2004-12-25

Development of a Framework for Preliminary Risk Analysis in Transportation Projects

Wei Guo
Worcester Polytechnic Institute

DEVELOPMENT OF A FRAMEWORK FOR PRELIMINARY RISK ANALYSIS IN TRANSPORTATION PROJECTS

by

Wei Guo

A Thesis

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Master of Science

in

Civil Engineering

December 2004

APPROVED:

Professor Guillermo F. Salazar, Advisor

Professor Leonard D. Albano

Professor Frederick Hart

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.

ACKNOWLEDGEMENTS

With a deep sense of gratitude, I wish to express my sincere thanks to my advisor, Professor Guillermo F. Salazar, for his encouragement, stimulating suggestions, and immense help in planning and executing the works in time. The confidence and dynamism with which Professor Salazar guided the work requires no elaboration. On the other hand, profound knowledge and timely wit came as a boon under the guidance of Professor Salazar. His valuable instructions and suggestions during the course of work are greatly acknowledged.

My sincere thanks are due to Professor Leonard D. Albano for providing me constant encouragement and extending timely help. The instructions and kind considerations I received from other faculty members of my department are gratefully acknowledged.

I specially thank Mr. Matthew Keamy for offering me the valuable opportunity for participating in a real transportation project and providing timely help and important information for my research all the time. I would like to thank Mr. Saptarshi Bhattacharya and many executives from Pioneer Valley Transit Administration for sharing their expertise and experience in risk analysis in transportation with me and proving important data for my research.

I wish I would never forget the company I had from my fellow research friend Ms. Jeannette Skoropowski. I enjoyed my work with her a lot. She was also of great help in research development and my thesis writing.

I also want to thank my parents, who taught me the value of hard work by their own example. I would like to share this moment of happiness with my mother, father and little sister. They rendered me enormous support during the whole tenure of my study at Worcester Polytechnic Institute and gave me the encouragement and motivation to carry out my study and teaching work.

Lastly, I am grateful to my husband Kehan Tian for the inspiration and moral support he provided throughout my study. Without his loving support and understanding I would never have completed my present work.

Finally, I would like to thank all whose direct and indirect support helped me completing my thesis in time.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Research Background

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 2004).

A Danish research study best illustrates the current challenge encountered in transit projects. Flyvbjer (2003) 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.

1.2 Research Objectives

Cost overruns in transport infrastructure projects do not isolate from other uncertainties or risks. Cost overruns combined with other deviations and uncertainties translate into significant financial risks. Design/construction risks and financial risks interact and affect the entire project. Scope changes or optimistic cost estimates, and delay in construction due to external or internal factors often yield cost overruns. Political atmosphere and financial issues also contribute to cost overruns. Those risks due to social or political factors are important. In this research, risks in design, construction and financial affecting project budget and schedule are the main focus because of the unmanageable characteristics of political risks.

Risk analysis methodologies have been developed and implemented over the years in many industries. Transit projects generally have large scales and have various parties involved including many related communities and numerous ordinary people who might become the potential clients. The unique characteristics of transit projects make project management and risk analysis more important than in other project sectors.

Using less time to meet higher expectations and fewer resources with which to work is really crucial for business. NASA attempts to achieve the “Faster, Better, Cheaper” by implementing Continuous Risk Analysis at a cost they can afford and have received good results (Rosenberg 1999). A continuous risk analysis is not a totally new concept in transportation infrastructure industry. The Department of Transportation also states that a continuous risk analysis is the key to identify, address, and handle risks before they become threats to success (FTA 1994).

However, current practices seldom incorporate this concept in real transportation projects due to various reasons. Moreover, 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 transportation projects.

The objective of this research is to develop a preliminary risk analysis framework to help solve the above application problems of current risk analysis methodology. Hence, continuous risk analysis could be enabled by implementing the framework, and then the ultimate target of “Faster, Better, Cheaper” could be achieved by continuous risk analysis.

1.3 Research Outline

The thesis first explores the potential obstacles in implementing the current formal structured risk analysis methodologies through a case study. Terminologies, definitions, techniques, and methodologies are also examined and clarified in the research.

Then, the thesis presents a preliminary risk analysis framework developed through a case study and enriched subsequently. The proposed risk analysis approach is to help achieve continuous risk analysis in transportation projects by enabling an early start, frequent implementation, extensive application and flexible adoption.

2 RISK ANALYSIS IN TRANSPORTATION PROJECTS

2.1 Current Status of Risk Analysis Techniques

2.1.1 Dynamic Risks

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.

2.1.2 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.

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 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.

2.2 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)

Figure 2-1. 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.

2.3 Evolution of Risk Analysis Concept

2.3.1 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 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 sometime.

2.3.2 Definitions of Risk Management

There are various definitions for risk management as well. In simple words, they fall into two statements. One defines risk management as a systematic approach for identifying, analyzing, communicating, and mitigating risks. This definition often considers risk analysis as the process of accessing risks, and includes risk analysis as a part of risk management procedure.

Another defines risk management as the process of evaluating and selecting action alternatives in response to risk assessment findings. Risk management is grouped as a follow-up of the previous risk accessing step. This definition is incorporated in this study. Thus the continuous risk management defined by NASA above utilizes the first definition of risk management. NASA's risk management concept in the continuous risk management is not consistent with the one is using in this study.

2.3.3 Evolution of Risk Analysis Definition

In a broad sense, risk analysis is defined to include risk assessment, risk characterization, risk communication, risk management, and policy relating to risk, in the context of risks of concern to individuals, to public and private sector organizations, and to society at a local, regional, national, or global level by the Society for Risk Analysis (SRA). Society for Risks Analysis (SRA) is a unique organization because its membership is drawn from the physical and biological sciences, engineering and the social sciences.

The scientists and practitioners associated with SRA treat this definition as the formal risk analysis definition in their researches and actual practices. This definition of risk analysis is incorporated by an increasing number of organizations in various industries nowadays. This definition is also implemented in this study that risk analysis is not only accessing risks, also communicating and managing risks.

2.4 Overview of Risk Analysis Implementation in Transportation

2.4.1 Typical Characteristics of Transportation Projects

The typical characteristics of transportation projects make project management and risk analysis more important than others. In general, transportation projects have a relatively large scale and have various parties involved even including many related communities and numerous ordinary people who might become the potential clients. Transportation projects are usually developed in several stages. It takes longer time to complete a transportation project than others.

Major capital transit projects are not an exception for budget overruns and schedule slippages due to various uncertainties and risks. 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 2004). Similar to the “Big Dig” project mentioned above, many recent rail projects have similar, well-documented histories.

Moreover, transportation projects are usually funded by government or public. In the conventional approach to project development, government is the project promoter and financier, and private firms who actually conduct the project are intended to do the best-case feasibility studies, produce the designs, and earn additional profits by numerous change orders later on. It’s going to be harder and harder to get public and political support for much-needed mega-projects unless we can come up with better-performing delivery models. The public-private partnership for risk allocation and project delivery method are not the focus of this study. Another critical approach is to incorporate risk analysis into early project development stage, such as feasibility studies.

2.4.2 Risk Analysis Implementation in Transportation

Risk analysis methodologies have been developed and implemented over years in transportation infrastructure industry. Headed by an Administrator who is appointed by the President of the United States within the U.S. Department of Transportation, Federal Transit Administration (FTA) provides financial assistance to develop new transit systems and improve, maintain, and operate existing systems. Federal Transit Administration (FTA) administers a multibillion-dollar program of financial assistance for grantees[1] that provide urban and rural public mass transportation. FTA has been aware of the necessity and urgency of risk analysis and then developed a comprehensive oversight program including project management oversight.

[1] Grantees are the recipients of the allocated funds appropriated by FTA.

Risk analysis is becoming more and more critical for the project management oversight. FTA is improving risk analysis methodologies to enhance the accountability and management, guidance and training and is attempting to extend the risk analysis practice to an increased number and type of projects they funded or monitored.

3 FEDERAL TRANSIT ADMINISTRATION RISK ANALYSIS

3.1 FTA and Its Role

The Federal government, through the FTA, provides financial assistance to develop new transit systems and improve, maintain, and operate existing systems. FTA administrates this financial assistance according to TEA-21. TEA-21 is the Transportation Equity Act for the 21st Century, a public law, authorizes the Federal surface transportation programs for highways, highway safety, and transit. Each year Congress provides an annual appropriation which funds the programs specified in TEA-21.

Upon receiving this appropriation, FTA apportions and allocates these funds according to formulas and earmarks. Generally, FTA funds are available to designated recipients that must be public bodies, such as states, cities, towns, regional governments, transit authorities and so on, with legal authority to receive and dispense Federal funds.

Whereas the grantees of these grants are responsible for the day-to-day management of their projects in accordance with Federal requirements, FTA is responsible for ensuring that grantees follow federal mandates along with statutory and administrative requirements and overseeing the proper use of federal transit funds. FTA conducts oversight reviews to ensure that these requirements are met.

FTA evaluates grantee adherence to grant administration requirements through a comprehensive oversight program which includes Triennial Reviews, Financial Management Oversight, Procurement Reviews, Drug and Alcohol Reviews, Security and Assessment Reviews, Civil Rights Reviews, Intelligent Transportation System Reviews, Planning Oversight, State Management

Oversight, and Project Management Oversight. Risk analysis has become an integrated part of the project management oversight.

3.2 FTA Risk Analysis Background

According to the Mass Transit Report to Congressional Committees, in 1992, the United States General Accounting Office designated FTA's management and oversight of billions of dollars in federal transit grants as a high-risk federal program that was especially vulnerable to fraud, waste, abuse, and mismanagement. Since that time, FTA has attempted to address the oversight weaknesses that were responsible for its high-risk designation and provide a more comprehensive strategy for staff and contractors to follow in overseeing grants management.

The development of a risk assessment process has provided a firm foundation for this improved strategy. Formalized in November 1994, the risk assessment process was a key element in allowing FTA to target its resources to ensure a coordinated, cohesive, and uniform level of oversight activity. In February 1995, as a result of the various initiatives that FTA was undertaking to improve its oversight, General Accounting Office removed FTA from its high-risk list with the understanding that General Accounting Office would continue to monitor the progress and implementation of FTA's oversight initiatives.

Over years, FTA has developed better guidance for its staff and grantees and has standardized its oversight procedures to improve the quality and consistency of its grants management program. In particular, the establishment of a risk assessment process for targeting limited oversight resources has provided a stronger foundation for improved oversight.

3.3 FTA Risk Analysis Fundamentals and Current Status

Ongoing initiatives and related organizational changes are continuing to strengthen FTA's oversight of federal transit grants and decrease the risk associated with providing billions of dollars each year to grantees. FTA defines oversight as a continuous review and evaluation of grantee and FTA processes to ensure compliance with statutory, administrative, and regulatory requirements.

FTA states that as early as the planning phase, alternative project delivery methods should be considered within the context of project risk analysis and procurement planning. Given the nature of the project to be implemented and the experience of the grantee, the project delivery and contracting approach should be selected that minimizes project risks and provides the greatest likelihood of implementation success. Success can be measured in terms of minimizing costs and schedule without sacrificing overall project quality. The general philosophy is that risks should be assigned to the party which is best able to manage them. Therefore, an early started risk analysis is the key.

As part of the improvement of its oversight program, FTA sponsors a Construction Roundtable twice a year to promote knowledge sharing among grant recipients who are in the process of designing and/or constructing major transit capital investments. "Risk Analysis is an effective Project Management Oversight tool for FTA. FTA and project sponsors have already benefited from risk analysis in less than one and a half years." (FTA 2004)

3.4 FTA Formal Risk Analysis Implementation Criteria

A risk analysis typically starts in Full Funding Grant Agreement (FFGA) or Final Design. Full Funding Grant Agreement (FFGA) is a unique contractual obligation that FTA employs when investing a significant amount of New Starts funding into a locally-developed fixed guideway transit project. New Starts Transit Projects with greater than $25 million funds require an FFGA.

According to the research of FTA and discussions with the executives from FTA's federal office and the local office, on a yearly basis, formalized risk analyses were conducted for around six to ten projects which are authorized FFGAs and range from $400 million to $4 billion before Fiscal Year 2003. The former risk analysis practices were productive and really beneficial to the decision-making of both FTA and local transit projects developers. Since Fiscal Year 2003, risk analyses are required for all projects authorized FFGAs; that is, all locally-developed new transit projects which are invested $25 million or more by FTA are required to conduct formalized risk analysis currently. The formal risk analysis implementation criteria are included in Figure 3-1.

Figure 3-1. FTA Project & Risk Analysis Criteria Summary

FTA Project & Risk Analysis Criteria Summary (FY2004)

Project	Amount	Funding	Formal Risk Analysis	
			Before 2003	2004
New Transit Systems			>=$400 million/project 6-8 projects/year (actual)	>=$25 million/project 26 projects (theory)
FFGAs	**26**	$1,368.28		
Existing FFGAs	19	$994.26		
New FFGAs	3	$139.02		
Expected FFGAs (FY04)	4	$235.00		
Non-FFGAs	**68**	\	N	N
Not Authorized	26	\		
Possible (Preliminary Design)	42	\		
Existing Transit Systems	**Hundreds**	\	N	N

The project summary is concluded according to the statistics of FY2004 published by FTA and is also shown in Figure 3-1.

Based on the Administration's proposed funding levels for FY 2004, the proposed New Starts funding level is $1,514.92 million. A total of $994.26 million for nineteen projects with existing FFGAs, a total of $139.02 million for three projects for which new FFGAs, and a total of $235.00 million for four proposed projects that are expected to be ready for FFGA commitments before the end of FY 2004.

Besides these twenty-six projects which were or will be authorized FFGAs, there are forty-two projects that are in the preliminary design stage and hundreds of existing projects from the former years which might have scope changes or major change orders and require risk analyses. For example, the Springfield Union Station Intermodel Project presented in the case study in Section 4 originally started in 1999 and conducted a risk analysis in its late preliminary design stage in 2003. As noted by FTA executive, FTA was experimenting with the Risk Analysis for Springfield Union Station. It was FTA's first attempt to conduct a risk analysis for a non-FFGA project.

According to FTA's annual report for FY2004, they set aside one percent of the total funds for its oversight activities, which was more than $15 million for FY2004. The challenge for FTA is to find a feasible and appropriate risk analysis approach because the current formal structured risk analysis method is difficult to apply in a context of "Faster, Better, Cheaper" for projects which are currently in preliminary design stage and might be authorized FFGAs later on or non-FFGA projects similar to the Springfield Union Station Project.

3.5 FTA Risk Analysis Methodology

3.5.1 FTA Documented Risk Analysis Process

According to FTA, the formalized process of risk analysis can be generalized by the following steps: Identify Risks, Evaluate and Measure Risks, Analyze Risk

Treatment Alternative, i.e., avoidance, prevention, mitigation/cost control, and insurance (purchased or self-insured), Assign Risk, Select Mix of Control Instruments, and Monitor and Evaluate Performance of Measures Instituted. This process is a generic risk analysis methodology documented by FTA previously.

3.5.2 FTA Current Formalized Risk Analysis Methodology

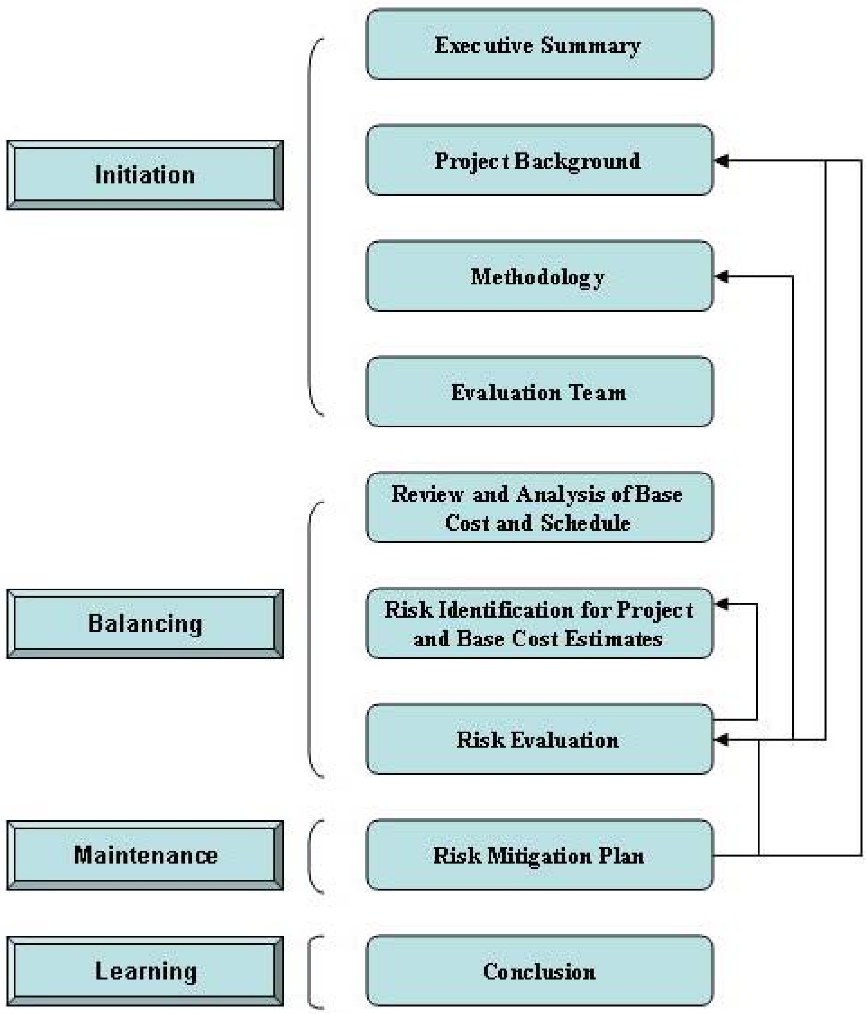
A specific standardized risk analysis methodology has been implemented recently by FTA. The flowchart in Figure 3-2 shows the process of this methodology. According to FTA, this methodology has become the main tool for risk analysis by its grantees.

In the first phase, project is familiarized and risk analysis methodology is studied and determined. Then a suitable risk analysis team will be formed to further the study.

In the second phase, the team would review in detail the base cost and schedule, and the scope of work, and identify risks for each line item or activity of the project. The next step is the development and implementation of a probabilistic model for analyzing project risks in terms of cost and schedule. The analysis is typically done by Monte Carlo simulation.

Based on the risk assessment results, the mitigation strategies are established and incorporated into the report, which would be used for future updates of the methodology.

Figure 3-2. FTA Risk Analysis Methodology



3.6 FTA Risk Analysis Lessons Learned

FTA and project sponsors have already benefited from risk analysis in recent years. FTA continues improving its risk analysis methodologies and management strategies.

Based on the presentation of 2004 FTA Construction Roundtable, the lessons learned from five projects are gathered and represented in this study. This experience provides the foundation for the future improvement of the risk analysis methodology. The Construction Roundtable in 2004 highlighted lessons learned from the past four completed projects in Figure 3-3.

Figure 3-3. FTA Risk Analysis Lessons Learned Summary

Project	Lessons Learned
LA East Side Project	*Subsequent to the initial risk assessment, the tunnel and the station excavation contract was bid and the price of the lowest bid exceeded the Full Funding Grant Agreement (FFGA) budget by more than 25%. *The Grantee undertook mitigation measures and a follow-up risk assessment. This established a confidence level to enable FTA to approve the FFGA.
Pittsburgh North Shore	*Resulted in a confidence level of about 70%, which FTA felt was adequate at 30% design completion level. *Helped the grantee to establish mitigation strategies to save additional $9 million.
Charlotte LRT	*The risk assessment is very constructive when performed during early design phase. Many issues that were identified may have been overlooked if the risk assessment were not done. *Risk Mitigation Plan most effective when developed jointly with the Grantee
Las Vegas Monorail	*Grantee schedule may be overly optimistic and not have reliable Revenue Operations Date. *Schedule issues identified in risk assessment. The outcome helps both Grantee and FTA.

In conclusion, risk analysis helped grantees to be approved the FFGA by FTA and should be performed during early design phase instead of starting at FFGA or Final Design. On the other hand, risk analysis helped both FTA and Grantees manage projects better in terms of project cost and schedule and other critical issues.

4 CASE STUDY

4.1 Case Study Introduction

4.1.1 Motivation for the Case Study

The preliminary work for this study started with a literature review in late August, 2004. Having read extensively in the areas of Project Planning, Contracting, Cost and Schedule, to Information Technologies, Quantitative Methods, and Construction Materials and Methods, I absorbed insights and essentials in a relatively short time and found that project risk analysis and management is a trend and key for construction project management globally.

A risk analysis study was conducted for a real project, the Springfield Union Station Intermodal Redevelopment Project (SUSIRP). It is a relatively complex, multi-phased project that includes Federal, State and local transportation agencies in addition to a private railroad company. Developers, private consultants, businessmen, and “average citizens” are all players in this highly visible and visionary project. The unique characteristics of the project provided me a lot of valuable experience and will be illustrated in details as the case study in my research.

