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RISK ANALYSIS IN TRANSPORTATION PROJECTS

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ABSTRACT

Over the years, risk analysis methodologies have been developed and implemented by many industries. NASA has implemented a cost efficient Continuous Risk Analysis methodology with good results. The U. S. Department of Transportation also states that a continuous risk analysis is the key in identifying, addressing, and handling risks before they become threats to success. However, current practices seldom incorporate this concept into real transportation projects. In general, risk is simply disregarded in feasibility studies. One of primary reasons is the lack of a feasible and effective risk analysis approach to guide efficient implementation in real projects.

This thesis reviews current risk analysis practices used in public transportation projects. Using a case study, it also explores potential obstacles encountered in the implementation of systematic risk analysis. Finally, this thesis presents a preliminary risk analysis framework developed through the case study and enriched subsequently by incorporating material documented in the literature.

The proposed risk analysis approach is to help achieve continuous risk analysis in transportation projects by enabling early start, frequent implementation, extensive application and flexible adoption.

I. INTRODUCTION

Due to various uncertainties and risks, major capital transit projects are not an exception for budget overruns and schedule slippages. The transportation infrastructure industry has a major credibility problem. Its track record on mega-projects is terrible. The costs are often grossly under-estimated, and traffic is all too often over-estimated (Poole 2013).

A Danish research study best illustrates the current challenge encountered in transit projects. Flyvbjer (2012) studied 258 projects including 58 rail projects, 33 fixed link projects such as bridges and tunnels, and 167 road projects in 20 nations. The result shows with overwhelming statistical significance that in terms of costs transport infrastructure projects do not perform as promised or estimated. Flyvbjer states that nine out of 10 transport infrastructure projects fall victim to cost overruns. For rail, the average cost overrun is 45%, for fixed links such as tunnels and bridges, the average cost overrun is 34%, for roads, the average cost overrun is 20% and for all project types average cost overrun is 28%. Based on his continuous research, cost overrun has not decreased over the past 70 years and seems to be a global phenomenon.

Flyvbjer pinpoints that the main reason for the unpleasant results of the studies is that "risk is simply disregarded in feasibility studies . . . by assuming what the World Bank calls the EGAP principle: Everything Goes According to Plan." But in mega-projects like the Boston's Central Artery/Third Harbor Tunnel Project, the "Big Dig", the largest public project in the United States, things seldom go according to plan, and nobody should expect that they would.

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- The preliminary risk analysis for framework is based on best practices in design and construction. those practices are adapted to the unique needs of highway project development. The iterative risk management framework is described in terms of the project development phases and project complexity. The framework is scalable from small and non-complex projects to large and complex projects. There are five imperative steps to managing project risk.
- 1**. *Risk identification*** is the process of determining which risks might affect the project and documenting their characteristics using such tools as brainstorming and checklists.
- 2. ***Risk assessment/analysis*** involves the quantitative or qualitative analysis that assesses impact and probability of a risk. Risk assessment assists in deriving contingency estimates.
- Quantitative and qualitative risk analysis procedures are applied to determine the probability and impact of risks.
- 3. ***Risk mitigation and planning*** involves analyzing risk response options (acceptance, avoidance, mitigation, or transference) and deciding how to approach and plan risk management activities for a project.
- 4***. Risk allocation*** involves placing responsibility for a risk to a party – typically through a contract. The fundamental tenants of risk allocation include allocating risks to the party

  best able to manage them, allocating risks in alignment with project goals, and allocating risks to promote team alignment with customer-oriented performance goals.
- 5***. Risk monitoring and control*** is the capture, analysis, and reporting of project performance, usually as compared to the risk management plan. Risk monitoring and control assists in contingency tracking and resolution.
- **Keys to Success**
- Lessons learned from the development of this Guidebook can be summarized in five keys to success for applying risk analysis tools and management practices to control project cost.
- 1. Employ all steps in the risk management process.
- 2. Communicate cost uncertainty in project estimates through the use of ranges and/or explicit contingency amounts.
- 3. Tie risks to cost ranges and contingencies as a means of explaining cost uncertainty to all stakeholders.
- 4. Develop risk management plans and assign responsibility for resolving each risk.
- 5. Monitor project threats and opportunities as a means of resolving project contingency.

