importance
 - Mega-projects extremely sensitive to changes

- Frequent change orders hampers united effort on the project
- Change orders can have huge cost ramifications
- Probable Causes
 - No formal change management process
 - Lack of resources to manage change
 - Unfit change management framework for the mega-project
- Potential Outcomes
 - Ineffective dispute prevention and resolution process
 - Inefficient audit plans
 - Unplanned escalation procedures
 - Friction in team due to unresolved disputes
 - Too many change approval levels

Factor C12 - Incomprehensive Risk Management

Factor Description

- Importance
 - Mega-projects need proactive, real-time decision-making on risks.
 - Overlooked or ignored risks compound and lead to large overruns.
- Probable Causes
 - Weak risk management team on the project
 - Lack of experience
 - Lack of a comprehensive corporate risk management process
 - Lack of regular risk audits
- Potential Outcomes
 - Ineffective proactive decision-making on risk mitigation actions
 - Reduced ability to handle surprises
 - Lack of lessons learned on key risks across an organization

Factor C13 - Unfit Procedures, and Processes

Factor Description

- Importance
 - Each mega-project has some unique characteristics that require adaption.
 - Aggressive schedules demand strong definition of project documents and plans.
- Probable Causes
 - Improperly designed project plans for the mega-project
 - Lack of ability to adapt project processes to fit characteristic of the project

- Inflexibility in project procedures and processes
- Potential Outcomes
 - Different working processes and procedures among the team members
 - Lack of lessons learned knowledge transfer
 - Unfit documents, procedures, and processes for specific mega-project
 - Cumbersome data gathering and reporting requirements

Category D - Governance and Stakeholders

This category consists of information about impact factors associated with *effective governance structure* and *stakeholder management* on mega-projects. An understanding of the category and its challenges will help project teams anticipate and mitigate the impact factors and their related issues.

Factor D1 - Unclear definition of Roles, Responsibilities and Authority

Factor Description

- Importance
 - Mega-projects have complex governance structure with large size teams.
 - Success depends on a cohesive effort from each team member.
- Probable Causes
 - Ill-defined responsibility matrix
 - Mismatch between responsibility and authority
 - Ill-defined work split
- Potential Outcomes
 - Lack of team unity and alignment
 - Lack of leadership and decision-making
 - Lack of accountability among team members
 - Ineffective organizational structure with mismatch between responsibility and authority

Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team

Factor Description

- Importance
 - Mega-project success is directly linked to effective management with experienced decision-makers.
 - Complex scopes with multiple packages require specialized skills and experience on project teams.
- Probable Causes
 - Lack of in-house execution personnel with owner
 - Hot market conditions leading to high attrition
 - Inappropriate salary levels
 - High cost of retaining team members on a remote project
- Potential Outcomes
 - Ineffective decision-making
 - Lack of ability to control the project

- Unrealistic goals and targets

Factor D3 - Cultural Differences among Stakeholders

Factor Description

- Importance
 - Mega-projects have an impact on a wide variety of stakeholders. In addition to the host government and active sponsors on the project, there is a growing influence on and from communities, locals, and other pressure groups.
 - Mega-project success requires bringing together diverse and complex cultures.
- Probable Causes
 - Diverse and complex cultures working together
 - Multiple nationalities and dialects involved
 - Different working styles
 - Unanticipated stakeholder changes
- Potential Outcomes
 - Different perception of success and achievement
 - Increased safety exposure due to differing tolerance to low safety standards
 - Lack of transparency among stakeholders
 - Increased potential of disruptions and disputes within different stakeholders
 - Conflicts between different craft groups (union/non-union, local/non-local)

Factor D4 - Inadequate Owner Collaboration with Other Stakeholders

Factor Description

- Importance
 - Owner organization is the glue that binds together all planning and management by the different stakeholders.
 - Owner input is key to thorough risk mitigation planning.
- Probable Causes
 - Inexperienced owner/project team
 - Lack of risk sharing culture
 - Incorrect owner perception of contracting as a means of risk transfer
 - Lack of communication
- Potential Outcomes
 - Misalignment among stakeholders
 - Overlooking key risks
 - Lack of a comprehensive risk mitigation plan

Factor D5 - Misalignment within Partner Organization

Factor Description

- Importance
 - More mega-projects are being done in partnership between organizations.
 - Governance structures have become more complex.
 - Project partnerships with different nationalities and diverse cultures are increasing..
 - Joint venture (JV) must be aligned in order to ensure common objectives and targets
- Probable Causes
 - Lack of experience working together
 - Large number of partners and interfaces
 - Different working cultures
 - Lack of implementing partnering best practices
 - Differences in project drivers
- Potential Outcomes
 - Unaligned strategic business objectives and project objectives
 - Ineffective decision-making
 - Uncoordinated team effort
 - Increased opportunity for friction between partners, leading to poor performance