At the same time, the risk analysis study required me to access extensive information of the project. This enabled me to utilize my knowledge and experience in construction, and fostered my interests in construction engineering and management as well as risk analysis integrated in project management. This also provided a firm background for my subsequent research.

4.1.2 General Description

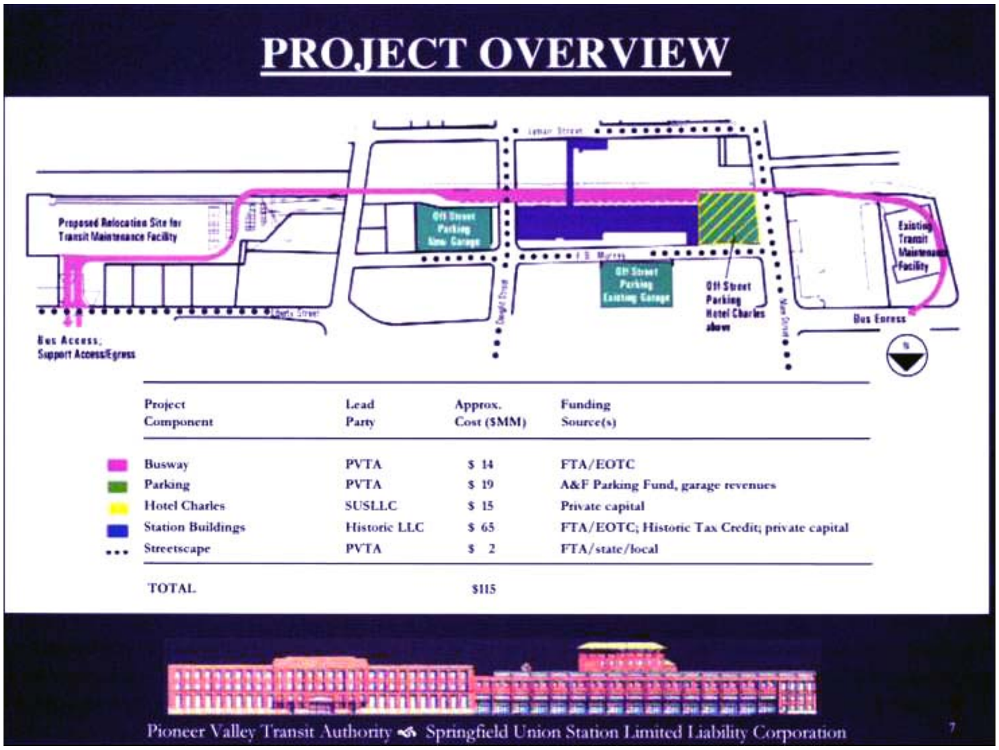
Originally built in 1926, Springfield’s Union Station, a historic, landmarked train station, has been dormant since the 1970’s. Located at 55 Frank B. Murray Street in Springfield, MA, the station is ideally situated directly off of I-91 and I-291, just minutes south of the Massachusetts Turnpike. According to PVTA, it is considered the crossroads of New England. The Union Station highlights the Northern section of the Central Business District (CBD) and is an integral part of Springfield's entertainment and cultural district which includes Symphony Hall and the Civic Center.

Pioneer Valley Transit Authority (PVTA) in conjunction with the Springfield Redevelopment Authority (SRA) and the City of Springfield is coordinating the efforts to redevelop the original station building into a vibrant, mixed-use intermodal transportation facility with bus and rail capabilities in addition to retail and office space, much like what other cities have done, such as the union station s in Washington DC and St. Louis. An exciting intermodel transportation facility is planned to be created to compliment Springfield's bustling CBD and entertainment districts.

In addition to the original building being redeveloped, the project includes two new parking garages, a new maintenance facility for Peter Pan Bus, and a new hotel. The new busway will maximize traffic flow through the area and accommodate both PVTA and Peter Pan buses. Housed within the station will be Amtrak offices and ticket agents and new facilities Peter Pan ticketing and waiting area. This is shown in Figure 4-1.

Another integral part of the project is the acquisition of several parcels of land surrounding the original station. These parcels are necessary to complete the busway ramps and parking garage facilities. The acquisition process on these parcels has been delayed pending the resolution of the major issue: negotiations with CSX.

Figure 4-1. Case Study_Project Overview



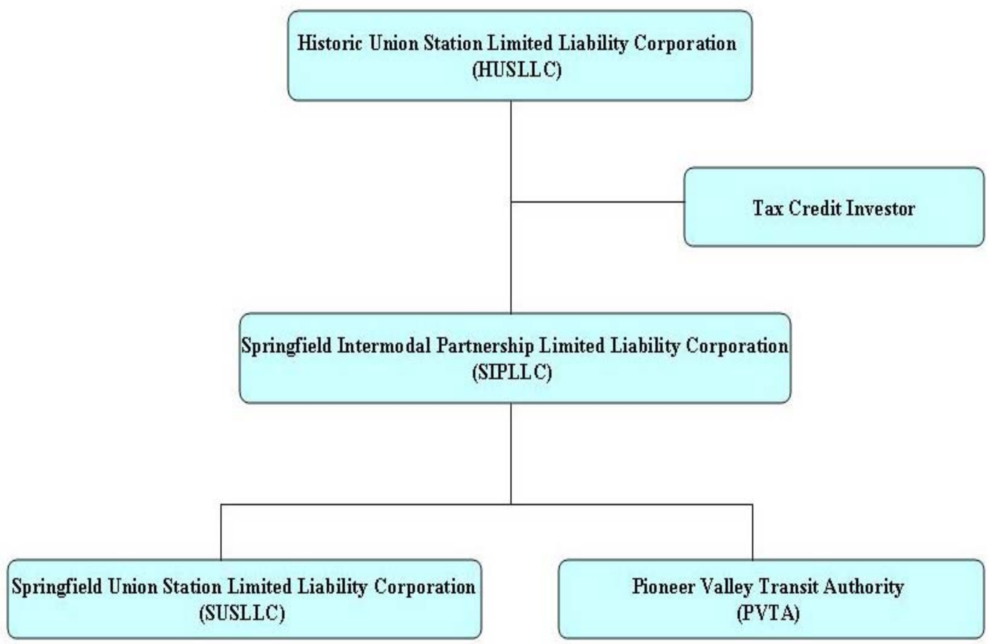
CSX Corporation is the parent company of a number of subsidiaries that provide freight transportation services across America and around the world. Formed in 1980, CSX Transportation operates the largest rail network in the eastern United States. CSX Intermodal provides transportation services across the United States and into key markets in Canada and Mexico. The busway is currently designed in such a way that it requires the utilization of bridges owned by CSX. This is the main issue that has stalled the project significantly.

4.1.3 Project Organization

The project organization is unique as shown in Figure 4-2. The Pioneer Valley Transit Authority (PVTA) and Springfield Union Station Limited Liability

Corporation (SUSLLC) have created a public-private partnership as Springfield Intermodal Partnership Limited Liability Corporation (SIPLLC). SIPLLC combines with a tax credit investor to form Historic Union Station Limited Liability Corporation (HUSLLC).

Figure 4-2. Case Study_Project Organization Chart



4.1.4 Project Funding

The project is funded by both the public sector and the private sector. The total project funding is $115.40 million. The total public funding is $63.70 million, and it is composed of both federal funds and state funds. The funding summary is shown in Figure 4-3.

Figure 4-3. Case Study_Project Funding Summary

Funding Summary (In Million)	
Springfield Union Station Intermodal Project	
Public Funding	**US$63.70**
FEDERAL	**US$37.50**
Original TEA-21	US$14.50
FY00-01 Appropriations	US$2.00
FY02 Appropriation	US$4.00
FY03 Appropriation	US$6.00
Remaining Request	US$6.00
Unforeseen Costs	US$5.00
STATE	**US$26.20**
Private Funding	**US$51.70**
Total Project Funding	**US$115.40**

4.1.5 Project Timeline

The original project major milestones are shown in Figure 4-4.

Figure 4-4. Case Study_Project Original Major Milestones

Timeline	MAJOR MILESTONES
1999/2000	Mater Plan Site Selection Conceptual Design Initiated Funding Committed
Spring 2002	Preliminary Design Completed
Summer 2002	Joint Development Agreement Signed
Winter 2002	Final Design Completed
Spring 2003	Full Construction Contracts Bid and Awarded
Summer 2003	Construction Begins
Summer 2004	Facility Open and Operating

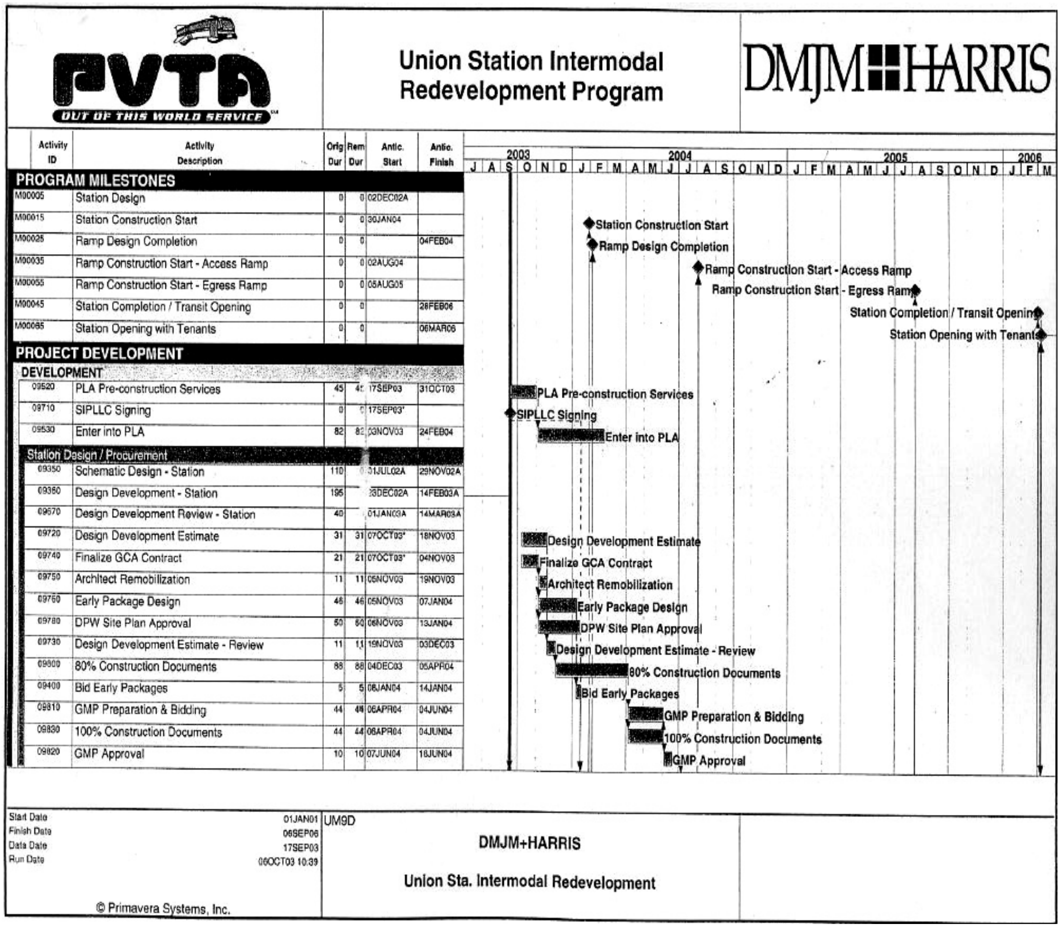
The project's master plan, site selection, and conceptual design were initiated in 1999 and 2000. Moving toward Spring 2002, Preliminary design was completed according to PVTA's publication *Destination*. Originally the project was slated to complete Final Design in the winter of 2002 and to begin Construction in the summer of 2003, and the Station Opening was slated for the summer of 2004.

The original plan was changed due to various external and internal factors. The risk analysis study started in September 2003. Based on the Progress Report of Springfield Union Station Project and project schedule documents provided by the FTA, preliminary development program has been established and Preliminary Design was almost completed in March 2002. The Joint Development Agreement was signed by the spring of 2003. In March 2003, the final design of busway was nearly completed and final design of station buildings and Full Construction Contracts bidding were underway.

Correspondingly, the construction did not begin in the summer of 2003 as originally planned. According to the updated project milestones as shown in Figure 4-5, the construction should have started in February 2004, and the facility will be finally completed by February 2006.

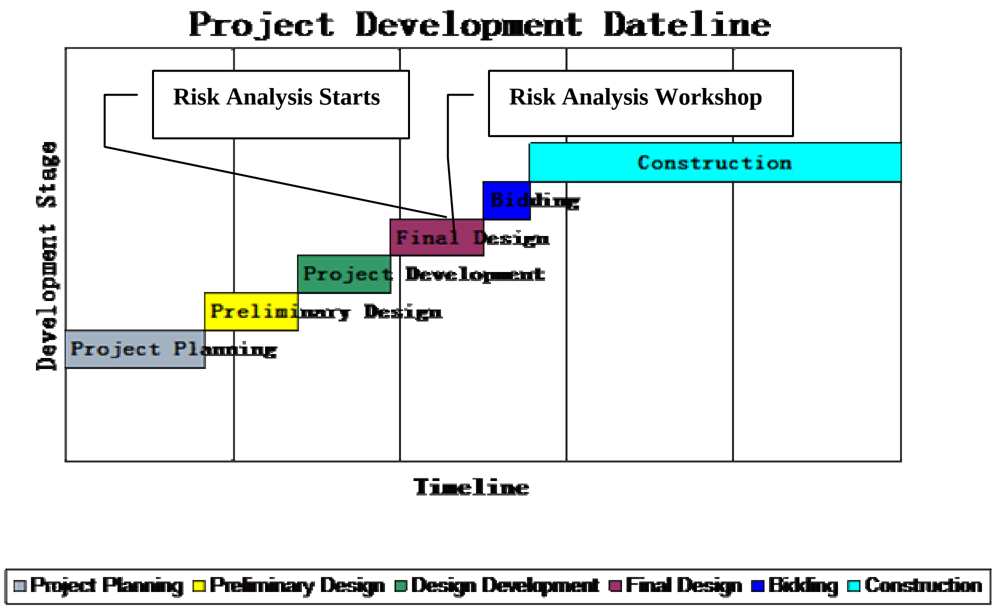
As of the risk analysis workshop date (04/27/2004), the construction had not started. By the date of the workshop on April 2004, the busway concept plan had not been approved by CSX and further information has confirmed that the primary busway concept was actually revised. According to PVTA, the negotiations with CSX have all but stopped at that time and PVTA along with their consultants and the redevelopment authority were assessing alternatives to the current busway design to try and get the project back on track. Therefore, the design of busway and even station buildings had to be revised.

Figure 4-5. Case Study_Updated Project Milestones



Based on the documents and information provided by PVTA and FTA from the beginning of the risk assessment study (September 2003) to risk assessment workshop (April 2004), the project phase can be categorized as the Final Design Stage. The dateline chart in Figure 4-6 shows the project development and the stage at which the risk analysis study conducted.

Figure 4-6. Case Study_Project Stage Illustration



4.2 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.

The process of assessing risks is critical in the whole risk analysis process. The tools or technologies should be selected very carefully. Two tools that are typically used to manage the level of risk associated with construction projects are the project cost estimate and the project schedule. Recent attempts to quantify the risk inherent in construction projects more reliably have focused on range estimating and stochastic scheduling (Isidore & Back, 2001). These tools involve modeling the duration and cost of the activities that make up construction projects as stochastic quantities.

Range estimating and Monte Carlo simulation have been selected as the tools by which we, the WPI risk analysis team, performed the probability of risk analysis on the Springfield Union Station Intermodal Redevelopment Project.

4.3 Study Evaluations

4.3.1 Cost Evaluations

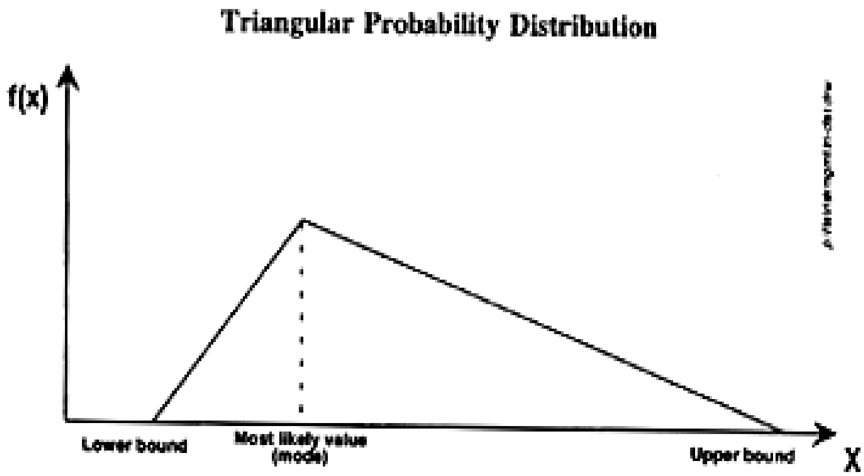
The risk of cost overrun can not be determined if only separate points of cost are given. In theory, cost estimates should be provided as distributions rather than separate points. Before the construction is completed, the actual cost is always an unknown. Many possible outcomes are in existence. If there are many possible outcomes, how to tell which one is most likely is the first problem. The full range of possible outcomes should be identified rather than selecting one value.

Range Estimating is the key and was implemented for risk analysis regarding cost for this case study project. Range estimating can be done in a rather simple fashion by selecting the 20 percent of the line items in the cost estimate that represent 80 percent of the cost, then developing a range for each of those items and adding the low and high ranges. A more advanced approach is to take the same 20-percent items, establish the range, and then use any one of several available software packages to perform a probabilistic simulation and produce a risk profile. This approach can give a more accurate projection of the logical highs and lows involved with the 20-percent drivers.

A three-point range: most likely, optimistic, and pessimistic was used for the cost simulation. A triangular distribution, shown in Figure 4-7, was selected for modeling the project costs. Triangular distributions are simple distributions commonly used in similar projects and are easily understood. Triangular distributions use the most likely, optimistic and pessimistic of a variable. In most cases, the triangular distribution works very well.

The next step is to collect data on the extreme optimistic, most likely and pessimistic cost data for each cost item. The data collection is the most important phase of cost analysis, and the most difficult. It involves getting information from different parties about the risks that they see in their own areas of expertise and responsibility.

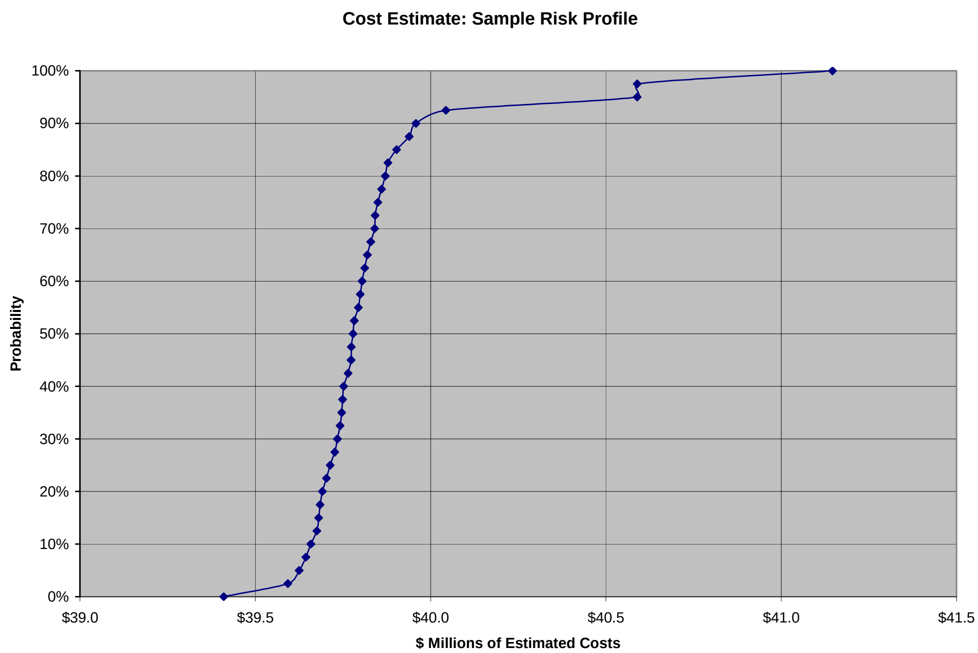
Figure 4-7. Cast Study_Cost Probability Distribution



Due to the characteristics of the project and information available at this stage, the probabilistic cost simulation is performed based on the cost components attached in Appendix A.

The ranges of each cost line item can be obtained through conference calls and interviews or from the risk analysis workshop. And then a cost risk profile can be generated. A sample risk profile, which is based on the line items listed in Appendix A, was generated according to the specific characters of the project and was based on the best information available. It is very difficult to obtain the ranges for each cost line item due to the particular stage at which the project was and potential scope change of the project. Therefore the variables utilized in range estimating are made up for the only purpose of turning a possible result of range estimating to a sample risk profile, as shown in Figure 4-8. The range estimating conducting process is enclosed in Appendix B.

