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RISK IDENTIFICATION AND MECHANISMS FOR MITIGATION

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ABSTRACT
All engineered and constructed projects have goals and risks associated with their achievement. As construction projects worldwide become more technically and contractually complex, the risks associated with them are magnified and the negative impacts to their execution are enhanced. These risks are further exacerbated by the current international trend of increased multinational participation/execution of projects. Thus, timely and adequate risk identification is paramount in order to enable risk to be adequately managed and administered.

This paper examines some of the major sources of risk on international engineered and constructed projects. This is accomplished through the analysis of the life cycle of a typical engineered and constructed project to understand the execution processes that occur during the stages of a project, their timing, relationships and dependencies. This knowledge is utilized to allow the identification and understanding of some of the major sources of risk that occur during the life of an engineered and constructed project, as well as the timing and magnitude of the resulting impacts. This paper offers insight and discussion relative to potential mechanisms and processes for mitigating the impacts resulting from the major sources of risk. Specific examples are detailed to offer insight to contractors, construction managers and owners involved with international engineered and constructed projects in order to properly identify and assess major sources of risks.

KEYWORDS
Risk, Impact, Delay, Disruption, Planning

1. INTRODUCTION

Risk is simply the potential for complications and problems with respect to the completion of a task and the achievement of a goal. Risk is inherent in all undertakings, including engineered and constructed projects. As such it can never be fully eliminated, but can be effectively managed to mitigate the impacts to the achievement of a project's goals. Engineered and constructed projects typically define goals in terms of time, cost and performance. For any project to meet these defined goals, risk must be managed, and thus must be integrated into the project constituents' overall project management approach. This integration can only be accomplished by first identifying the major sources of risk and when they occur during the life of an engineered and constructed project. Specific examples offer insight to contractors, construction managers and owners involved with international engineered and constructed projects to aid in properly identifying and assessing major sources of risks. Following the identification of the sources and timing of risk, an understanding of the various types of impacts that routinely result from those risks is necessary to facilitate the development of potential mitigating and managing mechanisms/processes.

In addition, to facilitate this understanding, it is necessary to analyze the life cycle of a typical engineered and constructed project, concentrating specifically on the processes that are being implemented as well as their relative timing. This project life cycle knowledge allows a comprehensive understanding of the major sources of risk identified, including the risk timing and impacts. It is only through this fundamental understanding that potential mechanisms and processes for mitigating the impacts resulting from the major sources of risk can be effectively implemented. This paper details the use of one such mechanism, the Risk Profile.

2. TYPICAL PROJECT LIFE CYCLE

While all engineered and constructed projects are unique, it has been well documented that they can be defined with a typical project life cycle. This project life cycle typically consists of four main stages: feasibility, planning and design, construction, and startup and turnover (Project Management Institute, 1996).

2.1 Stage 1 – Feasibility

The first aspect of any engineered and constructed project is the concept. This can be anything from a structure to a roadway to a power plant. For a concept to be reasonable and practical, the following criteria need to be met:

- The project can be physically engineered and constructed.
- The technology and expertise exist to enable the project to be engineered and constructed consistent with the expectations of the constituents.
- The expected benefit of the project justifies the cost of implementation.

Subsequent to the creation of the initial concept, a more detailed project formulation is developed. This typically involves comprehensive feasibility studies to determine whether the initially formulated project meets the basic criteria discussed above. Following the necessary feasibility studies and the securing of financing, the final component of this initial stage typically involves the generation of the design basis (conceptual design documents including general layouts). The goal of the Feasibility stage of the project is the decision of whether the project should go forward.

2.2 Stage 2 – Planning and Design

The Planning and Design stage of the project life cycle generally consists of continued strategy formulation, execution planning and design. During this stage, the basic parameters for executing the project are set. These include:

- Contract Type (Lump Sum, Cost-plus, Unit Price)
- Project Delivery Mechanism (Design-Bid-Build, Engineer-Procure-Construct, Turnkey)
- Primary Schedule Requirements (Project Start, Substantial Completion, Commercial Operation)
- Primary Cost Requirements (Design, Equipment, Materials, Construction)
- Detailed Planning (Project Management Processes including Staffing, Resources, Procurement, Scope Change)

Subsequent to the generation of the basic execution parameters, the design and engineering of the project are further advanced. This advancement of the detailed engineering enables the effective implementation of the bidding process. The implementation of the bidding process allows completion of the overall project team (including main subcontractors). The goal of the Planning and Design stage of the project lifecycle is the letting of the major contracts.