II. TRANSPORTATION PHASE DEVELOPMENT

- Due to slight variations in the terms used by the state highway agencies to describe their project development phases, generic set of terminologies are presented in this guidebook consistent with the *NCHRP(National Cooperative Highway Research Program) Report 574: Guidance for Cost Estimation and Management of risk for Highway Projects During Planning, Programming, and Preconstruction* project development phases: **1) Planning, 2) Programming, 3) Preliminary design, 4) Final design**. These phases are described in Table 2.1 and shown in Figure 2.1. To ensure the applicability of terms SHAs

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from across the country participated in a vetting of the project development phases described in the Report 574. Typically, a

SHA will prepare project cost estimates during each of the four phases of project development. Figure 2.1 depicts an overlapping approach in the Planning, Programming, and Preliminary Design phases. This overlapping indicates the cyclical nature of these phases as transportation agencies identify needs and define projects to address those needs.

III. DEVELOPMENT PHASES TYPICAL ACTIVITIES

- ***Planning***
- Purpose and need; improvement or requirement studies; environmental considerations; right-of-way considerations; schematic development; public involvement/participation; interagency conditions.
- ***Programming***
- (a.k.a. scoping,
- definition) Environmental analysis; alternative selections; public hearings; right-of-way impact; design criteria and parameters; project economic feasibility and funding authorization.
- ***Preliminary Design***
- Right-of-way development; environmental clearance; preliminary plans for geometric alignments; preliminary bridge layouts; surveys/utility/locations/drainage.
- ***Final Design***
- Right-of-way acquisitions; PS&E development – final pavement and bridge design, traffic control plans, utility drawings, hydraulics studies/final drainage design, final cost estimates.

IV. PROPOSED RISK ANALYSIS APPROACH

- Making good decisions that take account of real-world uncertainties can provide a margin of safety and profit. As for Springfield Union Station Intermodal Redevelopment Project, risk analysis is an opportunity and a critical tool to help solve problems and to enhance communications within the project for a more effective team effort. Guided by FTA formalized risk analysis methodology, the proposed risk analysis approach was tailored for Springfield Union Station Intermodal Redevelopment Project.
- The approach is composed of six steps which are:
- a) Identify the "stakeholders" in this process.
- b) Identify the specific risks from the point of view of the stakeholders.
- c) Identify the potential consequences of each of these risks in terms of cost and schedule, as well as the probabilities of occurrence of each of these events.
- d) Conduct quantitative risk analysis to determine the overall risk distribution of the cost and the schedule. Monte Carlo simulation is suggested by FTA formal structured risk analysis methodology.
- e) Conduct a risk analysis workshop and develop a mitigation plan by identifying alternative ways that could be used to mitigate or transfer the potential impacts of risk.
- f) Evaluate the consequences of each alternative response and select risk management strategies.

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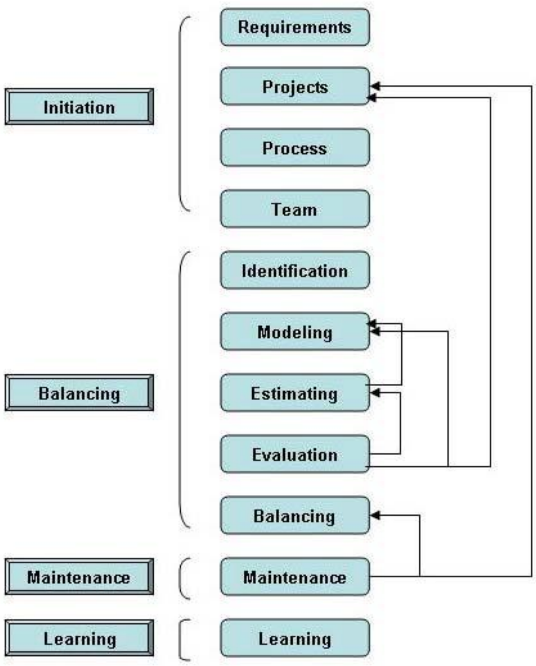
V. PRELIMINARY RISK ANALYSIS IN TRANSPORTATION PROJECTS..