Figure 4-8. Case Study_Sample Risk Profile_Cost



Roughly, the potential project cost ranges from $39.40 million to $41.15 million. There is a 10% chance that the cost will be less than $39.67 million, a 50% chance that the cost will be less than $39.80 million, and there is a 90% chance that the cost will be less than $39.95 million. The core accounting ceiling or the maximum project cost is $41.15 million.

4.3.2 Schedule Evaluations

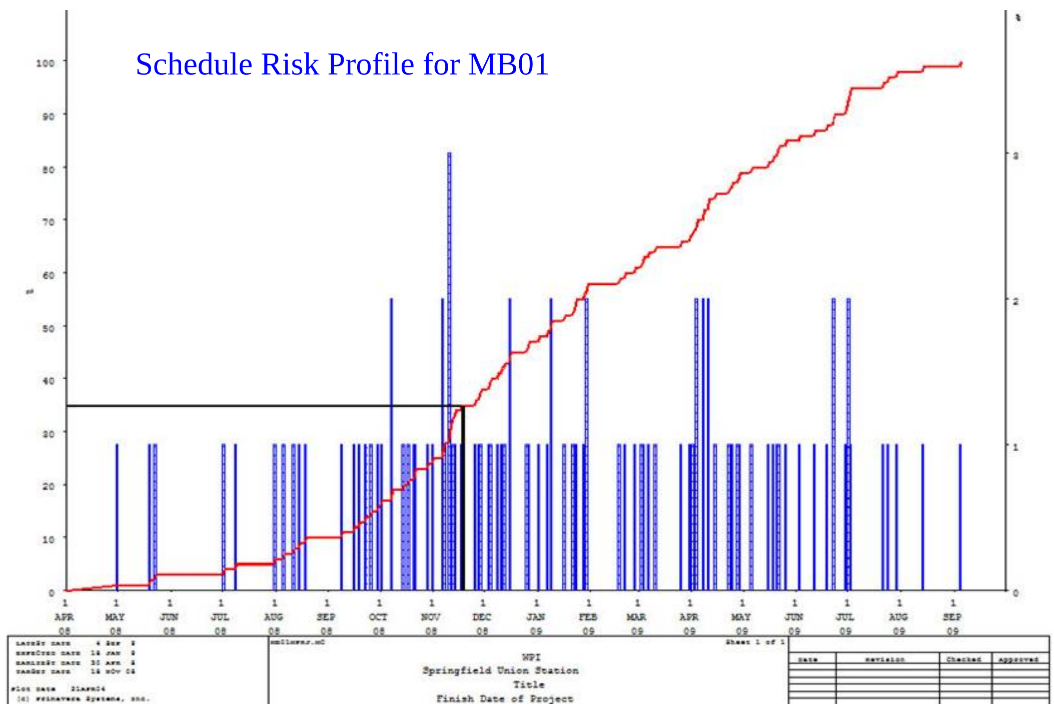
The initial intent with regard to the schedule was to perform an evaluation of the activities and to run a simulation utilizing Monte Carlo software to determine the probability of certain identified risks happening on the project and offer possible mitigation measures. The Monte Carlo software is for analyzing risk and mitigation measures. It uses the Monte Carlo simulation method to help quantify the effects of the many variables that can affect the outcomes of a project. It is linked with Primavera Project Planner Project scheduling data to analyze expected dates, and costs, and to critically develop contingency plans, or make go or no-go decisions. Range estimating provides the solution by synergistically combining Monte Carlo simulation, Pareto's law and experience of the decision makers to quantify and rank risks and opportunities for decision making.

The schedule documents obtained from FTA are enclosed in Appendix C. Since only a hard copy of the schedule was issued by FTA for the risk analysis study, a new schedule was recreated in Primavera Project Planner, and the best logic ties were assumed to create the schedule to be utilized for the simulations. It was apparent from the breakdown of the schedule that input from multiple parties would be needed to provide schedule updates accurately.

The first schedule run in Primavera Project Planner generated dates inconsistent with the issued schedule from the FTA. It was apparent that a few possibilities existed as explanations of the deviations. First, the schedule was not being updated. A second issue that can be argued is that the milestone dates are forced within the schedule to make it seem that the project’s end is still within the original time frame even though the dates are in essence slipping. A third potential problem could be the logic ties. Whereby certain activities do not have the correct predecessor / successor relationship will yield inaccurate dates. However, this is just an assumption without having knowledge of the logic ties.

The schedule regenerated by our risk analysis team was used to run a simulation in Monte Carlo. The regenerated schedule is enclosed in Appendix D. The results are shown in Figure 4-9. With the schedule that we generated, Monte Carlo is projecting roughly a 36% chance that the project will finish by the November 2008 date.

Figure 4-9. Case Study_Risk Profile_Schedule



Assumptions made in the revised schedule include the parcel acquisitions being started once the CSX issue is resolved. The current schedule has the acquisition process in motion for the four parcels prior to the CSX issue being resolved. Our risk analysis team discovered during our analysis of information and through the field trip, this simultaneous action is not possible. If the CSX issue cannot be resolved, it is most likely that PVTA will not move forward to acquire the remaining parcels. The acquisition activities were lumped into one activity per parcel with the same duration as the original schedule.

A second assumption was that the busway needed to be broken out into more activities to accurately reflect the construction duration. The Project Development sections of the schedule basically remained the same, and the dates reflected our risk study team's self-assessment are more accurate due to the logic.

It would be a recommendation with regard to the schedule that it is critical to have the schedule updated regularly, with input from the necessary parties responsible for their activities. A schedule is only as good as the information in it. With unrealistic dates or dates simply moving along the data line, that management will never have an idea of the project status or its projected completion. It would be at that juncture, once a more realistic schedule is in place, to perform another quantitative risk assessment and to identify the new probabilities for potential risks and the cost or opportunity associated with them.

4.4 Case Study Milestone

4.4.1 Study Method

From September 2003 to February 2004, we colleted and updated project cost and schedule data by all means, such as conference calls, interviews, brainstorming sessions and field trip to perform quantitative risk assessment.

The WPI risk analysis team and Mr. Matthew Keamy (FTA) toured the site in February 2004. We met initially with Gary Shepard, the administrator of PVTA and Richard Wilk, the on-site manager at the PVTA offices where they discussed the project background, history and challenges. Financial information provided to the WPI team indicated that the project was sectioned into two phases. However the schedule did not follow a similar breakdown. Once the design consultant presented their best alternative for the busway design, an issue arose with the railroad company, CSX. This issue involves the use of bridges by the PVTA and Peter Pan busses currently owed by CSX. This is the critical issue for the project because if it is unable to be resolved the project faces an uncertain future, if any. Extensive time and budget have been expended on this project since its inception in 2000, not to mention the potential for community growth and revitalization of the downtown Springfield area.

The visit to the site proved quite helpful to the WPI team in understanding the complex components of this project. It also gave us a better perception of the elements in the schedule and how they were impacted by the CSX negotiations and subsequent acquisitions. However, it was also the milestone for our risk analysis study because we could not follow the proposed risk analysis approach directed by FTA at that juncture.

4.4.2 Findings and Challenges

4.4.2.1 Challenges

The potential scope change due to CXS acquisition issue and incomplete cost and schedule data did not enable the risk analysis to be secured further according to the FTA formalized risk analysis methodology. FTA and PVTA must make a critical decision at that point to get the project back on track. They wished that the risk analysis could help their decision–makings and hope that we could continue conducting risk analysis workshop to guide thinking and stimulate communications among management. Thus, how to continue the risk analysis and foster their decision-making effectively became a real challenge.

4.4.2.2 Monte Carlo Limitations

Monte Carlo simulation is suggested by FTA formal risk analysis methodology. Quantitative risk analysis methods are flourishing these days, especially the application of Monte Carlo simulation. Executives tend to use Monte Carlo simulation for risk analysis because they know the importance of analysis and Monte Carlo has been introduced as a powerful tool for quantitative risk analysis; however, it has its specific limitations and applications.

Monte Carlo simulation is advantageous because it is a “brute force” approach that is able to solve problems for which no other solutions exist. Unfortunately, this also means that it is computer intensive and best avoided if simpler solutions are possible.

Brenda McCabe (2003) brings forward the limitations to Monte Carlo Simulation. In term of schedule risks, the CPM schedule to be used as basis for analysis must be complete and correct. Complete refers to having all activities properly tied in with predecessors and successors, and lags where appreciate. Correct refers to using durations that do not include float, that reflect the activity scope, and reflect the construction plan. Negative lags should be avoided as they do not represent the way activities are undertaken in the field. Moreover, experts are very comfortable estimating the most likely values of activity duration, but are not as experienced at estimating the lower and upper limits. The collection of real data to support these estimates would be very beneficial. Then unfamiliarity with the technique is another barrier. Last, it is quite difficult to accurately represent correlation between activities, so approximations have to be developed to simplify the process. The effects of these approximations are not known with certainty.

The most appropriate situation to use Monte Carlo methods is when other solutions are too complex or difficult to use. Therefore Monte Carlo simulation is not a recommended approach without full understanding of the project itself, the functions of this quantitative risk analysis technique, and meeting the applicable prerequisites of the technique.

From these points of views and the past experience of our risk analysis team, the quantitative risk analysis including Monte Carlo simulation and range estimating used for Springfield Union Station Intermodal Redevelopment project were not the most effective approach in that particular circumstance. Therefore, another feasible and effective method must be sought.

4.4.2.3 Valuation Problem in Risk Analysis

Large complex capital budgeting projects can be difficult to implement risk analysis. Decisions and alternatives are often many and complex, as well as difficult to quantify for valuation purposes. Additionally, there is frequently not enough quantifiable information available to perform a risk analysis. It is often also problematic to utilize quantitative risk analysis models based on questionable or incomplete data inputs. Such practical implementation issues cause the current quantitative risk analysis methodology utilized by Federal Transit Administration to be ineffective in some circumstances.

This is not only the current problem for large complex projects, but also a problem for smaller less complex projects. Project risk analysis process must be tailored to particular circumstances of the project. For example, in some circumstances, a current formalized risk analysis methodology might not be of great importance or too time consuming in practice for transit projects monitored by FTA.

Difficulties, such as those noted above, in applying quantitative risk analysis in practice suggest that the application of more qualitative processes can improve managerial decision-making. For example, a scenario analysis can help managers better identify the long-term risks and uncertainties that impact the project and assist them in defining possible alternatives and contingencies; and qualitative risk analysis is helpful in guiding management to consider the non-quantifiable value embedded in a project by then adding detailed structuring and, thus, allowing for a richer understanding of the scenarios identified.

5 DEVELOPMENT OF PRELIMINARY RISK ANALYSIS FRAMEWORK

5.1 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.

5.2 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 risk

In this study, two generic risk analysis methodologies for construction projects are studied and have provided insights for the development of the new risk analysis approach.

5.2.1 Construction Risk Management System – CRMS Model

The proposed model developed by Al-Bahar (1990) is entitled Construction Risk Management System (CRMS). Nowadays, risk analysis has not been limited to only risk assessment and evaluation. As defined in Section 2.3, the "risk management" noted in this system is the same as the risk analysis concept in this study. The model provided an effective systematic framework for quantitatively identifying, evaluating, and responding to risk in construction projects. The model consists of four processes: risk identification, risk evaluation, response management, and system administration.

The first step is Risk Identification, which is defined as "the process of systematically and continuously identifying, categorizing, and assessing the initial significance of risks associated with a construction project" (Al-Bahar 1990). As shown in Figure 5-1, there are six steps involved in the risk identification process.

In this process, all types of risks that affect productivity, performance, quality, and economy of construction should be included in a preliminary checklist. Then all reasonable possibilities associated with the realization of each primary source of risk included in the checklist are identified. Based on the identification of risk consequences, a graph of two dimensions which represent potential severity and probability of risk consequences is constructed. As a last step of the process, all the identified risks are classified to various categories, such as Acts of God, Political and Environmental, Design, and so on. Then a summary sheet will be prepared as shown in Figure 5-2.

Figure 5-1. CRMS_Risk Identification

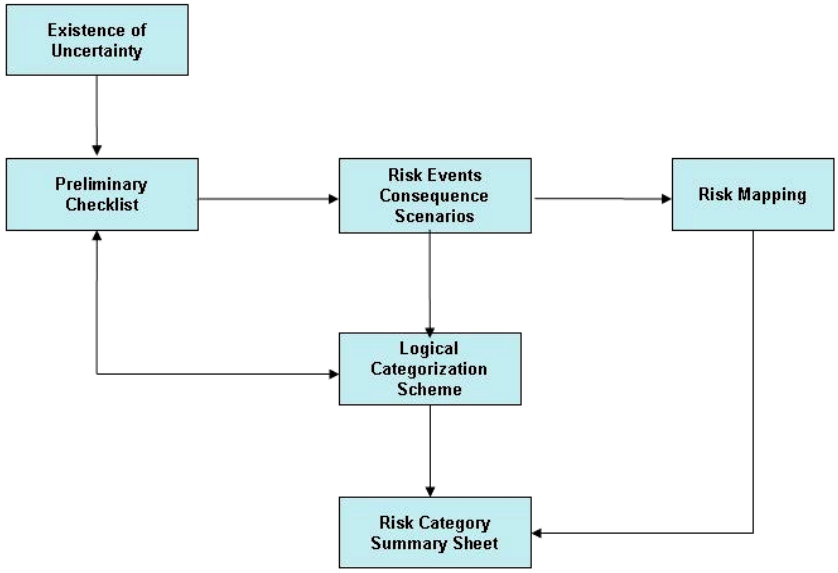


Figure 5-2. Risk Category Summary Sheet

Name of Project: Date: Prepared By:		
Risk	Description of Risk Event	Conditional Risk Variables
1. 2. 3. ……		

The second process is Risk Analysis and Evaluation, which is defined as “a process which incorporates uncertainty in a quantitative manner, using probability theory to evaluate the potential impact of risk” (Al-Bahar 1990). This process is to determine significance of risks quantitatively, through data collection, uncertainty modeling and potential impact of risk evaluation.

Having identified the risk exposure, and evaluated probabilistically its potential financial impact, the next step is to formulate suitable risk treatment strategies. The alternative strategies include risk avoidance, loss reduction and risk prevention, risk retention and risk transfer.

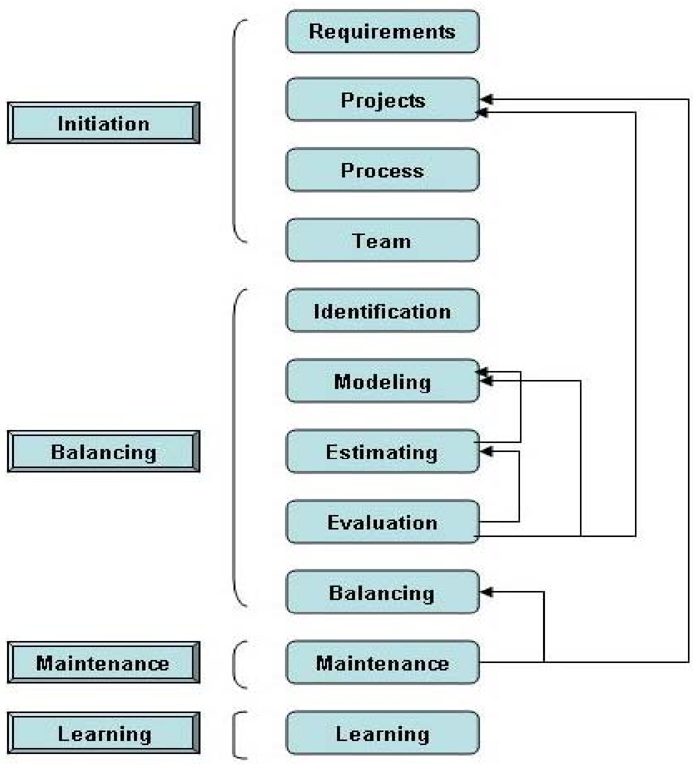
The final phrase of the CRMS model is administering the risk-management process by formulating a formal risk management policy and monitoring the CRMS model functions to improve risk management program.

5.2.2 Integrated Project Risk Analysis Methodology

A generic project risk analysis process for construction projects, which may be applied in general, or for specific project size and type as it is stated, has been developed in 2002 as Integrated Project Risk Management Methodology. According to the definitions of risk analysis and risk management in this study, the integrated project risk management methodology actually means Integrated Project Risk Analysis Methodology and will be applied to this study.

This generic or complete risk analysis process, which is based on the highest level of risk management maturity in the largest and most complex construction projects, consists of four levels: Initiation, Balancing, Maintenance, and Learning (del Cano 2002). The four levels include eleven stages. Figure 5-3 is a flowchart showing the four process stages and their breakdown.

Figure 5-3. Integrated Project Risk Analysis Process (del Cano 2002)



In the Initiation process, needs and constraints are established, the project is investigated in detail, and how the project's success will be measured should be defined. Then the risk analysis method will be established and examined, and a risk analysis team will be formed.

The following process is balancing the risk environment, in the sense of balancing opportunities with threats. It can be achieved through identifying and classifying risks and their potential responses, and then developing a model to analyze risks and responses in-depth. In the estimating step, the degree of uncertainty associated with risks will be calculated through qualitative or quantitative assessment, and the estimates will be introduced into the models defined in the modeling stages to evaluate project's risk and finally summarize the project's global plan by balancing between opportunities and threats.

The Maintenance phase refers to maintaining the equilibrium of the project's risk environment through monitoring risks, responses, risk models, and risk evaluations. Last, the Learning phase is about learning from this experience to improve on future activity and increase the body of corporate knowledge.

5.3 Literature Review Findings and Conclusions

5.3.1 Conclusions and Perspectives of Generic Risk Analysis Methodology

5.3.1.1 CRMS Methodology

The CRMS Model is a systematic analytical approach developed in 1990 starting with risk identification, probabilistic risk evaluation of significant risks, and development of alternative risk management strategies. It provides a closed-loop feedback to update the information in risk analysis. This methodology provides neither detailed descriptions of risk evaluation method and details of feasible risk analysis techniques, nor any information on application of the methodology to a real risk analysis practice.

The risk identification process is generic and should be tailored to shorten the process time frame. In this process, the development of preliminary checklist can be combined with the risk classification step.

In the risk evaluation process, data collection is critical and may come from historical records. However, in many cases, directly applicable historical data concerning the risk is not available in adequate amount. Hence, available data is mainly subjective in nature and must be obtained through careful questioning of experts or persons with the relevant knowledge. This questions the result of probability analysis, and in many cases, even the need of uncertainty modeling.

Probability is an explicit way of dealing with uncertainty. It is a device that permits management to incorporate all the available information concerning the likelihood of risk consequence into a single or combined number. However, without adequate data, the number is of no use and value. Probabilistic risk analysis is one of the steps of CRMS methodology. However, risk analysis techniques should be selected according to many factors regarding the project, the people conducting risk analysis, the available risk analysis techniques, and so on.

5.3.1.2 Integrated Project Risk Analysis Methodology

The integrated generic project risk analysis methodology is tailored for construction projects. Different from the CMRS model, the stages of this process can overlap and interact with the project management activities. Moreover, analysis techniques can be chosen according to the project, its determining factors, and the type of analysis to be executed. The main qualitative risk analysis techniques are listed and some recommendations are also provided.

A specific risk analysis process must be developed according to the particular circumstances of the project and the organization undertaking it. In this integrated risk management methodology, the generic process can be simplified according to various factors associated with the maturity of the organization, the relative size of the project, and its complexity. This is one of the advantages of this methodology. However, this generic methodology does not provide details of risk identification, classification and evaluation methods. It provides details in risk analysis techniques, but similar to the CMRS model, it only focuses on the general descriptions of the risk analysis process.

5.4 General Risk Analysis Techniques

Monte Carlo simulation is specified in the FTA formal risk analysis methodology. It is also suggested according to our risk analysis study for Springfield Union Station Intermodal Redevelopment project. In fact, tools and techniques for analyzing risk and making decisions under risk are many and must be chosen according to project, its determining factors, and the type of analysis to carry out. Any rigid recommendation in this field would be absurd (del Cano 2002).

In the context of management science, there are two broad categories of management techniques, which are deterministic and probabilistic or stochastic. Deterministic techniques assess risks qualitatively while probabilistic techniques make quantitative evaluation of risks. Deterministic techniques are also called qualitative techniques, and probabilistic techniques are called quantitative techniques. When one makes decision he or she needs to have clear objectives, goals, plans, and strategies. The tools and techniques help people to determine a decision, but can not make the decision, only humans can initiate the course of action (Flanagan & Norman 1993).