Factor D6 - Business Approach Differences among Stakeholders

Factor Description

- Importance
 - Mega-projects require common success definition for all stakeholders.
 - Differing priorities manifest into continuous disputes on mega-projects.
- Probable Causes
 - Difference in priorities among stakeholders (cost vs. schedule vs. quality)
 - Ineffective role definition for partners in a joint venture (JV) organization
 - Different long term business objectives of partners
- Potential Outcomes
 - Misalignment between partners
 - Potential for conflicts arising out of opposite business objectives

Category E - Delivery Strategy

This category consists of information about impact factors associated with *selecting the right contracting strategy* and *managing contracts and procurements* of a mega-project. An understanding of the category and its challenges will help project teams anticipate and mitigate the impact factors and their related issues.

Factor E1 - Inappropriate Project Delivery Contracting Strategy

Factor Description

- Importance
 - Each mega-project has unique characteristics and complexities that require a tailor-made contracting strategy.
 - Efficient, well-drafted delivery strategies are key to mega-project success.
- Probable Causes
 - Scope definition does not support contracting strategy
 - Government constraints in determining contract strategy
 - Financing limitations on selecting delivery strategy
 - Inadequate resources to effectively implement a particular contract type
- Potential Outcomes
 - Inadequate definition of contract packages, sequence, and division of responsibility
 - Frequent change order requests
 - Frequent disputes between sponsor and contract

Factor E2 - Unavailability of Qualified Major Contractors

Factor Description

- Importance
 - Unfamiliar locations and complex regulatory environments require experienced, capable local contractors/subcontractors.
 - Extensive magnitude of the scope of work requires major contractors with established processes and systems.
- Probable Causes
 - Inexperience with similarly sized projects
 - Incapability of contractors to scale up to match project scale
 - Political pressures to hire local contractors
 - Competing local projects
- Potential Outcomes
 - No pre-existing relationship between an owner and primary contractor

- Reduced chances of a cost-effective bid
- Hire of unqualified contractors

Factor E3 - Unclear Scope Definition in Contracts

Factor Description

- Importance
 - Mega-projects involve multiply parties working together, often for the first time.
 - Frequent disputes over contract can have serious consequences for project performance.
- Probable Causes
 - Ambiguous contract language
 - Immature scope definition during contract award
 - Inadequate information when drafting contract
 - Lack of experience in personnel drafting contracts
 - Inflexible contract strategy
- Potential Outcomes
 - Inefficient work packaging
 - Misinterpretation of contract terms and specifications
 - Unclear specifications
 - Lack of performance incentives

Factor E4 - Unexpected materials and / or equipment delays.

Factor Description

- Importance
 - High volume of material and equipment requirement on mega-projects increases the potential of delivery delays.
 - Mega-projects involve complex procurement cycles; aggressive schedules magnify sensitivity to materials delays.
- Probable Causes
 - Unavailability of material/equipment locally
 - Out of sync engineering, procurement, and execution plan
 - Lack of procurement input in front-end planning
 - Challenges in transportation and logistics
 - Poor warehousing and storage conditions
- Potential Outcomes

- Loss of direct man-hours and decreased productivity
- Throw lifting and construction sequences out of order
- Huge inventories of associated materials that cannot be executed

Factor E5 - Underperforming Contractor or Key Subcontractor

Factor Description

- Importance
 - Mega-projects involve huge investments that require contractors to carry extreme financial risks over a long period of time.
 - A poorly performing contractor or subcontractor on a mega-project can have damaging effects on overall project progress.
- Probable Causes
 - Poor prequalification processes for choosing contractors/fabricators
 - Wages don't meet prevailing rates
 - Lack ability to attract/retain craft and subcontractor
 - Multiple contracts to same contractor/subcontractor
 - Lack of experienced and capable local subcontractors
- Potential Outcomes
 - Inability of contractor to meet progress expectations
 - Bankruptcy of contractor can halt execution
 - Poor quality of work
 - Push construction and procurement processes out of sequence
 - Increased cost in rework or recover of lost schedule

Appendix F: Factor Recommendations

Category A - Location and Technology

Factor A1 - New or Unproven Technology

- Front-End Planning Phase (Pre-Approval):
 - Pilot test the technology before scaling up.
 - Understand the scale-up requirements and limitations.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Allocate sufficient time and resources to plan and execute the integration of new or unproven technologies.
 - Implement new tools on a smaller scale and measure their performance before introducing them into a mega-project environment.
 - Hold training sessions to introduce new tools and procedures.