2.3 Stage 3 - Construction

The Construction stage of the project life cycle is the actual execution of the full project scope of work, from the finalization of detailed engineering to the physical construction of the project. The Construction stage typically consists of the following major components of work:

- Equipment and Material Procurement
- Fabrication and Delivery of Major Equipment
- Mobilization
- Site and Civil Works
- Equipment Installation
- Mechanical Works
- Electrical Works
- Instrumentation and Control Works

While the overall definition of the Construction stage is relatively simple, in actuality it involves thousands upon thousands of decisions, actions and individual efforts to accomplish the goals established for the project. It is important to note that these actions are performed within the execution context established during stages 1 and 2. As such, the impacts resulting from the major sources of risk routinely manifest during this stage. The goal of this stage of the project life cycle is the achievement of substantial completion.

2.4 Stage 4 – Startup and Turnover

The final stage of the project life cycle is Startup and Turnover, which typically includes the following major components:

- Final Testing
- Commissioning
- System Turnover
- Contract Closeout
- Start of Operation and Maintenance

The timing of Startup and Turnover is directly correlated to the complexity of the project being executed. Similarly, when the technology associated with a specific project is untested or new, the duration of stage 4 typically increases. The goal of the Startup and Turnover stage is project completion.

A graphical representation of the typical project life cycle for an engineered and constructed project is provided below (adapted from Project Management Institute, 1996):

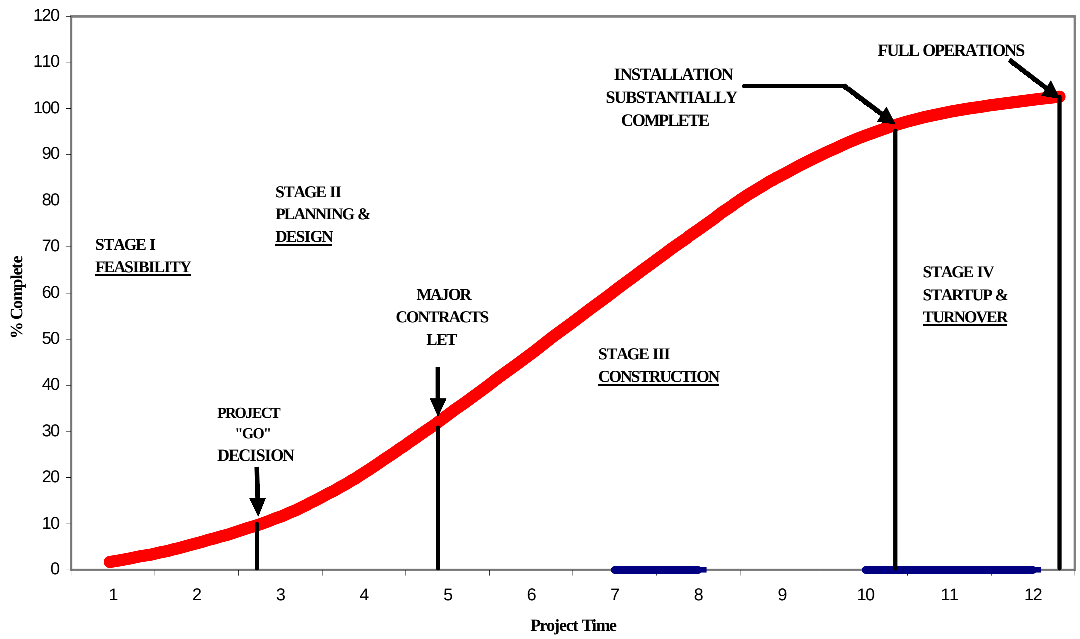

Figure 1: Typical Construction Project Life Cycle

3. ANALYSIS OF MAJOR SOURCES OF RISK

The fundamental understanding of the project life cycle in conjunction with my experience with dozens of internationally engineered and constructed projects over the past several years has led to my determination that the risks typically encountered on an engineered and constructed project result from several major sources. I have identified those sources as:

- Changes in Project Scope and Requirements
- Design Errors and Omissions
- Inadequately Defined Roles and Responsibilities
- Inaccurate Cost and Schedule Estimates
- Insufficient Skilled Staff
- Force Majeure
- New Technology

An analysis of these major sources of risk within the context of the typical project life cycle is provided in Table 1.