- ***New Approach Overview***
- To continue the risk analysis and help decision-making, a new, effective and feasible approach had to be determined in a timely manner. The new approach was developed based on lessons learned from the application of the FTA formalized risk analysis methodology on Springfield Union Station Intermodal Redevelopment project and academic surveys on generic risk analysis methodologies. Moreover, the newly-developed preliminary risk analysis framework was also tested on the Union Station project.
- ***Generic Risk Analysis methodologies***
- The basic project risk analysis steps are well known in many fields, ranging from aerospace projects, health and environmental management to IT, which are:
- 1) Identify the sources of risk
- 2) Identify the range of possible risk events
- 3) Assess the potential impacts of risk events on the project
- 4) Identify alternative responses to mitigate the hypothetical impacts of risk events
- 5) Identify the consequences of the alternative responses
- 6) Select risk management strategies including the allocation of projects.

VI. RISK ANALYSIS PROCESS



VII. RISK ANALYSIS IN TRANSPORTATION PROJECTS

Current Status of Risk Analysis Techniques

Dynamic Risks

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Uncertainties and risks inherently exist in construction projects. Construction projects are unique comparing to most of other industrial projects. The inherent uncertainties are generally not only from the unique nature of the project, but also from the diversity of resources and activities (CII 1989). Moreover, risks are not always independent and static in construction projects. The effect of two events is not necessarily the sum of their individual effects. For example, one-day delay due to snow storm and the same day delay due to a design change are two independent events, but in combination they have the same consequence – no work can be done that day. Accordingly, risks are usually dynamic, that is, their characteristic, probability and impact can change during the project process.

In addition, external factors can have a very significant effect on projects. Project success is usually measured by its schedule, budget and quality. Broadly, various risks can affect these three basic factors against the success of a project. In general, the project scale and complexity have close relation to the schedule of the project; and at the same time those two aspects have relations with the impact or severity of risk. That is, in many circumstances, the larger and more complex the project, the longer the time is required to complete the project, and more severely will it be affected by project uncertainties and risks.

Thus, for large and complex construction projects, budget overruns and schedule slippages are not rare and scope changes are inevitable as well. According to the research report of the FTA, in the United States, cost overruns in large complex projects such as power plants have been common. Cost estimates for the Boston's Central Artery/Third Harbor Tunnel Project, the "Big Dig", which is currently the

largest public project in the United States, have been continuously adjusted upwards in the past years.

I. Static Techniques

In many industries including construction industry, risk, if left unmanaged, could have a negative impact on project budget and completion and prevent the project from meeting its overall objective. If people intend to use appropriate data to solve problems, make forecasts, develop strategies, and make decisions, then risk analysis is an essential control tool for project management and an important aid in decision-making process.

Risk analysis is not far away from our everyday lives. Professional risk analysts perform risk analysis technologically, while most people rely on intuitive risk judgments and perceive risks subjectively. The implementation of risk analysis is increasingly being recognized as a vehicle to help meet project goals as well as improve project performance at the same time.

Use of formal risk analysis techniques in projects is widespread across many industries. The value of a proactive formal structured risk analysis approach has been widely recognized, and many organizations have been or are seeking to introduce risk processes in order to gain the promised benefits. In many areas its use is mandatory or required by client organizations, including defense, IT, offshore, nuclear industries and so on. It appears that risk analysis is a mature discipline, yet it is still developing and need to be understood better and implemented by managements.

And risk analysis is a process. There is some way to go before its full potential as a management tool is realized in construction industry.

II. 2.1.3 Development Lags

The construction industry lags much of many other industries in making use of risk analysis for civil infrastructure projects. And the development and implementation of risk analysis for transportation

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infrastructure projects in the United States also lags those in Europe. Therefore, the importance and urgency of risk analysis in today's transportation projects in the United States, in face of financial constraints, has spurred several research efforts in this area. Risk analysis is full of challenges in transportation infrastructure industry. Yet, it is imperative that the owners, sponsors and project participants engage in a rigorous, systematic analysis of major sources of risk.