Factor A2 - Logistics Challenges

- Front-End Planning Phase (Pre-Approval):
 - Assess and plan risks of working on unfamiliar and/or remote locations.
 - Consider resource availability and associated costs before finalizing estimates.
 - Incorporate adequate contingencies for managing logistics.
 - Consider resources and time requirements for setting up and managing worker camps.
 - Conduct detailed analysis on existing infrastructure.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Plan for potential weather disruption and consider its impact on estimates.

Factor A3 - Jurisdictional Complexities

- Front-End Planning Phase (Pre-Approval):
 - Send a team early to assess the project location's taxes, laws, and import/export requirements.
 - Work with local contacts to better define the jurisdictional challenges.
 - Start communications with local government agencies early in order to include their input.

Factor A4 - Unavailability of Qualified Craftsmen

- Front-End Planning Phase (Pre-Approval):
 - Analyze the demand and supply of the local skilled workforce.
 - Prepare contingency plans for dealing with low supply of skilled workforce.

- Plan for the possibility of having to deploy expats in order to supplement the local workforce.
- Identify the project peak demand of workers.
- Include training costs on initial budgets.
- Start training early and incorporate local resources into training programs.

Category B- Team, Organization and Communication

Factor B1 - Unplanned Changes in Key Personnel

- Front-End Planning Phase (Pre-Approval):
 - Implement effective succession plans, especially for key subject matter experts and project managers, to transfer knowledge and lessons learned to future projects.
 - Assess local culture's potential impacts on the project team.
 - Consider individual personality traits when forming the project team.
- Execution Phase (Post-Approval):
 - Include bonuses for key personnel who remain throughout the project.

Factor B2 - Ineffective Stakeholder Communication

- Front-End Planning Phase (Pre-Approval):
 - Conduct alignment activities early in order to reduce communication gaps among project team members.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Build trust and transparency between project team members, stakeholders, and different levels of involved organizations.
 - Ensure communication flows upwards and downwards on the different organizational levels to ensure alignment.
- Execution Phase (Post-Approval):
 - Organize timely steering team meetings for key management personnel and stakeholders to discuss key challenges and risks, as well as related action plans.

Factor B3 - Multi-Location Challenges

- Front-End Planning Phase (Pre-Approval):
 - Prepare and implement terminology usage guidelines and standardized procedures across multiple project team locations.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Have experienced people manage the key interfaces between globally dispersed teams.

- Prepare and implement terminology usage guidelines and standardized procedures across multiple project team locations.
- Schedule face-to-face interactions among different teams to increase communication.
- Have flexible working hours for people who communicate and who are different time zones.
- Ensure that teams have access to latest video/teleconference/Internet communication tools.

Factor B4 - Inadequate Organization Planning and Staffing

- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Include individuals with experience and expertise on execution in front-end planning and decision-making processes to analyze execution feasibility.
 - Deploy fulltime operations and maintenance personnel to the project team.
 - Have some key project team members who were involved in front-end planning continue with the team to the execution phase to facilitate knowledge transfer.
- Execution Phase (Post-Approval):
 - Improve employee communications with support from the human resources department to proactively identify and mitigate employee concerns.
 - Adjust the project team early with minimum changes.

Factor B5 - Ineffective Interface Management

- Front-End Planning Phase (Pre-Approval):
 - Prepare and implement an effective interface management plan with all interfaces identified and make it part of the execution plan.
 - Establish project roles specifically for interface management.
 - Include interface management resources and costs in the front-end engineering and request for proposal (RFP) packages.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Implement interface management through development of appropriate contract documents and definition of scopes of work.
 - Engage a third party to perform interface management when needed.
- Execution Phase (Post-Approval):
 - Track information flows within interfaces and have processes to flag inefficient interfaces.
 - Owner and prime contractor should work together to manage the interfaces.

Factor B6 - Inadequate Document Management Plan

- Front-End Planning Phase (Pre-Approval):
 - Have a project organization-wide document management plan to facilitate communications.
 - Implement an internet accessible document management tool.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Conduct document management training for project team members to teach document control processes and tools.
 - Implement effective processes to manage document revisions.
 - Include all drawing submissions and revisions as part of the document management plan that should be included in the project execution plan.