5.4.1 Qualitative Risk Analysis Techniques

The main currently used qualitative risk analysis techniques are (del Cano 2002):

- Checklists;
- Assumptions analysis;
- Data precision ranking, to examine the extent to which a risk is understood, the data available about it, and the reliability of the data in order to evaluate the degree to which the data about risks is useful;
- Probability and impact description, to describe those parameters in qualitative terms (very high, high, moderate, and so on);

- Probability-impact risk rating tables, which assign risk ratings (very low, low, moderate, and so on) to risks based on combining probability and impact qualitative scales;
- Cause-and-effect diagrams, also called Ishikawa or fishbone diagrams, to illustrate the interrelations between risks and their causes;
- Flowcharts and influence diagrams, as pure graphs reflecting the interrelations between activities, risks, and responses; and
- Event and fault trees, which are typically used in risk analysis of engineering systems and which can also be used in project management.

5.4.2 Quantitative Risk Analysis Techniques

The main currently used quantitative techniques are (del Cano 2002):

- Sensitivity analysis, to discover the criticality of various project parameters;
- Expected value tables, to compare expected values for different risk responses;
- Triple estimates and probabilistic sums applied to cost estimating;
- Monte Carlo simulation, to obtain the cumulative likelihood distributions of the project's objectives using probabilistic estimation of the input parameters;
- Decision trees to aid decision making when there are choices with uncertain outcomes;
- Probabilistic influence diagrams combining influence diagrams with probability and Monte Carlo theory to simulate aspects of project risk;
- Multi-criteria decision-making support methods (MDMSMs) for making choices among alternatives with conflicting demands. Analytic hierarchy process (AHP), for example, is a type of MDMSM that can be used for multi-criteria selection among different risk responses, mixing qualitative and quantitative criteria;

- Process simulation, using a variety of techniques to simulate specific project processes;
- System dynamics, combining influence diagrams with a more complex mathematical framework to dynamically simulate specific aspects of project parameters with feedback loops and the ability to simulate the selection among different alternative actions; and
- Fuzzy logic, with potential applications to scheduling, cost control, and multi-criteria selection among several alternatives.

5.4.3 Risk Analysis Techniques Selection Criteria

Del Cano (2002) emphasized that the best way to begin a risk evaluation would to be use qualitative techniques and later gradually increase the complexity of the techniques until one has achieved the best cost-profit ratio for each type of firm and project. Here the criterion is to compare the project budget with the typical budgets for small, medium, and large construction projects as shown in Figure 5-4. According to an organization's maturity, as well as the complexity and absolute or relative size of project, the analysis techniques are recommended in Figure 5-5. The definitions of maturity, complexity, size and classification of projects are elaborated in Section 5.5.

According to del Cano (2002), a Sensitivity Analysis, Monte Carlo, and Probabilistic Influence Diagrams do not take into account the possible correlation between risk aspects, while others do. The greater the maturity of the organization and the project's magnitude, the more such a correlation should be taken into account.

Figure 5-4. Project Classification (del Cano 2002)

		Absolute size	*Small*	*Medium*	*Large*
Maturity	*High level*	*High complexity*	Zone MC	Zone MD	Zone ME
		Medium complexity	Zone MB	Zone MC	Zone MD
		Low complexity	Zone MA	Zone MB	Zone MC
	Low level	*High complexity*	Zone mC	Zone mD	Zone mE
		Medium complexity	Zone mB	Zone mC	Zone mD
		Low complexity	Zone mA	Zone mB	Zone mC

		Relative size	*Small*	*Medium*	*Large*
Maturity	*High level*	*High complexity*	Zone M3	Zone M4	Zone M5
		Medium complexity	Zone M2	Zone M3	Zone M4
		Low complexity	Zone M1	Zone M2	Zone M3
	Low level	*High complexity*	Zone m3	Zone m4	Zone m5
		Medium complexity	Zone m2	Zone m3	Zone m4
		Low complexity	Zone m1	Zone m2	Zone m3

Figure 5-5. Recommendations of Risk Analysis Techniques (del Cano 2002)

	Main risk analysis techniques	*Zones*																			
		mA	*mB*	*mC*	*mD*	*mE*	*MA*	*MB*	*MC*	*MD*	*ME*	*m1*	*m2*	*m3*	*m4*	*m5*	*M1*	*M2*	*M3*	*M4*	*M5*
qualitative techniques	Probability and impact description	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Assumptions analysis	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Check lists	⊗	⊗	⊗	⊗	⊗	●	●	●	●	●	⊗	⊗	⊗	⊗	⊗	●	●	●	●	●
	Probability-impact tables	○	○	●	●	●	○	●	●	●	●	○	○	●	●	●	○	●	●	●	●
	Data precision ranking	○	○	○	○	○	○	○	○	●	●	○	○	○	●	●	○	○	●	●	●
	Flowcharts			○	○	○		○	○	○	○			○	○	○		○	○	○	○
	Influence diagrams			○	○	○		○	○	○	○			○	○	○		○	○	○	○
	Cause-and-effect diagrams				○	○			○	○	○				○	○			○	○	○
	Event and fault trees				⊗	⊗				○	○				⊗	⊗				○	○
quantitative techniques	Sensitivity analysis	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Probabilistic sums		○	○	○	○	○	○	●	●	●			○	○	○		○	○	●	●
	Monte Carlo and LHC simulation			⊗	⊗	⊗	○	○	●	●	●				⊗	⊗			○	●	●
	Probabilistic influence diagrams			⊗	⊗	⊗	○	○	●	●	●				⊗	⊗			○	●	●
	Expected value tables			○	○	○	○	○	○	○	○				○	○			○	○	○
	Decision trees				⊗	⊗				○	○					⊗				○	○
	Event and fault trees				⊗	⊗				○	○					⊗				○	○
	Multicriteria DMSM (AHP, etc.)				⊗	⊗				○	○					⊗				○	○
	Fuzzy logic										⊗										⊗
	Processes simulation										⊗										⊗
	Systems dynamics										⊗										⊗

Legend: ● normal / most frequent use ○ possible use for specific purpose / in specific circumstances
⊗ possible use preferably / necessarily with external help

Finally, sophisticated quantitative techniques (process simulation, system dynamics, fuzzy logic) will only be used in a small number of cases of high-level risk maturity organizations undertaking ‘‘megaprojects,’’ particularly when the organization wants to add a component of research and development. In general, more complex risk models and, consequently, more knowledge and experience are needed for that purpose.

In addition to the techniques noted above, other techniques such as brainstorming, interviewing and modifying one or more the above techniques can also be used in evaluating risks. del Cano (2002) stated that the selection of risk analysis techniques would also be affected by the following factors:

- In cases where a certain degree of maturity is involved, whether or not the organization is, for the first time, in the transition from applying the process in small and well-managed projects to its application in more problematic and larger ones;
- The motivation and attitudes of personnel involved in the implementation of the risk management process;
- Whether or not the risk management process is applied from the project’s inception;
- The way in which risk management is carried out in the program that includes the present project;
- The available resources (internal and external) and time;
- The type of contracting system; and
- The prioritization of objectives.

5.5 Risk Analysis Techniques Selection for Case Study

5.5.1 Project Classification by Complexity

5.5.1.1 Theory:

As del Cano (2002) states, a questionnaire with 69 short questions has been elaborated to estimate a project's complexity, in qualitative terms, in the following seven project areas:

- Project environment
- Facility to build
- Technology
- Project organization
- Project objectives
- Information
- Cultural aspects

In each project area there are two types of complexity, direct and indirect complexity. Direct complexity includes differentiation and interdependence among a system's elements. Indirect complexity relates to factors that tend to lead eventually to higher levels of interdependence among the elements of a system.

Answers are placed on a scale to show how much importance each factor in the above seven areas has for a particular project. At the same time, each question has a weighting or level of importance. The index of complexity refers to the quotient between the weighted average of the answers and the maximum value of complexity that can be obtained answering the questionnaire.

Thus, as real-life examples:

- Low complexity: Complexity Index measured up to 15%,

  For example, an apartment building complexity Index is about 7%
- Medium complexity: Complexity Index is 15% to 30%
- High complexity: Complexity Index is higher than 30%,

  For example, for the channel tunnel, is about 50%.

In this case, project complexity is classified subjectively because the goal of this classification is only to establish recommendations within a flexible methodological framework. The above examples can serve as the reference for classification in terms of project complexity.

5.5.1.2 Application to Case Study

A point that needs to be emphasized is that the goal of the classification is only to establish recommendations with a flexible methodological framework. The developed questionnaire to estimate complexity of construction projects is not available, and it may also waste time and effort to go through the questionnaire even when it is accessible. Therefore, instead of using a questionnaire, the project can be classified by considering direct and indirect complexity of the factors including project environment, facility to build, technology, project organization, project objectives, information, and cultural aspects.

The project for case study can be classified as a high level complexity. Although the facility to build and technology applied to the case study project may not be in a high complexity level, the other project characteristics make the project a high lever complexity. It is a multi-phased project that includes Federal, State and local transportation agencies in addition to a private railroad company. The project organization is unique as stated hereinbefore. The project objectives and information required and cultural consideration involve a lot of people or parties. Therefore, the Springfield Union Station Intermodal Redevelopment project can be classified as a high level complexity.

5.5.2 Project Classification by Project Size

5.5.2.1 Theory

Project can be classified by either relative size or absolute size. According to del Cano (2002), the criterion to classify project by project relative size is to compare project budget and company's capitalization. For example, the project can be classified as small, medium or large when the project budget is on the order of 1/100, 1/10, or 1/1 of the company's capitalization, respectively.

To classify a project by project absolute size, the criterion is to compare the project budget with the typical budgets for small, medium, and large projects in a particular field. For example, a project can be classified as small, medium or large when the project budget is less than US$25 million, between US$25 million and US$100 million or greater than US$100 million for construction projects generally.

5.5.2.2 Application to Case Study

As of June 2003, the Funding Allocation Plan indicated that the Union Station project has received FTA and EOTC funding commitments in the amounts of $44.125 million. With the corresponding increment in state matching funds, this requested earmark would bring the combined FTA / EOTC commitment to $56 million. Therefore, the proposed total funding is $100.125 million. And according to Use of FTA / EOTC Funds, the total estimated project cost is $115.416 million. Because the case study project is a joint-developed project by both public sector and private sector, the project relative size is difficult to determine by comparing project budget and company capitalization. Therefore, the project is classified by its absolute size as Large.

5.5.3 Project Classification by Organization Risk Maturity Level

5.5.3.1 Theory

Hillson (1997) establishes possible organization risk management maturity levels as followed:

1) **“naïve”**: the organization is unaware of the need for risk management
2) **“novice”**: the organization is beginning to experiment with risk management through a small number of individuals, but there is no generic, structured approach to manage risk
3) **“normalized”**: risk management is included in normal business processes and consistently implemented on all or most projects
4) **“natural”**: the organization has a risk-aware culture with a proactive approach to risk management in all aspects of the business and with an emphasis on opportunity management.

The low maturity level includes levels 1 and 2 from Hillion’s model. The high maturity level includes level 3 and 4. Few organizations are currently at level 4; many organizations are either at level 2 or 3, and a significant number remain at level 1. Normally, non-project-driven organizations are at level 1 (Hillson 1997).

5.5.3.2 Application to Case Study

Federal Transit Administration (FTA) is the main organization conducting risk assessment for the project, and FTA does have a generic, structured approach to manage risk, and risk management has been included in their normal project process.

The earliest risk assessment was done in 1995 on the Baltimore Light Rail Transportation project. After that, they have continued making efforts in risk assessment to help decision making. There are four risk assessment model projects, Lower Manhattan Recovery Office project, Seattle Sound Transit Central Link project, Pittsburgh North Shore Connector project recently. Therefore the organization risk maturity level can be considered level 3, which is a high maturity level.

5.5.4 Risk Analysis Techniques Recommendation for Case Study

Risk analysis techniques can be chosen according to the project, its determining factors, and the type of analysis to carry out (profitability, time, cost, and so on). The main qualitative risk analysis techniques are listed and recommendations are provided.

A summary of the classification of Springfield Union Station Intermodal Redevelopment project by complexity, relative size, and organization risk maturity level is: high-level organization risk maturity, high complexity, and large absolute size. Based on the classification matrix provided by del Cano (2002) shown in Figure 5-4, the project is located in Zone ME. Then based on the recommendation matrix in Figure 5-5, risk analysis techniques regarding Zone ME are recommended.

Normal or most frequently used risk analysis qualitative techniques include:

- Probability and impact description
- Assumptions analysis
- Probability-impact risk rating tables
- Data precision ranking

Normal or most frequently used quantitative techniques include:

- Sensitivity analysis
- Probabilistic sums
- Monte Carlo and Latin Hypercube simulation
- Probabilistic influence diagrams

Therefore, both qualitative risk analysis techniques and quantitative analysis techniques can be selected and applied to the case study project.

Monte Carlo simulation has been recommended by FTA. Unfortunately, after five-month's data collection and updating, the resources were still incomplete for conducting Monte Carlo simulation at that particular phase of the project. Because the main objectives of quantitative analysis are to provide participants with an opportunity for reflection and to make any uncertainty in the project as clear as possible to those participants, a quantitative analysis should never be idolized. It should be done seriously and rigorously; otherwise, it is preferable to avoid it altogether. It should also be used with prudence, mainly as a communication tool. Therefore, a qualitative risk analysis technique or modified analysis method should be applied to the case study project in this particular circumstance.

5.6 Preliminary Risk Analysis Process for the Case Study

5.6.1 Pre- workshop

Our risk analysis team has been familiar with the project and analyzed base cost and schedule independently. By all means we tried to update the project information and to identify independent project events and the associated risks. The next step was to conduct a workshop in which the current critical issues could be addressed and hence stimulate the management's decision-making. Several actions were taken for preparation of the further effective risk analysis process.

5.6.1.1 Update Project Information and Pre-identify Risks

We concluded that it is critical to get a progress schedule and other available updated information from FTA as to the project status. We can not obtain any progress schedule form FTA because there were actually no updates on the project schedule and no cost information. FTA has had several meetings with PVTA and their design consultant right following our field trip to the site. We received the updates of the project from FTA as follows:

1) "CSX does not want the PVTA's busway to utilize their RR bridges without significant cost sharing in the rehabilitation. This will have to be negotiated in the near future. The design consultant is looking to see if it is possible to build adjacent structures and not utilize the RR bridges."
2) "Property acquisition is delayed on one parcel."
3) "Water infiltration from the busway slab is causing damage to the east wall of Union Station." FTA may be authorizing the grantee to go ahead and replace this slab now. The cost could be significant because this slab runs the entire length of the building.

Based on our field trip to the site and meeting with Gary Shepard and his staff, and the updates provided by FTA, we identified the following risks:

1) Timing and availability of the car lot to be used as the new maintenance facility for Peter Pan.
2) Participation and cooperation by CSX in issues related to the use of the corridor that runs parallel to the building and the ownership and subsequent maintenance of the bridges.
3) Amtrak's lack of economic contribution to the operation and maintenance of the building as well as the moving of the $1 M control panel.

4) Busway slab leaking problem may incur significant replacement cost.
5) Impact of the delays in starting construction on the overall present condition and security of the building.

We concluded that the two most critical items at this time are (1) and (2). Without acquiring the required parcels, the project scope would have to be changed and the project would not be able to be furthered.

5.6.1.2 Identify Workshop Participants

Another critical issue is identifying the participants in the workshop. The identification is becoming more critical due in large part to the logistics of getting the multiple parties to arrange their schedules to attend the workshop.

Our risk analysis team developed a list of whom we think should be invited but we needed FTA to confirm and/or edit these participants, as follows:

Designer Representative
PVTA Representative
FTA
Peter Pan Representative
CSX Representative
AMTRAK Representative
Springfield Union Station Redevelopment Authority Representative

The schedule also indicates that there are both public and private funds which will affect the project. The team deferred to the FTA as to whom the representatives are and whether they should be invited to participate.

We also discussed the private citizen who owns the property that is being tapped to house the Peter Pan maintenance facility. Again we deferred to FTA on the decision of his involvement.

5.6.1.3 Develop Workshop Worksheet

As the basis of information to begin and guide discussions at the workshop, our risk analysis team developed two spreadsheets, one for cost and one for schedule.

The schedule spreadsheet contained the program milestones and major activities in each of the components of the project. Relevant to each activity, time schedule, potential risks, party involved, and risk correlations could be evaluated by participants, if applicable.

Participants would be directed to assign values of probability to the risks they identified, if applicable. Participants were also encouraged to discuss the impacts due to the potential risks. We utilized the anticipated start and completion dates from the schedule in the hope that more realistic dates could be determined by the participants while assigning the potential risks to the activities.

It was determined that the cost estimate worksheet could not correlate back to the schedule items due to the incomplete cost breakdown information. Hence, the schedule spreadsheet became the main worksheet in the workshop and is included in Figure 5-6.

Figure 5-6. Case Study_Workshop Worksheet

Activity	Anticipated Start	Anticipated Completion	Risk	Party	Related to	Optimistic Estimate	Most Likely Estimate	Probability of Most Likely Estimate	Pessimistic
PROGRAM MILESTONES									
Station Design	2-Dec-02	18-Jun-04							
Station Construction	30-Jan-04	2-Feb-06							
Station Completion / Transit Opening		28-Feb-06							
Station Opening with Tenants		6-Mar-06							
Ramp Design Completion		4-Feb-04							
Ramp Construction Start - Access Ramp	2-Aug-04								
Ramp Construction Start - Egress Ramp	5-Aug-05								
Activity	**Anticipated Start**	**Anticipated Completion**	**Risk**	**Party**	**Related to**	**Optimistic Estimate**	**Most Likely Estimate**	**Probability of Most Likely Estimate**	**Pessimistic**
PROJECT DEVELOPMENT									
PLA Agreement	17-Sep-03	24-Feb-04							
Station Design/Procurement	1-Jul-02	18-Jun-04							
Station Construction	17-Sep-03	28-Feb-06							
F.B Murray Garage Design/Procurement	1-Aug-02	15-Jul-05							
Carpaso Garage Design/Procurement	6-Jan-03	6-Sep-06							
Private Financing	14-Mar-02	1-Jul-04							
Public Financing (Challenger)	17-Sep-03	14-Jan-05							
Marketing and Leasing	2-Jun-03	6-Mar-06							
Property Management	14-Mar-02	6-Mar-06							
PROPERTY ACQUISITION									
11 Liberty /1176 Main St. (Picknelly)	2-Jul-01	20-Apr-04							
331 Libert Street (Roy)	2-Jul-01	3-Apr-04							
95 - 119 FB Murray Street	2-Jul-01	17-May-04							
30 -50 FB Murray Street	2-Jul-01	17-May-04							
CSX	1-Jul-03	17-Mar-04							
BUSWAY									
Preliminary Work	17-Sep-03	26-Oct-04							
Design	19-Jul-01	17-Mar-04							
Bid	2-May-04	28-Jul-04							
Construction Access Ramp	2-Aug-04	29-Mar-05							
Construction Egress Ramp	5-Aug-05	17-Feb-06							

5.6.2 Workshop

5.6.2.1 Goals

The goal of the workshop was to gather the representatives from the main parties of this project to address the critical issues they were encountering; to evaluate potential risks that had been identified by our risk analysis team based on the best updated cost, schedule and scope information available before the workshop; and to determine any potential risk issues that participants may bring forward during the workshop.

The WPI team had developed a spreadsheet identifying risks on which to base the workshop, and these risks were based on major schedule components. Representatives assessed probability to the identified risks as determined by the schedule milestones and major schedule components and at the same time other potential risks which are not determined by the available cost and schedule information obtained by our risk analysis team was further identified from the point of views of the representatives.

There was also the intent to determine a responsible party for said risks. The major components identified for discussion were: (1) Project Building Components including the Station, the Busway, and Garages (FB Murray & Caparso), (2) Parcel Acquisition including CSX negotiations for the bridges and (3) Developmental Components of the projects including financial, marketing and property development.

5.6.2.2 Workshop Participants

The workshop was conducted on April 27, 2004 at the PVTA offices in Springfield. The participants included:

- PVTA: Gary Shepard (Administrator), Sandra Sheehan, Kevin Walkowski (Legal Council)
- City of Springfield: Robert Warren
- Hayes Development: Maureen C. Hayes
- DMJM+HARRIS: Michael Hunter (Design Consultant to PVTA)
- CMG/PVTA: Richard Wilk (On-site manager)
- FTA: Matthew Keamy and Saptarshi Bhattachria
- WPI Team: Guillermo Salazar, Ph.D., Wei Guo and Jeannette Skoropowski

5.6.2.3 Methodology

Our intention was to have a main session involving all participants and then two smaller sessions in which the group would be split, one to discuss cost issues and one to discuss schedule issues identified in the large session and then a recap of the small group discussion in the large forum. Due to the size of the group in general, the smaller breakouts were forgone and all participants discussed each item based on cost and schedule implications. This method proved to be quite beneficial in facilitating much discussion and identification of other potential risk issues not readily determined by the cost and schedule information.