VIII. CONTINUOUS RISK ANALYSIS

Uncertainties are inherent and risks are dynamic. As a project proceeds, a continuous risk analysis would be more beneficial. Risk analysis should be applied to all stages of the project lifecycle, from conception, feasibility and design, through development into implementation, operations and maintenance. The contribution which risk analysis can make at each stage different, but is nevertheless of importance.

Risk analysis should start in a very early stage of the project process and need to be done frequently. Only with the aid of a continuous risk analysis process can short-term and long-term impact of identified risks are determined and updated, and hence help decision-making and project management. NASA presents a six-function of continuous risk management as shown in Figure 2-1.

The six functions of continuous risk management are (1) Identify the risks in a specific format; (2)Analyze the risk probability, impact/severity, and timeframe; (3)Plan the approach; (4)Track the risk through data compilation and analysis;

(5)Control and monitor the risk; (6)Communicate and document the process and decisions. (Rosenberg 1999)

Continuous Risk Management Diagram

The continuous risk analysis concept has been incorporated into real practice in many industries including IT, defense, nuclear industries and so on. However, continuous risk analysis has not been actually applied to construction projects including transportation infrastructure projects. Most current formal structured risk analysis methodologies do not support the continuous risk analysis very well, due to time, cost and some other constraints for transportation projects.

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IX. EVOLUTION OF RISK ANALYSIS CONCEPT

Various Risk Analysis Definitions

Risk analysis is defined as estimating the probabilities needed as input data for the evaluation of decision alternatives (Lifson and Shaifer 1982). Risk analysis can also be described as any method qualitative and/or quantitative for assessing the

quality control analysis. impacts of risk on projects or plans. General Accounting Office defines risk analysis as a technique to identify and assess factors that may jeopardize the success of a project or achievement of a goal. This technique also helps define preventive measures to reduce the probability of these factors from occurring and identify countermeasures to successfully deal with these constraints when they develop.

No matter how one defines risk analysis, the objectives of risk analysis in any field are to determine the probability of failure of a system to meet a predetermined level of performance during a given period, to improve the decision-making process within projects, and to help organizations to reduce risk exposure. However, various definitions always cause confusions and misunderstanding some times.

X. CONCLUSION

- The preliminary risk analysis framework has been developed as an alternative of risk analysis methodology when risk data is not sufficient to implement quantitative techniques. The results of risk analysis by using this approach are generated by guiding participants' real perspectives on the project. Wilson (2001) mentioned that a real beneficial risk analysis is focused on a very strong emphasis on the word *thorough*. Many attempts to perform risk-benefit analysis have been inadequate. If time, knowledge and resources do not admit of a thorough analysis, the preliminary risk analysis framework might be justifiable.
- This methodology facilitates improved communications among parties involved in the project at an early stage of a project. The success of many formal risk analysis methodologies relies on relatively complete and precise project information in cost and schedule to generate relatively precise and useful risk profiles. This often prevents an early effort of risk analysis and management. Otherwise, implementing risk analysis using Monte Carlo simulation or other quantitative techniques when required data are not sufficient for evaluation will mislead the decision-making process and lose its functions to benefit management. Under this situation, this preliminary risk analysis framework could be implemented at an early stage of project. This framework would be more helpful for managing expectations for budget and schedule in this environment.
- A continuous risk analysis is the key to identify, address, and handle risks before they become threats to success, and, this preliminary risk analysis framework could enable the realization of a continuous risk analysis for transportation projects. It facilitates the validation of continuous risk analysis in transportation infrastructure projects by enabling early commitment, extensive application, flexible adoption and frequent implementation, hence it is beneficial for communications among project participants and decision-making of management.

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FUTURE SCOPE..

- **Tests on Real Projects**

The preliminary risk analysis framework was developed through the case study and improved based on the lessons learned from the real risk analysis practice in Springfield Union Station Intermodal Redevelopment project and the literature review. This improved preliminary risk analysis approach should be examined.

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