Category C - Planning and Execution Processes

Factor C1 - Lack of Execution Input to FEP

Recommendations:

- Front-End Planning Phase (Pre-Approval):
 - Establish auditable procedures to ensure early engagement of the execution team.
 - Implement a stage-gate approval process to ensure that expected outcomes and project requirements are well defined.
 - Ensure that experienced execution personnel are involved in the creation of project specifications and contracts.

Factor C2 - Optimism Bias

Recommendations:

- Front-End Planning Phase (Pre-Approval):
 - Establish a rigorous risk management and mitigation process that incorporates lessons learned.
 - Define appropriate contingency levels.
 - Use a front-end scope definition process prior to sanction (PDRI, FEL, Peer Review, etc.).

Factor C3 - Inadequate Front-end Planning (FEP) Resources

- Front-End Planning Phase (Pre-Approval):
 - Reinforce the importance of effective front-end planning.

- Implement and follow a gate approval process to ensure alignment between the project team and the owner(s).
- Benchmark against industry standards/best practices.

Factor C4 - Inadequate Risk Assessment and Mitigation

- Front-End Planning Phase (Pre-Approval):
 - Develop and establish a rigorous risk-management plan and process.
 - Incorporate lessons learned from past mega-projects.
 - Conduct an independent, third-party, risk-management plan review (peer review).

Factor C5 - Inadequate Project Controls Systems

- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Ensure project controls system can adequately track and report cost, schedule and changes throughout the project.

Factor C6 - Lack of Execution Plan Alignment

- Front-End Planning Phase (Pre-Approval):
 - Have all stakeholders sign off on the project execution plan (PEP).
 - Reference PEP milestones into schedule.
- Execution Phase (Post-Approval):
 - Have PEP review sessions.

Factor C7 - Inadequate Integrated Schedule

- Front-End Planning Phase (Pre-Approval):
 - Require all parties to agree on the schedule prior to starting the project.
- Execution Phase (Post-Approval):
 - Conduct regular schedule review meetings.
 - Provide regular status updates to all stakeholders.

Factor C8 - Regulatory and Environmental Delays

Recommendations:

- Front-End Planning Phase (Pre-Approval):
 - Identify constraining points should project get fast-tracked and try to mitigate them. For instance, order long-lead materials earlier.
 - Identify contingency line item for potential fast tracking.
- Execution Phase (Post-Approval):
 - Perform comprehensive cost and schedule risk analysis, including all stakeholders.

Factor C9 - Baseline Schedule Acceleration

- Pre-Sanction:
 - Identify constraining points should project get fast tracked and try to mitigate them. For instance, ordering long lead materials earlier.
 - Identify contingency line item for potential fast tracking.
- Post-Sanction:
 - Perform comprehensive cost and schedule risk analysis including all stakeholders.

Factor C10 - Quality Compromised for Schedule

- Front-End Planning Phase (Pre-Approval):
 - Ensure detailed project specifications are developed during front-end planning.
 - Ensure project specifications are included in subcontractor/vendor bid documentation.
- Execution Phase (Post-Approval):
 - Increase level of quality surveillance.
 - Re-baseline the schedule to allow for proper quality.

Factor C11 - Ineffective Change Management

- Front-End Planning Phase (Pre-Approval):
 - Develop and implement change management plan.
 - Ensure effective governance in place to handle changes when they occur (PM authority level, etc.).
 - Staff a change management coordinator and expeditor.
 - Ensure the scope is well defined at sanction to establish good baselines for changes.
- Execution Phase (Post-Approval):
 - Only implement changes that are required for safety, regulatory, or to ensure that facility will work. Others need to be strongly justified.
 - Review status of change management weekly at the project management team level and at periodic sponsor meetings.

Factor C12 - Incomprehensive Risk Management

- Front-End Planning Phase (Pre-Approval):
 - Ensure that comprehensive risk assessment and risk management plan are completed in FEP.

- Include an appropriate level of contingency in the estimate.
- Defer sanction until all risks are well identified and understood.
- Staff a risk coordinator.
- Execution Phase (Post-Approval):
 - Conduct a comprehensive risk workshop with key stakeholders (i.e., owner, contractor) to assess risks.
 - Continue to assess risks at key milestones throughout the project and evaluate as needed.

Factor C13 - Unfit Procedures, and Processes

- Front-End Planning Phase (Pre-Approval):
 - Develop and implement project procedures that are appropriate for the project, rather than using procedures directly taken from other projects.
 - An external team should review projects procedures prior to sanction.
 - Ensure project reporting requirements are included in the project contracts/subcontracts.
- Execution Phase (Post-Approval):
 - Reevaluate procedures and make changes as necessary to fit project needs.