As the basis of information to begin discussions at the workshop, the worksheet that contained the program milestones and major activities in each of the components of the project had been developed. During the workshop discussions, the worksheet turned out to be useful and helped to guide the discussions. When evaluating each schedule item, a column was added during the course of the workshop and to record any cost risks associated with the activity. However, the participants felt that it would be nearly impossible to determine more realistic dates at this juncture while the CSX issue was still unresolved.

We moved forward identifying potential risks associated with each milestone activity. Several secondary but pertinent discussions and some potential mitigation measures ensued along the way as each item was discussed. In terms of potential risks, including optimistic, most likely and pessimistic time frames and then a probability (percentage) of the most likely and most pessimistic options was determined among the participants.

As discussions progressed, unsolicited mitigation ideas began to emerge into the discussions. This was an unexpected additional benefit to the workshop results.

Generally mitigation measures in keeping with current FTA methodology are presented and discussed at a later phase in the process. The ideas presented and discussed as the workshop progressed are valuable avenues to pursue as the project moves forward. In some instances, if the mitigation measures ultimately become a reality, they will allow the project to move forward. The participants were raising ideas and issues previously not explored on the project. Potential mitigation measures have been captured within the appropriate project component narrative below.

5.6.2.4 Project Component Discussions

Station Design: Scope change was determined to be a potential risk. If the issue with CSX is unable to be resolved and subsequently the busway unable to be built as currently designed, the station could encounter changes due to the relocation of the busway. There was some discussion as to the amount of rework needed via scope change as some participants felt it would be minimal, mainly traffic flow within the station would need to be reevaluated. It was discussed in regard to the CSX issue and its impact that the possible effects could become potential solutions and therefore mitigation measures in the future.

Station Construction: Currently the construction of the station is phased and the drawings are at the 60% due diligence stage. Should there be a scope change that would allow construction to be completed in 1 stage, there is the possibility for cost savings overall. The busway design does not impact the construction of the station. Potential risks discussed included material costs (steel in particular) and labor prices. It was determined that these would cancel each other out. A risk identified here was the tunnels within the station in regard to liability. A secondary issue raised was the ADA regulations and compliance. Gary Shepard mentioned that the tunnels are a key to the traffic flow of the station to the tracks and also a marketing tool that would be negated should the tunnels be eliminated form the project.

Busway Design and CSX Negotiation: The current design of the busway will not be feasible if the CSX issue is not resolved and PVTA can acquire an easement to allow use of the 3 bridges owned by CSX. PVTA has directed their designer DMJM+HARRIS to investigate alternatives to the current design to make the busway work without utilizing the bridges. It was mentioned that CSX also has to approve the design of the busway.

PVTA (Walkowski) stated that CSX would sell/grant permanent easement for no cost and would “do it tomorrow”; however, PVTA must assume all maintenance and operational costs associated with the bridges. He further stated that CSX is not willing to enter into any deal that would increase their liability one percent or their costs one dollar when it comes to negotiation on this issue. Several discussions ensued concerning the condition of the bridges, life cycle analysis of the bridges, PVTA owing the bridges and responsibilities for maintaining them (how to price contingency liability), historical issues in regard to the Main Street Bridge, and the possibility of HAZMATS in relation to the bridges. Also discussed was the lack of maintenance records that CSX has in regard to the bridges, so there is no way to evaluate what has been done in terms of upkeep. Discussions progressed to alternative ways to deal with the CSX issue, suggestions included: rebuilding half the bridges, build independent new bridges, and the possible role that the historical commission will play. Possible funding opportunities were discussed where a “fund” would be set up and maintained to cover the maintenance and operation of the bridges. This money could come from Federal agencies, or a new transportation funding bill. This avenue needed to be investigated further to determine exactly what stipulations were set forth in the funding bill in order to see if the project would qualify.

Final issues discussed with regard to the busway were flagged availability and restrictive access to site. These items were applicable to the construction of the busway ramps in general and both were assigned a one month negative impact on the schedule.

<u>Acquisition Issues:</u> The City consultant felt that the acquisitions were, in essence, not very complicated, and therefore it was easy to determine the range and probability of the potential risks. However, the acquisitions of the parcels were again contingent upon the resolution of the CSX issue. A secondary issue brought up at this juncture was the "deep pockets" of Peter Picknelli who they felt could take legal action to block the acquisition of his parcels if PVTA attempted to take the properties without his buy in. There was a discussion surrounding the appraisal values of the said properties being "not in the same vicinity" of one another. There is such a difference in the appraised values the PVTA (Walkowski) felt that it would be difficult to come to an amicable settlement for the sale and acquisition of his properties.

In relation to cost risks where the acquisitions are concerned, a 15% plus 4% escalation was put to these parcels to cover any delays while acquiring the parcels. The 19% does not include any outside of the normal legal fees that may ensue as a result of the acquisition process.

<u>*Project Development:*</u> In large part the participants felt at this juncture that he activities under this heading couldn't be assessed in terms of risk potential. This is due primarily to the flux of the project at this time. A discussion was held in

regard to the PLA agreement which project leaders had previously announced would be in place but have since found out that they are currently prohibited. It was also mentioned that the marketing and leasing and property management issues couldn't be addressed at this time again do to where the project is currently at with no solid end date. Market analysis has been done.

5.6.2.5 Findings and Results

Included in Figure 5-7 is the worksheet from the workshop, including comments. Much of the narrative from the workshop that supports the worksheet can be found in the above section.

Figure 5-7. Case Study_Workshop Worksheet with Results

Activity	Anticipated Start	Risk	Risk	Opportunity	Party	Related to	Optimistic Estimate	Most Likely Estimate	Probability of Most Likely Estimate	Pessimistic	Cost (most likely)
PROGRAM MILESTONES											
Station Design	2-Dec-02	scope change	busway		PVTA/FTA/E OTC Coordination	CSX	2 months	4 months	80%	6 months	20%
Station Construction	30-Jan-04			possbile							
		tunnels				Amtrak/CSX	2 months	6 months	100%	18 months	10%
Station Completion / Transit Opening											
Station Opening with Tenants											
Ramp Design Completion											
		CSX Approval									
Ramp Construction Start - Access Ramp	2-Aug-04	HAZMATS									
Ramp Construction Start - Egress Ramp	5-Aug-05										
Activity	**Anticipated Start**	**Risk**			**Party**	**Related to**	**Optimistic Estimate**	**Most Likely Estimate**	**Probability of Most Likely Estimate**	**Pessimistic**	
PROJECT DEVELOPMENT											
PLA Agreement	17-Sep-03	currently prohibited							100%		
Station Design/Procurement	1-Jul-02										
Station Construction	17-Sep-03										
F.B Murray Garage Design/Procurement	1-Aug-02										
Carpaso Garage Design/Procurement	6-Jan-03										
Financing	14-Mar-02	Availability of Private Funds				tax credits					
Public Financing (Challenger)	17-Sep-03	Availability of Public Funds									
Marketing and Leasing	2-Jun-03										
Property Management	14-Mar-02	enhancements to property security and safety									look for areas for funding
PROPERTY ACQUISITION & RELOCATION											
11 Liberty /1176 Main St. (Picknelly)	2-Jul-01	Landtaking Liability	HAZMAT				120 days	18 months	80%	24 months	escalation + admin (15% of acquisition costs) not legal fees
331 Libert Street (Roy)	2-Jul-01	Landtaking Liability					120 days	6 months	80%	12 months	SAME
95 - 119 FB Murray Street	2-Jul-01	Landtaking Liability					120 days	6 months	80%	8 months	SAME
30 -50 FB Murray Street	2-Jul-01	Landtaking Liability					120 days	6 months	80%	8 months	SAME AS ABOVE
CSX - negotiated	1-Jul-03	Conveyance contingencies					grant permanent easement to construct the busway: 6 months	9 months	80%	PVTA owning maintenance & total liability: 2 years	7 million
BUSWAY											
Preliminary Work	17-Sep-03	HAZMATS			PVTA	Bridges	2 months	4 months	80%	6 months	5%
		Condition of Bridges				Bridges	3 months	6 months	75%	9 months	250,000/per bridge
		Historical Issues			PVTA	Bridges		3 months	100%		
Design	19-Jul-01	CSX has to approve			CSX		6 months	9 months	80%	12 months	5%
		Design Omissions									5%
Bid	2-May-04										
Construction Access Ramp	2-Aug-04										
Construction Egress Ramp	5-Aug-05	Bungalow									

Comments:

- from upper level as currently designed
- once begins - possiblity that all at once - no phasing so more cost effective
- steel prices / availability
- CSX negotiations are at a standstill
- Flagged - cant assess
- -contingent liability is unknown -"fund required" for maint/operation
- Flagged - funding gaps to be filled to complete project as currently perceived
- -separate construction item -take but still resposible for maintenance
- applicable to construction on ramps in general

The results of the workshop proved quite worthwhile to the project. While the CSX issue was quite apparent to be the dominating one, in terms of risk to the project moving forward, several other "secondary" risks were identified and discussed among the participants. At this juncture of the project, the risk analysis study did not follow the FTA formal risk analysis methodology to conduct Monte Carlo simulation; however, the forum produced much thought-provoking discussion that could lead to diminished potential risks in the future, once the CSX issue is resolved.

5.6.2.6 Challenges and Difficulties

Three main challenges we encountered were:

First, data or resources available for evaluating or analyzing the risks through qualitative risk analysis techniques, such as Monte Carlo simulation recommended by FTA, were incomplete.

Second, the workshop is an important way for representatives from the major project parties to share thoughts and make decisions. However, attendance of all the critical representatives from the main project parties was difficult to achieve.

Last, the time to start the risk analysis study for Springfield Union Station Intermodal Redevelopment project was late. Some risky issues such as the acquisition of CSX parcel did not be mitigated or even not be noticed by the management before it became an critical risk which caused the project scope change.

It is true that there is a trade off between an early start and sufficient and precise data. However, an early commitment through qualitative risk analysis techniques in many circumstances is certainly more important than waiting for the complete data for risk evaluation. The most important point is to find a right way or method to conduct a risk analysis at an early stage of the project before any risky issue becomes a critical risk and has a significant unpleasant impact on the project.

5.6.2.7 Conclusions

The information we have provided and the discussions that were the result of the workshop exercise provide a strong fundamental basis for the project participants to think over as they move forward with the Springfield Union Station Intermodal Redevelopment Project. A better understanding of the project's realm and how the multitude of activities affect and effect one another will ultimately offer various alternatives to the many challenges of the project. New ideas and possible solutions were presented through the workshop and gave the participants avenues to pursue to possibly mitigate many potential risks. In some cases their discovery of mitigation possibilities will allow the project to move forward where currently it has been otherwise stalled as a result of the CSX issue. On the other hand, the case study examined the generic integrated project risk analysis methodology and was of great value in the future improvement of risk analysis methodology.

5.6.3 Post-workshop

After the workshop, the discussions and results were collected and reported. And feedback was collected from the participants through questionnaire. We received feedbacks from the main participants which are PVTA, FTA and busway design consultant. A sample questionnaire is included in Appendix E, and the feedback obtained from the workshop participants is enclosed in Appendix F.

As discussed hereinbefore, an early risk analysis commitment is certainly critical before any risky issue becomes a critical risk and has a significant unpleasant impact on the project. To start a risk analysis at an early stage of the project, identifying risks would be more difficult than the risk identification performed in this case study because potential risks are still not clear. And it would be also difficult to collect or update data used for risk analysis at an early stage of the project. Hence, an improvement of the risk analysis approach implemented in the case study would be helpful for an early risk analysis commitment.

According to the feedback, the workshop was successful in terms of addressing critical issues and fostering decision-making. The CSX issue was highlighted during the workshop. This was a very good opportunity for participants to realize the importance of CSX acquisition issue. During the discussion, the main topic was focused on this issue since many other issues or activities are related to CSX issue. The risk related to the CSX issue is very obvious. On the other hand, too much focus on one issue may neglect some other critical issues and may make the workshop not as effective as it should be. Therefore, an improvement to address this problem would be of benefit.

Moreover, risk management and mitigation step was not formally included in the risk analysis workshop for the case study. The mitigation plan should be discussed at a later phase according to FTA formal risk analysis methodology. In the new approach developed to continue the risk analysis for Springfield Union Station Intermodal Redevelopment project, risk management and mitigation was not expected to be addressed in the workshop. However, during the workshop as discussions progressed, unsolicited mitigation ideas were emerging into the discussions which provided a better understanding for decision-makers. To foster decision-making and improve the effectiveness of the workshop, formally addressing risk management and mitigation in the workshop would be one of the important contributors.

5.6.4 Future Improvement

The new risk analysis approach implemented in the case study can be enriched and improved in the following facets:

- Risk Checklist could be beneficial for risk analysis team to identify risks at an early stage of the project.

- Risk Classification could be incorporated in the process to improve the effectiveness of the workshop discussions and to stimulate the decision-makers' better understanding of potential risks.

- Risk Management and Mitigation could be addressed formally in the workshop.

- Other improvements, such as Web-Biuld to enhance risk communications among project participants would be of great value.

6 IMPROVED PRELIMINARY RISK ANALYSIS FRAMEWORK FOR TRANSPORTATION PROJECTS

6.1 Overview

Considering potential future outcomes when an organization pursues a project helps to earn additional value in the project. It helps to identify what management knows, but may not be able to quantify. Whereas the current use of risk analysis focuses very heavily on how to quantify the uncertainties, the real discussion is how to think about all of the potential losses and opportunities. It requires an effective risk analysis methodology to be able to apply to projects at a very early stage without sacrificing the quality of risk analysis results, and can be easily implemented at a lower cost and shorter time frame, as well as serving as a quick follow-up risk analysis, if applicable, to enhance risk communication.

The preliminary risk analysis framework has been developed and tested on the Springfield Union Station Intermodal Redevelopment project. This newly-developed approach was of great value in the circumstances that the formal structured FTA risk analysis methodology was not feasible and applicable. The results of applying this preliminary risk analysis framework to the real project were very good. Hence, being improved based on the lessons learned and conclusions from the case study, this proposed framework would be able to achieve an effective early risk analysis commitment at a relatively low cost while providing the much-needed flexibility to improve project decision-making and reduce risk exposure for transportation projects.

Finally, this risk analysis approach increases the chance of a project’s success and the opportunity for a better return on investment. Furthermore, this approach can be integrated with the current formalized risk analysis approach into a continuous risk analysis methodology that can assist executives in managing uncertainties, mitigating risks, and exploiting opportunities effectively.

6.2 Development of Risk Checklist

6.2.1 Methodology

To enrich the proposed preliminary risk analysis framework, a generic risk checklist was developed through literature review, brainstorming sessions and discussions with experts and experience of risk analysis practice in Springfield Union Station Intermodal Redevelopment project.

6.2.2 Risk Definitions

Risk is a major concern in many fields from the study of lotteries to economics and banking to engineering (Kottegoda and Rosso 1997). Any commercial venture is affected by risk. Risk is defined in many different ways in different disciplines. Risk is usually defined as the chance or probability of loss, harm, failure, or danger in Webster's Dictionary. In a broad definition, in terms of a hazard, bad consequences, loss, or exposure to mischance, risk is defined as the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment (Society for Risk Analysis 2003). In a more technical sense, risk is the combination of the probability of a possible unwanted event and the associated quantity of possible damage.

Lawrence Livermore National Laboratory of the United States Department of Energy defines risk as the quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event (Environment, Safety and Health Manual 2001).

Hertz and Thomas (1983) provide an alternative definition of risk in the context of uncertainty. They describe risk as uncertainty and the result of uncertainty. And they also stated that risk would have to involve some kind of damage or loss. For a construction project, it refers to a lack of predictability about structure, outcomes, or consequences in a planning or decision situation. Symbolically, Risk = Uncertainty + Damage.

Risk in this study is defined as "the exposure to the chance of occurrences of events adversely or favorably affecting project objectives as a consequence of uncertainty" (Al-Bahar and Crandall 1990). From this definition, a risk equation can be written as: Risk = f (Uncertainty, Consequence).

"Uncertainty" represents the probability that an event occurs. A consequence of uncertainty can be positive ("gain/opportunity") or negative ("loss/hazard/threat"). Here, "gain" is referred to profit and benefit, and "loss" is economic loss and physical damage. The risk definition here is no longer limited to the probability of loss and damage. This description has been brought forward by Al-Bahar and Crandall. They explained that even in situations of potential gains, uncertainty is unattractive since the knowledge of the exact gains is unknown, and people seldom give credit to an unknown gain.

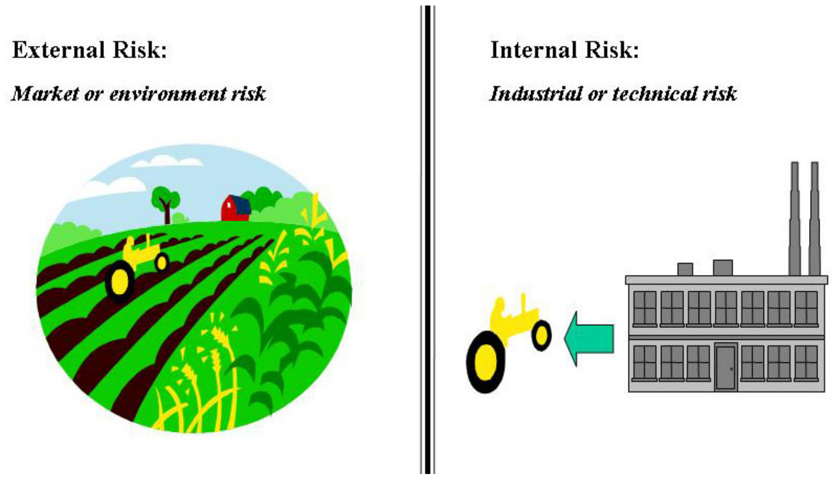
Risks are not restricted to hazards, liabilities, threats and difficulties but also opportunities. The opportunity for advancement cannot be achieved without taking risk. "Risk in itself is not bad; risk is essential to progress, and failure is often a key part of learning. But we must learn to balance the possible negative consequences of risk against the potential benefits of its associated opportunity" (Scoy 1992). This concept of risk does not conflict with the former definitions. Furthermore, it describes risk in a more objective sense and provides a foundation for the complete understanding of risk and its relative consequence, especially when potential gains would be significant and neglecting account for these factors may lead to misestimate total potential consequence of risks.

For the purpose of the subsequent research of a risk analysis methodology, another important definition is introduced here. In a decision-making context, risk can be written as: Risk = Sum {Probability * Severity}. (Wilson and Crouch 2001) "Our perception of the magnitude of risk from some event depends on some form of product of how often we think the event will occur and how serious we consider each occurrence to be in its effects." To associate risks with more complex events or actions, it is necessary to break down the actions into individual smaller actions. Then "Sum" stands for the summation of those risks of the smaller actions. The equation can be also written as: Risk = Sum {Probability * Severity * Weight}. The weight factor is included separately here – it could also be included in the "severity" term if the equation relates perceptions.

6.2.3 Risks in Construction

Construction projects are complex in nature. Uncertainties inherently exist in all construction projects, from the political factors to the price of various materials, weather and site conditions, and so on. Uncertainties are not only from the unique characteristic of the construction projects, also from the diversity of resources and activities (CII 1989). There are very few industries that have the risks of the construction industry, especially with the increasing growth of fast-track delivery methods, such as design-build. There are various ways to categorize construction risks. Risk can be classified as external risk and internal risk according to its nature and primary source as illustrated in Figure 6-1.

Figure 6-1. External Risk and Internal Risk (Alquier and Tignol 2001)



Alquier and Tignol stated that external risk is the risk that the company does not control. It is also called the market or environment risk. This kind of risk is related to factors external to the company, such as customers, market, environment, suppliers and so on. External risk sources can be varied: market shifts, government action, project interactions with the environment, market competition, external constraints like regulation, legal context, currency fluctuations, customer's country regulation mechanisms and instances. Correspondingly, internal risk is the risk that is supposed to be under the company control. The internal risk is associated with the technical solutions under analysis during the project development process. Internal risk represents the risk managed by the company for building a building. Internal risk sources can be new technology, resources needed for the project, processes, and cost estimates.

In terms of the nature of the risk itself, risk can be classified as knowns, known-unknowns, or unknown-unknowns (Diekmann 1988). As Diekmann described, a known risk is an item or condition that is understood, but cannot be measured with complete accuracy. Generally, such risks occur at a relatively high rate and contain a range of possible outcomes. Labor productivity is a good example of a known risk. Known-unknowns conditions are events that are foreseeable, but not normally expected. Normally, such events have a relatively low frequency and result in severe consequences. Earthquakes, hurricanes, strikes and unusual difficulty with a contractor are examples of this type of risk. Unknown-unknowns are conditions or events that cannot be predicted. These items are generally catastrophic in nature and have a low probability of occurring. Examples of unknown-unknown include asbestos-related hazards or AIDS before they were recognized. Once an unknown-unknown is identified, it becomes a known-unknown.