Table 1: Major Sources of Risk Within Typical Project Life Cycle

Main Source of Project Risk	Examples	Timing of Risk	Timing & Types of Impacts
Change in Project Scope & Requirements	- Increased Plant Capacity - Increased Battery Limits - Additions of Systems - Change Orders	- Stage 1 (easiest) - Stage 2 (moderate) - Stage 3 (difficult) - Stage 4 (most difficult)	Stages 3 and 4 typically in form of inefficiency, disruption and delay
Design Errors & Omissions	- Deficient Design Documents - Improperly Sized Equipment - Design Calculation Errors	Typically stage 2	Stage 3 in the form of increased engineering support and construction disruption and inefficiency
Inadequately Defined Roles & Responsibilities	- Design-Bid-Build vs. Lump Sum Turnkey - Multinational Participants	Typically stage 2 Sometimes stage 1	Stage 3 in the form of overall inefficiency, disruption and delay
Inaccurate Cost & Schedule Estimates	- Cost of Equipment, Materials and Labor - Resource Allocation - Task Duration Estimating	Typically stage 2 Sometimes stage 1	Stage 3 in the form of inefficiency and disruption from poor coordination and insufficient resources
Insufficient Skilled Staff	- Project Location (USA vs. International) - Engineering Disciplines - Commissioning Specialists	Typically in stage 2	Stages 3 and 4 in the form of productivity inefficiency as work can not be completed per schedule
Force Majeure	- Extreme Weather - Labor Unrest - Theft of Material/Vandalism - Differing Site Conditions - Power and/or Feed Supply Loss	Typically stages 1 and 2 Sometimes stages 3 and 4	Stages 3 and 4, impact can be substantial, often resulting in complete stoppage of work
New Technology	- New Plant Capacity - New Combination of Systems or Assemblies - New System Layout - Unproven Technology - Operation in New Climate	Typically stage 1 and 2	Stage 4 in the form of increased commissioning costs and time

Review of these major sources of risk within the execution context of numerous projects of various types (including infrastructure, process, power, transportation and general building) has yielded specific patterns and trends with respect to risk. The first trend is that, regardless of the source of risk, the catalyst typically occurs during stages 1 and 2 of the project life cycle while the resulting impacts do not usually manifest until stages 3 and 4. As such, stages 1 and 2 of the project life cycle are the most critical stages of a project's life, specifically relative to risk, as there are enormous complexities encountered when projects advance from idea to execution. During stages 1 and 2 the catalyst of risk occurs, and that is also when decisions relative to risk mitigation must be made in order to be effective. In addition, stages 1 and 2 of the project life cycle establish the execution context in which the project will be executed.

The second pattern and trend is that impacts that result from the major sources of risk typically do not manifest themselves until either stage 3 or 4 of the project life cycle. This delay in manifestation increases the difficulty in identifying project risk, particularly during the feasibility and planning stages of a project. Unless specific attention is paid to the implementation of project-specific risk analysis and mitigation mechanisms, risk may be overlooked and/or remain hidden from management until the resulting impacts begin to manifest. As stated previously, these impacts routinely manifest during stages 3 and 4. During this timeframe the largest portion of capital expenditure (utilization of labor, equipment and materials) is usually occurring, as actual construction is being undertaken. Therefore, impacts from sources of risk not only have a direct effect on productivity in the form of inefficiency due to rework and/or modifications, but also often have severe ripple impacts to both follow-on work and work occurring concurrently. Often these ripple impacts are a result of site access issues, congested work areas, stacking of labor trades and forced overtime in an attempt to mitigate the delay and impact caused initially by the risk issue.

This ripple effect in turn exacerbates the impact attributable to the particular risk issue in the form of increased disruption. Therefore, risk issues are extremely significant as the resultant impacts, typically in the form of productivity inefficiency and disruption, routinely cause large project cost and time overruns.

4. MECHANISMS FOR RISK MITIGATION

To effectively manage the major sources of risk previously discussed and their resultant impacts, it is necessary to implement effective project risk management. Effective project risk management has three steps:

1. Identification of the project risks;
2. Evaluation of those risks for likelihood of occurrence and potential impact; and
3. Mitigation planning for those risks identified and evaluated as having a high potential of occurrence and/or significant financial impact on the project.

Since this paper has previously discussed steps 1 and 2, this section focuses on establishing a project risk mitigation mechanism.