Category D - Governance and Stakeholders

Factor D1 - Unclear definition of Roles, Responsibilities and Authority

- Front-End Planning Phase (Pre-Approval):
 - Implement team-building practice and include its cost in the budget.
 - Conduct team-building sessions prior to construction.
 - Team building meetings should include all levels of the team and be conducted by a third party.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Define the roles, authorities, and responsibilities of each role and have the entire team sign off.

Factor D2 - Inadequate Size, Skills, and Experience of Project Management Team

- Front-End Planning Phase (Pre-Approval):
 - Consider measures to address attrition of personnel that is usual in long duration mega-projects.
 - Consider additional staffing positions and cross training that can support normal personnel absences.

- Establish a mentoring program to help train future project leaders.
- Understand the skill level needed to effectively perform each role and budget appropriately.
- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Staff project based on skillsets and necessary wage levels to attract needed professionals.

Factor D3 - Cultural Differences among Stakeholders

- Front-End Planning Phase (Pre-Approval):
 - Engage locals in front-end planning.
 - Understand the political landscape and try and meet with key players in advance of the project.
 - Engage non-governmental organizations during the front-end planning process in order to gain their support and understanding.
- Execution Phase (Post-Approval):
 - Consider host country work practices (e.g., work hours, holidays) in planning.

Factor D4 - Inadequate Owner Collaboration with Other Stakeholders

- Front-End Planning Phase (Pre-Approval):
 - Conduct a complete project review with the owners and contractors during front-end planning so that all parties can identify and discuss risks and establish mitigation measures.
 - Identify which stakeholder is in a better position to handle the risk.
- Execution Phase (Post-Approval):
 - Conduct periodic risk review meetings with all stakeholders.

Factor D5 - Misalignment within Partner Organization

- Front-End Planning Phase (Pre-Approval):
 - Assign Project Director/Managers with work experience in joint venture (JV) partners.
 - Implement partnering, alignment, and team building processes.
 - Define roles, responsibilities, and accountability clearly.

Factor D6 - Business Approach Differences among Stakeholders

- Front-End Planning Phase (Pre-Approval) and Execution Phase (Post-Approval):
 - Define partner roles at the time of JV formation and follow lead partner philosophies in respective roles.

- Execution Phase (Post-Approval):
 - Identify differences in execution and involve higher management early in order to resolve conflicts.

Category E - Delivery Strategy

Factor E1 - Inappropriate Project Delivery Contracting Strategy

- Front-End Planning Phase (Pre-Approval):
 - Assess project objectives and scope definition level in the selection of the most appropriate project delivery strategy.
 - Define the scope of work and interfaces between different scope packages clearly.

Factor E2 - Unavailability of Qualified Major Contractors

- Front-End Planning Phase (Pre-Approval):
 - Increase staffing of the project team to assist contractors where necessary (e.g., development of work packages, creation of safety and quality plans, commissioning help).
- Execution Phase (Post-Approval):
 - Work in collaboration with inexperienced local contractors to support and maintain progress
 - Have an experienced project management consultant (PMC) to maintain close oversight in case of inexperienced local contractors.
 - Assess contractor capabilities and organization strength before awarding multiple contracts to the same contractor.

Factor E3 - Unclear Scope Definition in Contracts

- Front-End Planning Phase (Pre-Approval):
 - Define specifications in contracts with clearly stated expectations and roles.
 - Include well-defined milestone incentives in contracts.
 - Have a well-established baseline as part of the contract and manage changes with respect to the agreed baseline.
 - Define interfaces in the contract, taking special care to avoid scope overlap.

Factor E4 - Unexpected materials and / or equipment delays.

- Front-End Planning Phase (Pre-Approval):
 - Identify critical path procurement items and place orders early to avoid delays.

- Integrate engineering, procurement, and execution plans.
- Establish special role(s) for managing a complex logistics network.
- Execution Phase (Post-Approval):
 - Hold periodic review meetings with the materials management group to identify potential procurement delays.
 - Hire experienced personnel to manage key materials management functions.

Factor E5 - Underperforming Contractor or Key Subcontractor

- Front-End Planning Phase (Pre-Approval):
 - Distribute the scope of work in multiple packages to hedge risk that one of the contractors/subcontractors may fail to meet expectations.
 - Have strong pre-qualification requirements process in place and evaluate the capability of the contractor before the award is made.
- Execution Phase (Post-Approval):
 - Owners need to provide support and organizational guidance to local contractors and work with them in a collaborative way to identify and remove roadblocks.
 - Evaluate contractor/subcontractor performance regularly.
 - Conduct final “lessons learned” on contractor performance and document results

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