Another approach is more direct for many construction companies to categorize risks. Based on their effects on the project, risks are classified as cost risks, schedule risks and quality risks for a construction project. The weak point to classify risks using this method is that risks are easy to be counted to more than one category. This may lead to subsequent confusion or misestimating the consequences of risks

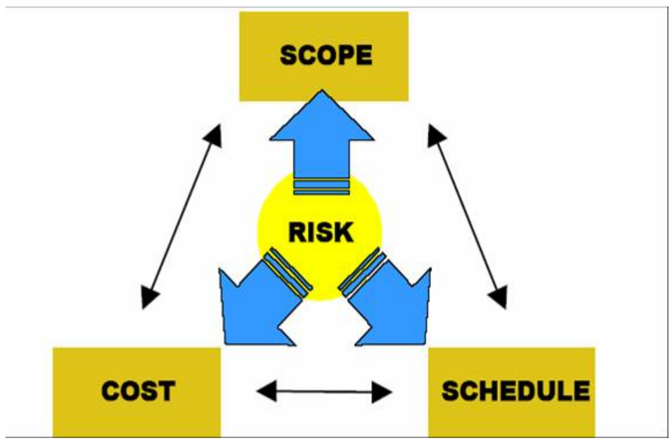
.

6.2.4 Risks in Transportation Projects

Project risk is defined by Federal Transit Administration (FTA) as an unexpected event or circumstance that has a chance of occurring and that may prevent a project from meeting its schedule and cost estimate (FTA 2004).

“Risks” are defined as cost overruns and schedule slippages in transit projects by FTA. In the project process of complex capital projects such as fixed guideway transit systems, cost overruns and schedule slippages are relatively common and inevitable due to the uncertainties inherent in transit projects. Considering the generic risk equation “Risk = f (Uncertainty, Consequence)”, the “consequence” is considered as impact of project schedule and cost in an unfavorable way by Federal Transit Administration. This concept is illustrated distinctly in Figure 6-2.

Figure 6-2. FTA Risk Definition



The Construction Roundtable of Federal Transit Administration classifies risks as three types: Budget Risks, Event Risks, and Scope Risks. Budget risks are risks that budget elements will deviate from the cost estimate, such as deviations in unit prices and deviations in quantities. Event risks are risks due to internal or external events that force the project team to work beyond the estimate just to meet the project scope and schedule, for example, extreme weather and contractor non-performance. Scope risks are significant changes to project scope due to external pressures, such as community pressures for changes in alignment or station location.

The researchers of Federal Transit Administration have divided project risks into two main categories: design/construction risks and financial risks. Design/construction risks pertain to the process of construction and technical factors that affect the construction cost and schedule. Examples include unusual inclement weather, unfavorable underground conditions especially in projects where tunneling comprises a major portion of the work, and possibility of contractor's inability to meet project deadlines and/or quality standards. Financial risks relate to all aspects of project financing and budgeting and may include unfavorable changes in interest rate, shortfall in the estimated revenues, and uncertainty in construction budget cash flows. In addition to evaluating these risks, one has to consider the interaction between financial and construction risks. For example, a shortfall in revenues dedicated to the project may delay construction. Conversely, a delay because of construction difficulties may increase the financial burden on project sponsors (FTA 1994).

Figure 6-3. FTA Risk Classification Table (FTA 1994)

Federal Transit Administration Risk Classification

I.	Project Feasibility
II.	Funding
III.	Planning
IV.	Engineering
V.	Type of Contract
VI.	Contracting Arrangement
VII.	Regional and Local Business Conditions
VIII.	Contractor Reliability
IX.	Owner Involvement
X.	Regulatory Conditions
XI.	Acts of God
XII.	Site
XIII.	Labor
XIV.	Loss or Damages
XV.	Guarantees

Based upon this classification, a further breakdown has been developed to provide a systematic checklist of risks by FTA in 1994. From the owner's point of view, risks are divided into fifteen major categories as showed in Figure 6-3. The complete risk classification table including subcategories is included in Appendix H.

6.2.5 Generic Risk Checklist

Based on the literature review, brainstorming sessions and discussions with experts and the above FTA risk classification developed in 1994, risks are classified as eighteen major categories for transportation projects as showed in Figure 6-4. A detailed breakdown list of potential risks is included in Appendix I.

The risk listing would be beneficial for preliminary risk analysis or management planning. It serves as a generic guideline of potential risks for transportation projects. The list would be helpful for breaking down all risks into manageable components as well.

The subcategories of risks reflect all areas of risk for transportation projects. It would provide a systematic and objective approach to the risk identification process and ensure that no major risk element is overlooked. With various project delivery methods, the provisions addressed in the terms and conditions of construction contracts, and various project resources and characteristics, risks should be identified specifically upon needs for a specified project.

Figure 6-4. Generic Risk Checklist Summary

GENERIC RISK CHECKLIST FOR TRANPORTATIN PROJECTS

A. Planning and Selection Risks

B. Financial Risks

C. Contractual Risks

D. Organizational Risks

E. Site Risks

F. Resource Risks

G. Environmental Risks

H. Technology Risks

I. Communication Risks

J. Waiver Risks

K. Expectation Risks

L. Completion Risks (Time Schedule)

M. Completion Risks (Cost)

N. Completion Risks (Quality)

O. Project Administration Risks

P. Force Majeure Risks

Q. Political Risks

R. Currency Risks

6.3 Improved Preliminary Risk Analysis Framework

As described in the case study, the preliminary risk analysis framework can be enriched as a straightforward five-step risk analysis process presented as followed.

6.3.1 Perform a Pre-Analysis Inquiry

For most transportation projects, this pre-analysis inquiry can be combined with the process of risk identification. The goal of pre-analysis inquiry is to familiarize with the project including the available cost data, schedule information, project scope, parties involved and so on. The duration of this step depends on characteristics of the specific project.

This is mainly the same as the first step that was followed in the case study. The only difference is a generic risk checklist has been developed for transportation projects as presented in the previous section. This generic risk checklist can be used to help in identifying risks. The traditional risk identification process often lasts for a relatively long period of time. It is of considerable importance since the subsequent risk analysis steps may only be focused on identified potential risks. Therefore, the risk identification process must involve an investigation into all possible potential risks. This process can be very difficult, particularly if the risk analysis starts at an early stage of a project, such as preliminary design stage. The generic and complete risk checklist enclosed in Appendix I would be very useful to identify all potential risks in a relatively short time and low cost associated with the identification process. This preliminary risk analysis framework is advantageous since it is feasible for starting a risk analysis at the early stage of a project. In an early stage of the project, the risk analyst or risk analysis team can develop a specific risk checklist for the project based on the generic risk checklist through pre-analysis inquiries by any means which can best fit, such as conference calls, emails, interviews and so on.

6.3.2 Classify Risks and Develop Workshop Worksheet

Unlike the process in the case study, after the risk analysis team identified risks, risks should be classified based on two main factors which are the potential consequences and the evaluators’ uncertainties about the consequences. In other words, the key factors that are related to the definition of risk in the context of decision-making. From these two factors the seven categories are established in Figure 6-5.

Figure 6-5. Risk Classification (Aven 2003)

Category			**Level of Risk**	**Level of Authority Involved**	**Stakeholder Implications**	**Treatment of Societal Values**
Potential Consequences		**Uncertainties of Consequences**				
1	S	S/M/L	Low	Low	Low	Low
2	M	S				
3	M	M				
4	M	L	↓	↓	↓	↓
5	L	S				
6	L	M				
7	L	L	High	High	High	High

S = Small, M = Moderate, L = Large

These seven categories show a tendency of increased risk, level of authority involved, stakeholder implications, and treatment of societal values. The arrows mean the tendencies, but not strictly increasing values.

The potential consequence should not be categorized as Small, Moderate or Large simply by measuring associated losses and damages, such as economic loss, number of fatalities or days of schedule delay. The basis of categorizing the potential consequence is related to the following five key factors (Aven 2003):

1) *Ubiquity*: how common is the potential consequence or the geographic dispersion of potential damages.
2) *Potential of mobilization*: means violation of individual, social or cultural interests and values generating social conflicts and psychological reactions by individuals and groups who feel afflicted by the risk consequences.
3) *Delay effect*: a long time of latency between the initial event and the actual impact of damage.
4) *Persistency:* the possibility of restoring the situation to the state before the damage occurred.
5) *Persistency*: the temporal extension of potential damage.

Each of the above factors is assigned a value ranging from zero to three. The larger the value, the larger the negative or unpleasant impact the factor has on the potential consequence. Among the above five key factors categorizing potential consequences, if any of the five factors is assigned a "three" for a risk, then the risk is categorized as "L"; if all the factors are assigned a value that is smaller than "1" for a particular risk, then the risk is categorized as "S"; other than the above two cases, the risk is categorized as "M".

To characterize the uncertainty of consequence, the key factors are considered:

1) The degree of predictability of consequences;
2) The difficulty in establishing appropriate performance measures; and
3) Persons or groups that assess or perceive the uncertainties.

Based on the above three factors, a percentage is assigned (0-100%). The larger the percentage, the more uncertain the consequence of a risk is. If the percentage is lower than 15%, the related uncertainty of consequence will be "S"; Uncertainty of consequence is characterized as "L" when the percentage is larger than 55%. The percentage between 15% and 55% will be related to "M" uncertainty of consequence.

Risks are classified by their potential consequences and uncertainties of consequences and listed in a table that will be developed for the use of workshop discussions. Instead of listing critical project activities or project major milestones in the first column of the workshop worksheet as what has been done in the case study, the classified risk activities can be listed in the first column of the worksheet. The other columns of the workshop can be kept unchanged from the one developed for the case study as shown in Figure 5-7

It is possible that some risks are "obviously" too large to be acceptable, and others are too small to be worth discussing. When a risk is so large that the action or substance must obviously be banned or so small as obviously to be ignored, then a detailed analysis is unnecessary. Therefore, risks that are classified as "S" potential consequence, no matter the characterization of the related uncertainties, the risks can be ignored for the workshop discussions if this category of risks is of only a small amount within the total amount of risks. At the same time, the risk category "7" which have "L" potential consequence and "L" uncertainties of consequences may not be of importance for workshop discussion since risk management strategy can be easily selected without too much in-depth evaluation and further discussions.

Thus, depending on the categories of risks, the corresponding risk management and mitigation strategy can be clearly addressed during the course of workshop as discussions of risks process. At the same time, according to the time duration of the workshop, the discussions can be actually focused on the critical risks and associated methods by selecting risk items from the worksheet based on their classification. This would make the workshop more effective and flexible while improving the understanding of workshop participants.

6.3.3 Workshop: Evaluate Risk

Instead of implementation of probabilistic model, such as Monte Carlo simulation techniques, the analysis is typically done subjectively by using an appropriate qualitative method, similar to the method conducted in the case study.

Risk analysis should be tied closely to the project model, usually in the form of a project schedule. This ensures that high-risk and opportunistic areas of a project can be easily identified and monitored. In the previous step, risk activities have been classified by their potential consequences and uncertainties of the consequences and worksheet are prepared as presented above. People who have valuable perspectives on the risks, and representatives from various parties involved in the project will be able to bring an independent view on important areas of project uncertainty.

6.3.4 Workshop: Perform a Further Analysis and Analyze Results

This should be led by an experienced risk analyst who is familiar with project development issues and risks, and this step is usually conducted simultaneously with the previous risk evaluating step. The insights and feelings of participants regarding to the project are guided by an experienced risk analyst in interpreting and finalizing the discussion and findings.

Similar what was done during the workshop in the case study, risk management and mitigation strategies should be addressed in the workshop. The worksheet developed according to the classified risk activities would ease the discussions. One of the many reasons for identifying, classifying and assessing risks is to find ways of reducing them, and to provide an input into decision processes about taking various actions. The primary risk responses include controlling risk, transferring risk, removing risk and retaining risk. These risk responses can be discussed and selected for the risk activities by the participants simultaneously with the risk evaluating process.

Risk control involves avoiding particularly hazardous conditions or situations, or taking special measures such as training, preventive maintenance, and safety programs to reduce the frequency and severity of potential losses. Risk transfer means shifting the burden of financial responsibility for potential losses to a third party, such as an insurer. Contractual phrases such as "hold-harmless" clauses, which specify responsibility for liability, are another form of risk transfer. Risk removal or avoidance involves eliminating those situations that involve a higher than acceptable level of potential risk. Risk retention refers to a management's decision to take financial responsibility for all or some portion of a potential loss. A combination of all four techniques is usually implemented in the risk management programs.

It is important to use the preliminary risk analysis method as intended, which is an engineering and communication tool. While it may be tempting, it may be dangerous, to follow the methodology stiffly because it is more important to focus on what key messages the result express, and to use those messages as information to help make good project management decisions. That being said, it is also critical that the project team understands the results, thus ensuring that the intended risk or opportunity impacts and consequences were determined reasonably and will be managed effectively.

6.3.5 Report Records and Evaluate the Risk Analysis Process

After the workshop, keeping appropriate records is essential because these records form the basis for reports emanating from the risk management function in regard to any further modification of risk mitigation strategies. Evaluation of the risk analysis process is an effort to improve the procedures of risk identification, evaluation, and response management.

6.4 Conclusions and Future Work

6.4.1 Conclusions

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.

It is important to realize that most decisions about risks are made every day by millions of ordinary individuals. We are the decision makers. Life is a risky business. Wilson (2001) pinpoints that the method of analysis and managing risks by professional risk managers should not differ too much from the methods used by ordinary people in their decisions, lest the decision becomes much too hard to explain and will be less acceptable. Therefore it is important to have a procedure, and a terminology, that are consistent with these "ordinary" methods. The proposed preliminary risk analysis method satisfies the above criterion.

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.

6.4.2 Future Work

6.4.2.1 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

6.4.2.2 Delphi Method for Improved Risk Communication

Besides the future testing of the improved preliminary risk analysis framework on real projects, Delphi Method would be of value for future improvement of this process because it was originally developed for market research and sales forecasting purposes. It is a proven and effective methodology for allowing a group of people to deal with complex problems. It has even been used for evaluating contract administration procedures. This method could be integrated into the preliminary risk analysis framework.

It is found that sometimes bringing experts together in a conference room introduces factors that may have little to do with the issue at hand. Therefore, the Delphi method can be developed and designed to remove conference room impediments to a true expert consensus. A possible means is introducing Web-Build to risk analysis procedures. Anonymity may be applied to encourage a true opinion and independent of personalities. The flexibility of web discussion due to its asynchronism is another advantage. However, to get right people together to a workshop is still a good way to gain objectives. If the workshop can be conducted without many difficulties, Web-Build may provide some assistance.

REFERENCES

Al-Bahar, Jamal F. and Crandall, Keith C. (1990). "Systematic Risk Management Approach for Construction Project." J. Constr. Eng. Manage., 116(3), 533-546.

Alquier, A. M. and Tignal, M. H. (2001). "Project Management Technique to Estimate and Manage Risk of Innovative Projects." IPMA International Symposium and NORDNET.

Aven, T.,(2003). "Foundations of Risk Analysis: A knowledge and Decision-Oriented Perspective." John Wiley & Sons Ltd

Construction Roundtable (2004). "FTA Risk Assessment." Federal Transit Administration Workshop Presentation, Newark, NJ, May 4, 2004.

Construction Industry Institute (CII). (1989). "Management of Project Risks and Uncertainties." Publication 6-8, Cost/Schedule Control Task Force. University of Texas, Austin, Tex., 2-23.

del Cano, Alfredo and de la Cruz, M. Pilar. (2002). "Integrated Methodology for Project Risk Management." J. Constr. Eng. Manage.,128(6), 473-485.

Flanagan, R. and Norman, G. (1993). "Risk Management and Construction." Blackwell Scientific Publications.

Flyzbjerg, B., Bruzelius, N., Rothengather W. (2003). "Megaprojects and Risk: An Anatomy of Ambition." Cambridge University Press.

Flyvbjerg B., Skwmeris, M. K. and Buhl, S. L. (2003). “How common and how large are cost overruns in transport infrastructure projects?” Tyler & Francis Group, Transport Reviews, 2003, VOL. 23, NO. 1, 71-88

Hertz, D.B., and Thomas, H. (1983). “Risk Analysis and its Applications.” Wiley, New York, 1-5.

Hillson, D. A. (1997). ‘‘Towards a Maturity Model.’’ Int. J. Project and Business Risk Management, 35–46.

Isidore, L., Back, E. (2001). “Integrated Range Estimating and Stochastic Scheduling.” Cost Engineering, Vol. 43, No. 02.

Kottegoda, N.T., and Rosso, R. (1997). “Probability, statistics and reliability for civil and environmental engineers.” McGraw-Hill, New York.

Lifson, M.W., and Shaifer, E.F. (1982). “Decision and Risk Anlaysis for Construction Management.” Wiley, New York, 133-134.

McCabe, B. (2003). “Monte Carlo Simulation for Schedule Risks”. Proceedings of the 2003 Winter Simulation Conference.

Poole, R. W. Jr. (2004) “Addressing the ‘Big Dig Syndrome’”. Public Works Financing. May 14, 2004.

Risk Assessment in Fixed Guideway Construction, FTA, Report # FTA-MA-26-0022, Northeastern University, January 1994

Rosenberg, L., Gallo, A., and Parolek, F. (1999). “Continuous Risk Management Structure of Functions at NASA.” AIAA 99-4455, American Institute of Aeronautics and Astronautics.

Scoy, Van and L., Roger (1992). “Software Development Risk: Opportunity, Not Problem.” Software Engineering Institute, CMU/SEI-92-TR-30, ADA 258743.

Skoropowski, J., Guo, W., Guillermo, F. S. (2004). “Springfield Union Station Intermodal Redevelopment Project – Risk Analysis Study”. Independent Study Report. Worcester Polytechnic Institute.

Slovic, P., Finucane, M. L., Peters, E. and MacGregor, D. G. (2004). “Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk, and Rationality.” Risk Analysis, Vol.24, No.2, 2004.

Thomas Cool, (1999). “Proper Definitions for Risk and Uncertainty.” Econ-WPA, ewp-get/9902002.