4.1 Risk Profile

A Risk Profile is one of the tools used to systematically guide the implementation of sound, effective risk management on engineered and constructed projects. A Risk Profile may be used in every project situation, from first inception to final completion, growing and changing as the project life cycle is advanced. A Risk Profile is a dynamic tool that needs to be updated and changed through each stage of the project life cycle.

The first task of a Risk Profile is to identify the scope of risk contained within the project as established by the project stakeholders and as allocated within the contract documents. When the scope of work is completed, a profile of the specific risks inherent within the project emerges. Developing the Risk Profile requires attention to various fundamental principles and sequential steps that must be undertaken to complete a useful profile and mitigation mechanism.

First, the fundamental principals:

- Elements of project risk exist in every project and on every page of the contract document set associated with a project, from the formal signature page to the last cited code or exhibit.
- Elements of risk exist independent of the protections or limits of liabilities established within the contract document set and, for the purposes of managing the project, risks should not be ignored because of the protections or limitations of the contract. Neither the owner nor the contractor should manage a project to a contractual limit of liability; rather, projects should be managed to control risk and its sources.
- No one person is competent to identify and/or evaluate all of the risk elements associated with a project and its contract document set.
- Communication of risk and its potential sources among all project constituents is critical. If the appropriate parties have not identified potential sources of risk, they cannot implement action to avoid or mitigate that risk.
- Each engineered and constructed project is unique. As such, the Risk Profile must be developed and tailored to the meet the specific needs and peculiarities of the project.
- Having developed a project specific Risk Profile, it is necessary to audit the project against it, as well as to update the Risk Profile periodically. This process allows the inclusion of new risk sources that may potentially occur during execution and also facilitates addressing changes to risk elements originally identified.

Once the fundamental principals of risk and its sources are understood, an effective Risk Profile can be generated to provide the project management team with a mitigation mechanism. A Risk Profile generally first identifies elements of risk into three categories: 1) project organization and relationships, 2) hard scope of work and 3) soft scope of work.

Project organization and relationships involve those formal, informal and scope-dependent relationships that exist in every project when more than one firm is involved. This is typically the case and the trend in international practice. These relationships can be shown in a pair of organization charts in which different levels of formal responsibility and roles can be identified. The project organization and relationships are concurrently direct and indirect, formal and informal and, unless known and properly identified, represent a major source of risk, as previously discussed.

The hard scope of work is generally the easiest component to identify, as it consists of what are commonly known as deliverables within the contract document set. A hard scope of risk element normally requires a product, some tangible action or a quantifiable result. Hard deliverables include such items as monthly progress reports, cost estimates, schedule updates, design packages, etc. Hard scope items carry clear terms of success or failure (the project team either completed and submitted the design package or it did not) and often have significant liquidated damages associated with them.

The soft scope of work consists of the stated obligations, responsibilities and duties that require interpretation to define. These issues are often difficult to measure compliance against or to prove. Soft scope risk elements exist in provisions of the contract document set that use the words “coordinate,” “assure,” “best efforts,” etc. A soft risk element can be disputed on a number of different levels from interpretation of the requirement itself, to how the execution of the element is to be judged. In most projects, soft scope claims are the easiest to make and the most difficult to defend against.

Listing the risk elements inherent in a project via these three categories is only the first step. It is also necessary to evaluate each of those risk elements for likeliness of occurrence and potential impact on the project. Table 1 provides a solid first step but, as all projects are unique, the information in Table 1 can only serve as a starting point. Using the above three components, risks imposed solely by the contract requirements (Contract Risks) and risks inherent to the execution plan developed for the project (Execution Risks) need to be identified and evaluated systematically by a group of key members of the project team supported by industry experts. All project constituents must manage the costs associated with managing risks. Therefore, for all project constituents it is important to prioritize the risk management resources set aside for the project in order to address first the sources of risk with the greatest potential to impact the project.

In conclusion, from the first day of initiation of any engineered and constructed project, potential risk is inherent. Development of a Risk Profile should begin very early in a project in order to provide a mechanism for identifying the main sources of risk and mitigating the impacts resulting therefrom. Every constituent involved in the assembly of the project should contribute to the baseline Risk Profile. That project-specific baseline Risk Profile is the start of a dynamic document, one that needs to be routinely updated and implemented through the entire project life cycle. The Risk Profile represents only one step of the full risk management process. It is a tool that will provide effective risk mitigation only when it is properly implemented.

5. REFERENCES

Project Management Institute (1996). “A Guide to the Project Management Body of Knowledge”. *Project Management Institute Standards Committee*, pp 11-15.