Wilson, R. and Crouch E. A.C. (2001). “Risk-Benefit Analysis.” The Center for Risk Analysis, Harvard University Press, Second Edition, P8-10.

http://www.llnl.gov/

http://www.projectrisk.com

http://www.pvta.com

http://www.sra.org/

APPENDICES

APPENDIX A - Case Study_Project Cost Summary

Project Component	**Cost ($ Million)**
Busway	$14,926
Parking (Off-street parking)	$15,638
Hotel Charles	$14,000
Station Buildings	$68,852
Area Improvement / Streetscape	$2,000
TOTAL	**$115,416**
Stage I	**Cost ($ Million)**
Sources	
PVTA	$22,800,000
SULLC / Private Investment	$8,168,891
Total	**$30,968,891**
Uses	
Hard Costs	
Construction	
Sitework /Landscaping	$1,943,320
Base Building	$13,815,000
Transportation Fit-Out	$500,000
Pre-Construction Estimating	$85,000
Tenant Allowances	$400,000
Hard Cost Contingency (10%)	$1,634,332
Total Hard Costs	**$18,377,652**
Soft Costs	
A & E	

Architecture	$2,114,865
Structural Engineer	In Arch. Line
MEP Engineer	In Arch. Line
Civil Engineer	$50,000
Landscape Architect	$40,000
Reimburseables	$50,000
A & E Total	**$2,254,865**
Misc. Consultants	
Historical Consultant	$30,000
Lighting Consultant	$15,000
Accoustical Consultant	$10,000
Graphic Consultant	$40,000
Roofing Consultant	$25,000
Parking Consultant	$40,000
Retail Consultant	$20,000
Geotechnical Consultant	$25,000
Structural Peer Review	$10,000
Security Consultant	$15,000
Reimberseables	$30,000
Total Misc. Consultants	**$260,000**
Surveys & Testing	
Probes	$50,000
Borings	$40,000
Initial Survey	$20,000
Final Survey	$20,000
Material Testing	$50,000
Misc. Testing	$30,000
Surveys & Probes Total	**$210,000**
Permits	
Building Permit	$50,000
Misc. Permits	$15,000

Permits Total	**$65,000**
Development OH & Fee	
Financial Services	$300,000
Project Coordination	$400,000
Design & Construction	$1,100,000
Marketing, Leasing & Property Management	$200,000
Incentive Fee	$700,000
Reimberseables	$75,000
Additional Paid Fee based on Expanding	$778,000
Developer Fee Loan	$1,411,923
Development Fee and Overhead Total	**$4,964,923**
Legal	
Tax Credit Attorney	$300,000
Agreements	$200,000
Legal Total	**$500,000**
Leasing & Merchandising	
Leasing Commission & Fees	$32,074
Legal	$50,000
Tenant Criteria	$40,000
Renderings / Project Sign	$80,000
Brochures and Website	$40,000
ICSC Convention	$35,000
Events	$100,000
Misc.	$20,000
Leasing & Merchandising Total	**$397,074**
FF&E	
Food Court Amenities	$50,000
Retail Signage /Directories	$255,000
Waiting Room Amenities	$20,000
Common Area Amenities	$125,000

FF&E	**$450,000**
Financing	
Financing Fees	$142,978
Bridge Construction Loan Interest	$353,283
Environmental Study	$25,000
Financing	**$521,261**
Other Costs and Reserves	
Tax Credit Reserve	$755,372
Operating Reserves	$423,981
Capitalized CAM Reserve	$1,197,123
Accounting	$100,000
Insurance	$170,000
Other Costs and Reserves Total	**$2,646,476**
Soft Cost Contingency	
Misc. Costs	$4,058
Soft Cost Contingency (7.0%)	$317,581
Soft Cost Contingency Total	**$321,639**
Total Soft Costs	**$12,592,238**
Total Costs (Stage I)	**$30,968,890**
Stage II	**Cost ($ Million)**
Demolition	$295,000
Excavation & Foundation	$450,000
Structural	$1,800,000
Exteriors	$4,785,000
Interior Finishes	$1,900,000
Special Requirements	$75,000
Plumbing	$250,000

Fire Protection	$100,000
HVAC & Controls	$550,000
Electrical	$750,000
Hard Costs Total	**$10,955,000**
Hard Cost Contingency (10%)	$1,095,500
General Conditins & Fee (15%)	$1,643,250
Total Construction Costs	**$13,693,750**
Design & Consultant Fees (15%)	**$2,054,063**
Total Costs (Stage II)	**$15,747,813**

APPENDIX B – Case Study_Range Estimating

Items File (used to generate the sample risk profile)

69
"Sitework/Landscaping",1,1943320,100,1943020,1943920
"Base building",1,1.3815E+07,90,1.3815E+07,1.3815E+07
"Transportation Fit-Out",1,500000,100,400000,500900
"Pre-Construction Estimating",1,85000,100,85000,85000
"Tenant Allowances",1,400000,80,400000,409000
"A&E",1,2114865,100,2114865,2114865
"Civil Engineer",1,50000,100,50000,50000
"Landscape Architect",1,40000,100,40000,40000
"Reimburseables",1,50000,70,30000,50000
"Historical Consultant",1,30000,100,30000,30000
"Lighting Consultant",1,15000,100,15000,15000
"Accoustical Consultant",1,10000,100,10000,10000
"Graphic Consultant",1,40000,100,40000,40000
"Roofing Consultant",1,25000,100,25000,25000
"Parking Consultant",1,40000,100,40000,40000
"Retail Consultant",1,20000,90,10000,40000
"Geotechnical Consultant",1,25000,100,25000,25000
"Structural Peer Review",1,10000,100,10000,10000
"Security Consultant",1,15000,58,13000,19000
"Reimburseables(A&E)",1,30000,100,30000,30000
"Probes",1,50000,100,50000,50000
"Borings",1,40000,100,40000,40000
"Initial Survey",1,20000,100,20000,20000
"Final Survey",1,20000,100,20000,20000
"Material Testing",1,50000,100,50000,50000
"Misc.Tesing",1,30000,100,30000,30000
"Building Permit",1,50000,100,50000,50000
"Misc.Permits",1,15000,100,15000,15000
"Financial Services",1,300000,100,300000,300000
"Project Coordination",1,400000,100,400000,400000
"Design&Construction",1,1100000,100,1100000,1100000
"Marketing,Leasing and Property Management",1,200000,100,200000,200000
"Incentive Fee",1,700000,100,700000,700000
"Reimburseables(Development Fee&OH)",1,75000,100,75000,75000
"Additional Paid Fee based on Expande",1,778000,100,778000,778000
"Developer Fee Loan",1,1411923,80,1211923,1511923
"Tax Credit Attorney",1,300000,100,300000,300000
"Agreements",1,200000,100,200000,200000
"Leasing Commission&Fees",1,32074,100,32074,32074
"Legal",1,50000,100,50000,50000

"Tenant Criteria",1,40000,100,40000,40000
"Renderings/Project Sign",1,80000,100,80000,80000
"Brochures and website",1,40000,100,40000,40000
"ICSC Convention",1,35000,100,35000,35000
"Events",1,100000,100,100000,100000
"Miscellaneous",1,20000,100,20000,20000
"Food Court Amenities",1,50000,100,50000,50000
"Retail Signage/Directories",1,255000,100,255000,255000
"Waiting Room Amenities",1,20000,100,20000,20000
"Common Area Amenities",1,125000,100,125000,125000
"Financing Fees",1,142978,100,142978,142978
"Bridge Construction Loan Interest",1,353283,98,303283,393283
"Environmental Study",1,25000,100,25000,25000
"Tax Credit Reserve",1,755372,100,755372,755372
"Operating Reserves",1,423981,100,423981,423981
"Capitalized CAM Reserve",1,1197123,90,1097123,1997123
"Accounting",1,100000,100,100000,100000
"Insurance",1,170000,100,170000,170000
"Miscellaneous costs",1,4058,100,4058,4058
"Demolition",1,295000,100,295000,295000
"Excavation and Foundation",1,450000,100,450000,450000
"Structural",1,1800000,100,1800000,1800000
"Exteriors",1,4785000,89,4705000,4985000
"Interior Finishes",1,1900000,100,1900000,1900000
"Special Requirments",1,75000,100,75000,75000
"Plumbing",1,250000,100,250000,250000
"Fire Protection",1,100000,100,100000,100000
"HVAC and Controls",1,550000,100,550000,550000
"Electrical",1,750000,100,750000,750000

Perform Range Estimating

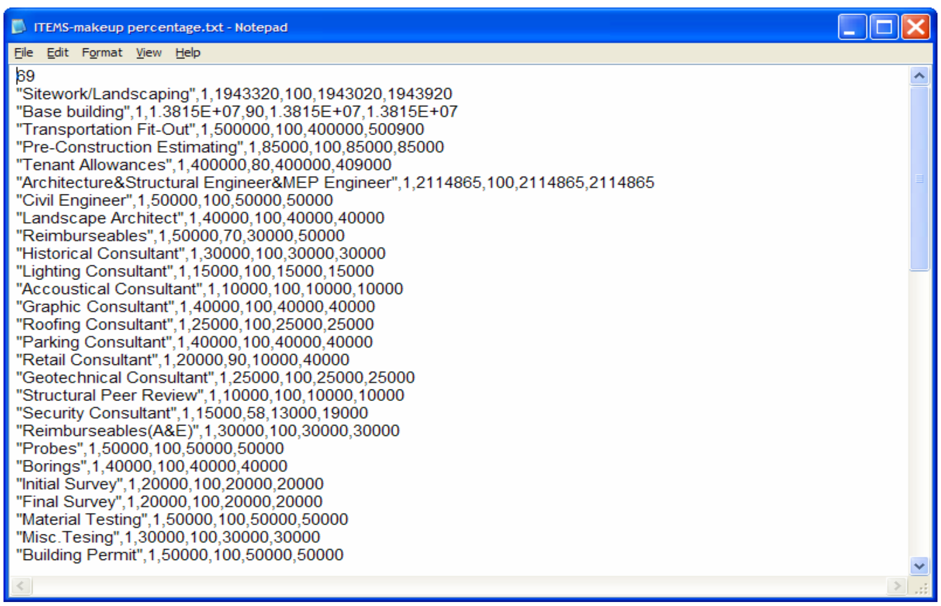
The software Range was utilized to perform range estimating and generate a series of data used for risk profile. The following steps can be easily followed:

I. Edit "Items" files

- Open file using NOTEPAD

- Adjust confidence factors and Cost Range

For Example, "Exteriors",1,4785000,89,4705000,4985000


ITEMS-makeup percentage.txt - Notepad

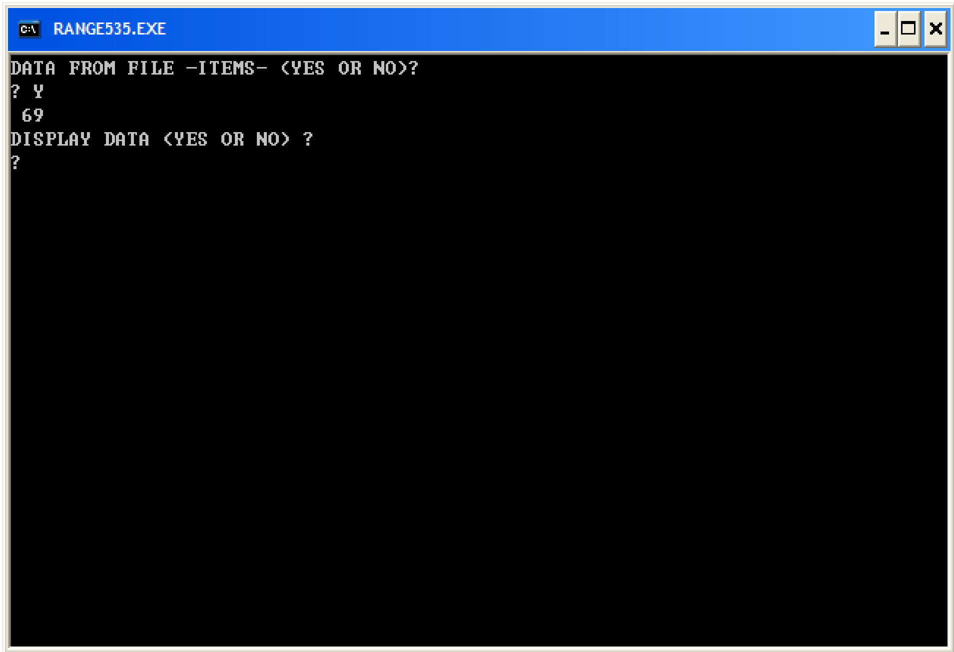
File Edit Format View Help

```
69
"Sitework/Landscaping",1,1943320,100,1943020,1943920
"Base building",1,1.3815E+07,90,1.3815E+07,1.3815E+07
"Transportation Fit-Out",1,500000,100,400000,500900
"Pre-Construction Estimating",1,85000,100,85000,85000
"Tenant Allowances",1,400000,80,400000,409000
"Architecture&Structural Engineer&MEP Engineer",1,2114865,100,2114865,2114865
"Civil Engineer",1,50000,100,50000,50000
"Landscape Architect",1,40000,100,40000,40000
"Reimburseables",1,50000,70,30000,50000
"Historical Consultant",1,30000,100,30000,30000
"Lighting Consultant",1,15000,100,15000,15000
"Accoustical Consultant",1,10000,100,10000,10000
"Graphic Consultant",1,40000,100,40000,40000
"Roofing Consultant",1,25000,100,25000,25000
"Parking Consultant",1,40000,100,40000,40000
"Retail Consultant",1,20000,90,10000,40000
"Geotechnical Consultant",1,25000,100,25000,25000
"Structural Peer Review",1,10000,100,10000,10000
"Security Consultant",1,15000,58,13000,19000
"Reimburseables(A&E)",1,30000,100,30000,30000
"Probes",1,50000,100,50000,50000
"Borings",1,40000,100,40000,40000
"Initial Survey",1,20000,100,20000,20000
"Final Survey",1,20000,100,20000,20000
"Material Testing",1,50000,100,50000,50000
"Misc.Tesing",1,30000,100,30000,30000
"Building Permit",1,50000,100,50000,50000
```

- Save Changes

II. Run Range.exe file

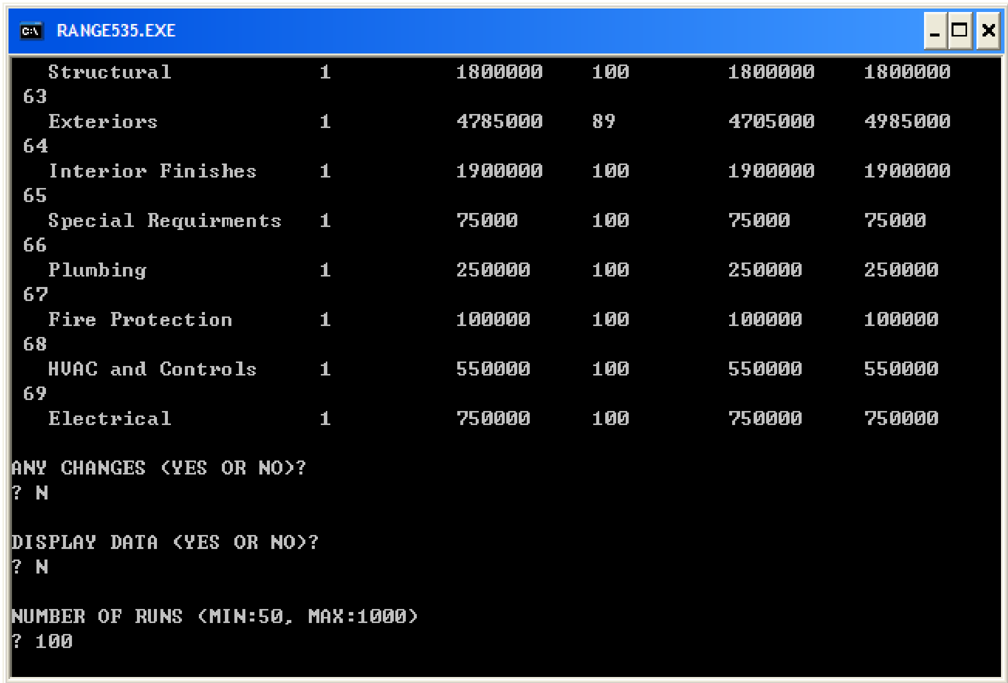
- Lock the Caps key and Respond to program prompts



```
RANGE535.EXE
DATA FROM FILE -ITEMS- (YES OR NO)?
? Y
 69
DISPLAY DATA (YES OR NO) ?
?
```

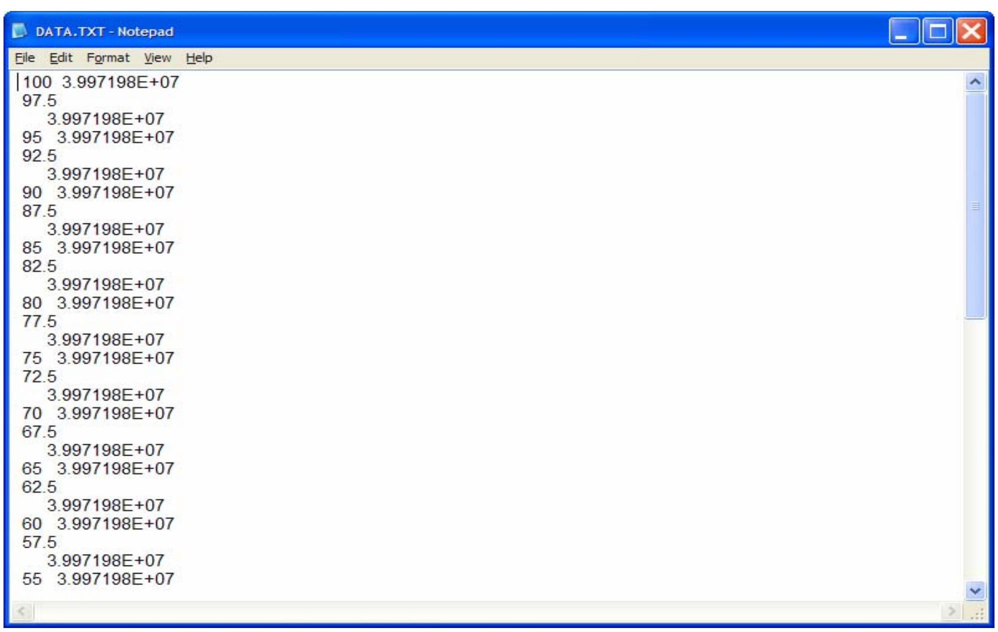
```
RANGE535.EXE
 60
   Demolition              1          295000     100         295000      295000
 61
   Excavation and Foundation
                           1          450000     100         450000      450000
 62
   Structural              1          1800000    100         1800000     1800000
 63
   Exteriors               1          4785000    89          4705000     4985000
 64
   Interior Finishes       1          1900000    100         1900000     1900000
 65
   Special Requirments     1          75000      100         75000       75000
 66
   Plumbing                1          250000     100         250000      250000
 67
   Fire Protection         1          100000     100         100000      100000
 68
   HVAC and Controls       1          550000     100         550000      550000
 69
   Electrical              1          750000     100         750000      750000

ANY CHANGES (YES OR NO)?
? N
```

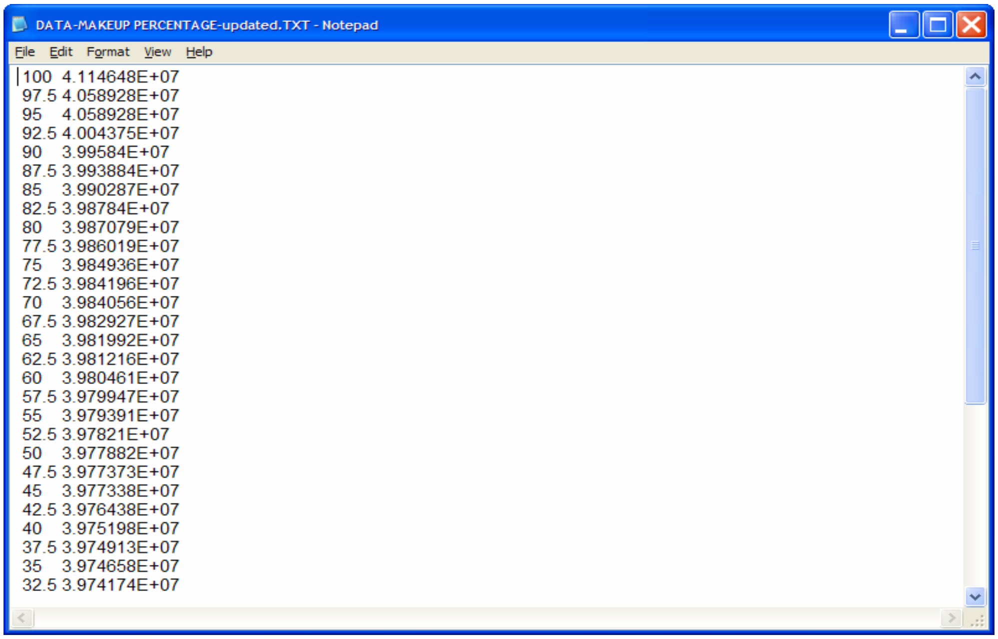
- Choose number of runs = 100



- Close the MS DOS window

III. Edit “DATA.DAT” file to a set of orderly data without irregular spaces

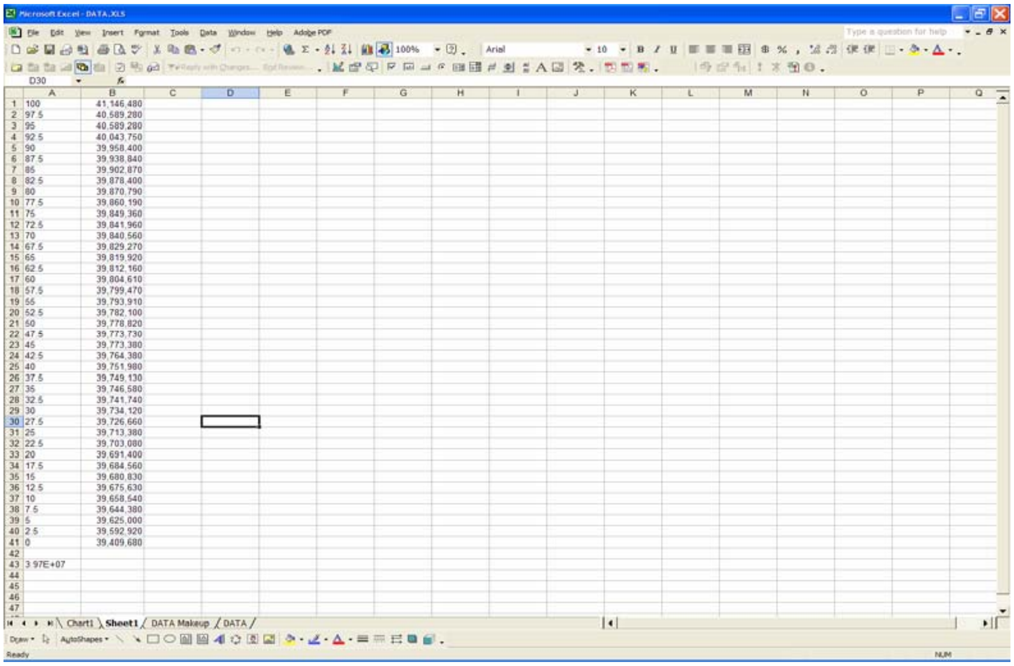




DATA-MAKEUP PERCENTAGE-updated.TXT - Notepad

100	4.114648E+07
97.5	4.058928E+07
95	4.058928E+07
92.5	4.004375E+07
90	3.99584E+07
87.5	3.993884E+07
85	3.990287E+07
82.5	3.98784E+07
80	3.987079E+07
77.5	3.986019E+07
75	3.984936E+07
72.5	3.984196E+07
70	3.984056E+07
67.5	3.982927E+07
65	3.981992E+07
62.5	3.981216E+07
60	3.980461E+07
57.5	3.979947E+07
55	3.979391E+07
52.5	3.97821E+07
50	3.977882E+07
47.5	3.977373E+07
45	3.977338E+07
42.5	3.976438E+07
40	3.975198E+07
37.5	3.974913E+07
35	3.974658E+07
32.5	3.974174E+07

IV. Import "DATA.DAT" file into "DATA.XLS" file and Move Column, Sort, Format to a desirable format



Microsoft Excel - DATA.XLS

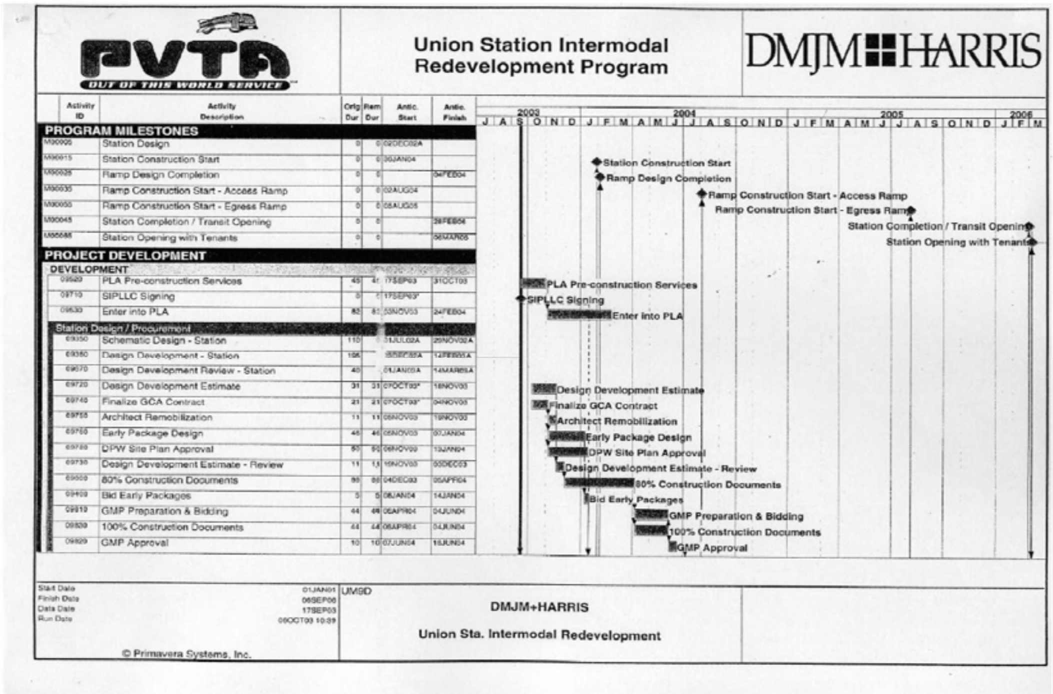
	A	B
1	100	41,146,480
2	97.5	40,589,280
3	95	40,589,280
4	92.5	40,043,750
5	90	39,958,400
6	87.5	39,938,840
7	85	39,902,870
8	82.5	39,878,400
9	80	39,870,790
10	77.5	39,860,190
11	75	39,849,360
12	72.5	39,841,960
13	70	39,840,560
14	67.5	39,829,270
15	65	39,819,920
16	62.5	39,812,160
17	60	39,804,610
18	57.5	39,799,470
19	55	39,793,910
20	52.5	39,782,100
21	50	39,778,820
22	47.5	39,773,730
23	45	39,773,380
24	42.5	39,764,380
25	40	39,751,980
26	37.5	39,749,130
27	35	39,746,580
28	32.5	39,741,740
29	30	39,734,120
30	27.5	39,726,660
31	25	39,713,380
32	22.5	39,703,080
33	20	39,691,400
34	17.5	39,684,560
35	15	39,680,830
36	12.5	39,675,630
37	10	39,658,540
38	7.5	39,644,380
39	5	39,625,000
40	2.5	39,592,920
41	0	39,409,680
42		
43	3.97E+07	

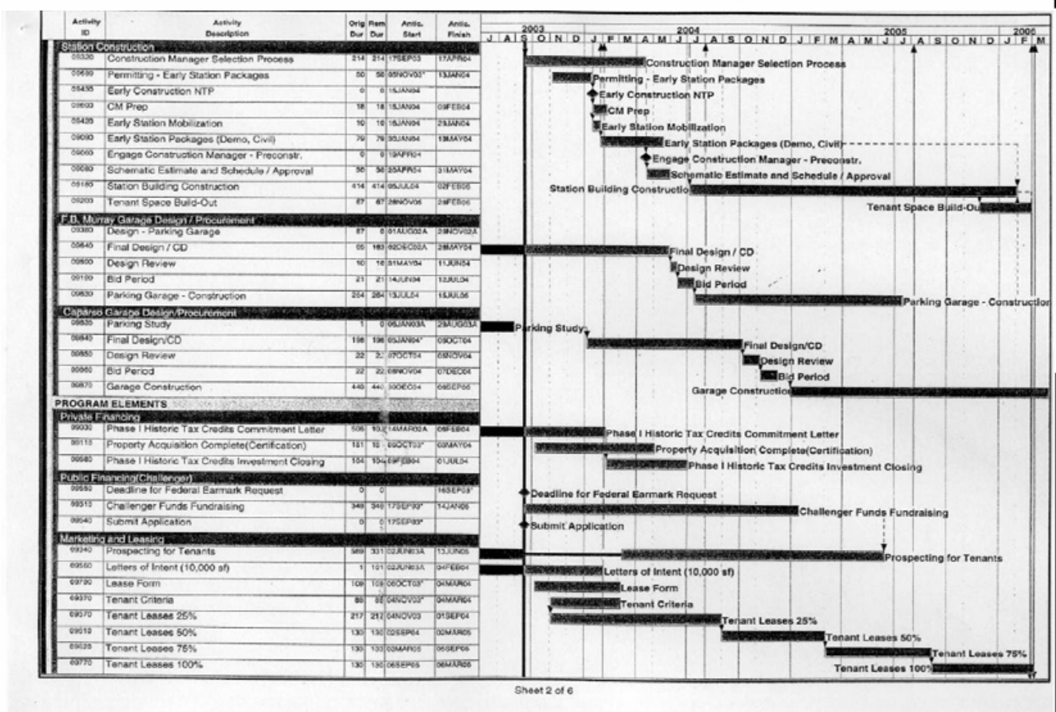
Chart1 / Sheet1 / DATA Makeup / DATA

Data File (generated by running Range)

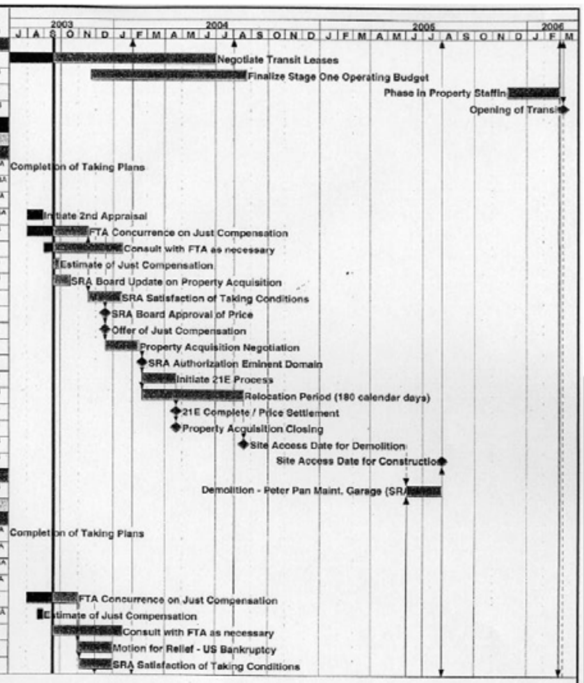
100	4.114648E+07
97.5	4.058928E+07
95	4.058928E+07
92.5	4.004375E+07
90	3.99584E+07
87.5	3.993884E+07
85	3.990287E+07
82.5	3.98784E+07
80	3.987079E+07
77.5	3.986019E+07
75	3.984936E+07
72.5	3.984196E+07
70	3.984056E+07
67.5	3.982927E+07
65	3.981992E+07
62.5	3.981216E+07
60	3.980461E+07
57.5	3.979947E+07
55	3.979391E+07
52.5	3.97821E+07
50	3.977882E+07
47.5	3.977373E+07
45	3.977338E+07
42.5	3.976438E+07
40	3.975198E+07
37.5	3.974913E+07
35	3.974658E+07
32.5	3.974174E+07
30	3.973412E+07
27.5	3.972666E+07
25	3.971338E+07
22.5	3.970308E+07
20	3.96914E+07
17.5	3.968456E+07
15	3.968083E+07
12.5	3.967563E+07
10	3.965854E+07
7.5	3.964438E+07
5	3.9625E+07
2.5	3.959292E+07
0	3.940968E+07

APPENDIX C – Case Study_Schedule Documents Issued by FTA



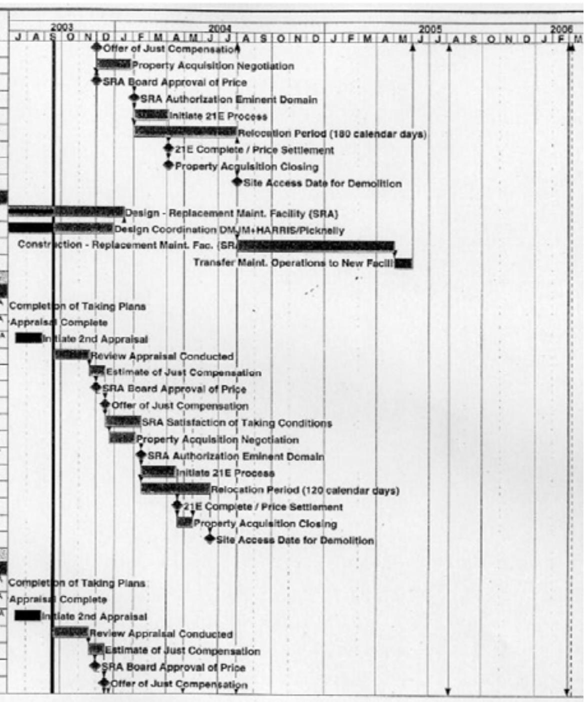


Activity ID	Activity Description	Orig Dur	Rem Dur	Antic. Start	Antic. Finish
Property Management					
09460	Negotiate Transit Leases	317	207	14MAR02A	01JUL04
09330	Finalize Stage One Operating Budget	197	197	24NOV03*	24AUG04
09690	Phase in Property Staffing	67	67	28NOV05*	28FEB06
09700	Opening of Transit	0	0		06MAR06
PROPERTY ACQUISITION					
11 Liberty / 1776 Main Street (Picknelly)					
11 Liberty / 1776 Main Street					
10100	Completion of Taking Plans	45	0	02JUL01A	30JUN03A
10125	Appraisal Complete	0	0		13MAR03A
10120	Review Appraisal Conducted	21	0	01JUN03A	21JUN03A
10105	Initiate 2nd Appraisal	21	0	01AUG03A	29AUG03A
10135	FTA Concurrence on Just Compensation	62	62	01AUG03A	11NOV03
10115	Consult with FTA as necessary	123	123	31AUG03A	17JAN04
10130	Estimate of Just Compensation	10	10	17SEP03	26SEP03
10180	SRA Board Update on Property Acquisition	23	23	17SEP03	17OCT03
10190	SRA Satisfaction of Taking Conditions	43	43	18NOV03	15JAN04
10110	SRA Board Approval of Price	0	0	18DEC03	
10140	Offer of Just Compensation	0	0	18DEC03	
10145	Property Acquisition Negotiation	60	60	18DEC03	15FEB04
10155	SRA Authorization Eminent Domain	0	0		20FEB04
10150	Initiate 21E Process	60	60	21FEB04	20APR04
10160	Relocation Period (180 calendar days)	180	180	21FEB04	18AUG04
10165	21E Complete / Price Settlement	0	0		20APR04
10170	Property Acquisition Closing	0	0		20APR04
10175	Site Access Date for Demolition	0	0		18AUG04
10185	Site Access Date for Construction	0	0		04AUG05
Garage Demolition					
00105	Demolition - Peter Pan Maint. Garage (SRA)	63	63	03JUN05	04AUG05
331 Liberty Street (Roy)					
331 Liberty Street					
09000	Completion of Taking Plans	45	0	02JUL01A	30JUN03A
09005	Initiate 2nd Appraisal	34	0	01JAN02A	15FEB02A
09015	Appraisal Complete	0	0		13MAR03A
09015	Review Appraisal Conducted	21	0	01JUN03A	21JUN03A
09065	FTA Concurrence on Just Compensation	90	46	01AUG03A	31OCT03
09029	Estimate of Just Compensation	10	0	22AUG03A	31AUG03A
09909	Consult with FTA as necessary	123	123	17SEP03	17JAN04
09100	Motion for Relief - US Bankruptcy	61	61	01NOV03	31DEC03
09025	SRA Satisfaction of Taking Conditions	43	43	03NOV03	31DEC03

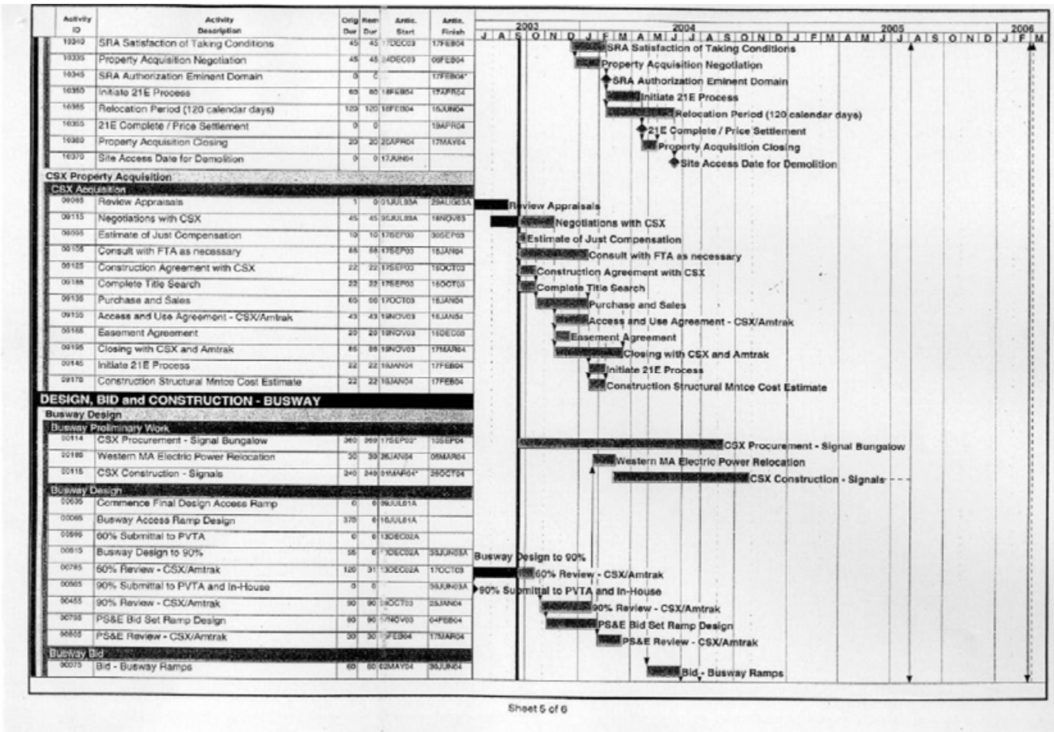


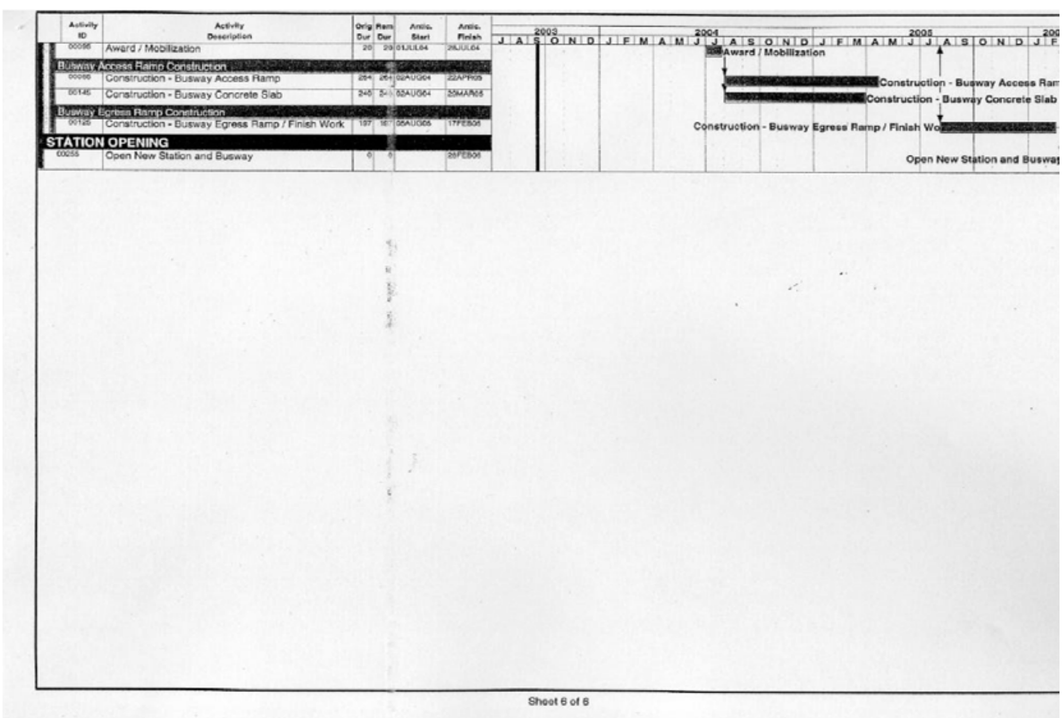
Sheet 3 of 6

Activity ID	Activity Description	Orig Dur	Rem Dur	Antic. Start	Antic. Finish
01005	Offer of Just Compensation	0	0	01DEC03	
01010	Property Acquisition Negotiation	60	60	01DEC03	29JAN04
09075	SRA Board Approval of Price	0	0	01DEC03	
01015	SRA Authorization Eminent Domain	0	0		03FEB04
09035	Initiate 21E Process	60	60	04FEB04	03APR04
09040	Relocation Period (180 calendar days)	180	180	04FEB04	01AUG04
09050	21E Complete / Price Settlement	0	0		03APR04
09070	Property Acquisition Closing	0	0		03APR04
09055	Site Access Date for Demolition	0	0		01AUG04
Replacement Maintenance Facility					
00130	Design - Replacement Maint. Facility (SRA)	276	123	01JUN03A	17JAN04
00175	Design Coordination DMJM+HARRIS/Picknelly	100	75	02JUN03A	30DEC03
00155	Construction - Replacement Maint. Fac. (SRA)	274	274	02AUG04	02MAY05
00165	Transfer Maint. Operations to New Facility	31	31	03MAY05	02JUN05
95 - 119 FB Murray Street (Carparso)					
95 - 119 FB Murray Street					
10200	Completion of Taking Plans	45	0	03JUL01A	30JUN03A
10225	Appraisal Complete	0	0		20JUN03A
10205	Initiate 2nd Appraisal	34	0	14JUL03A	28AUG03A
10220	Review Appraisal Conducted	45	45	17SEP03	18NOV03
10230	Estimate of Just Compensation	20	20	19NOV03	18DEC03
10210	SRA Board Approval of Price	0	0	01DEC03	
10240	Offer of Just Compensation	0	0	17DEC03	
10290	SRA Satisfaction of Taking Conditions	45	45	17DEC03	17FEB04
10245	Property Acquisition Negotiation	45	45	24DEC03	06FEB04
10255	SRA Authorization Eminent Domain	0	0		17FEB04*
10250	Initiate 21E Process	60	60	18FEB04	17APR04
10260	Relocation Period (120 calendar days)	120	120	18FEB04	16JUN04
10265	21E Complete / Price Settlement	0	0		19APR04
10270	Property Acquisition Closing	20	20	20APR04	17MAY04
10280	Site Access Date for Demolition	0	0	17JUN04	
30 - 50 FB Murray Street (Picknelly)					
30 - 50 FB Murray Street					
10300	Completion of Taking Plans	45	0	02JUL01A	30JUN03A
10305	Appraisal Complete	0	0		20JUN03A
10310	Initiate 2nd Appraisal	34	0	14JUL03A	28AUG03A
10320	Review Appraisal Conducted	45	45	17SEP03	18NOV03
10325	Estimate of Just Compensation	20	20	19NOV03	16DEC03
10315	SRA Board Approval of Price	0	0	01DEC03	
10330	Offer of Just Compensation	0	0	17DEC03	

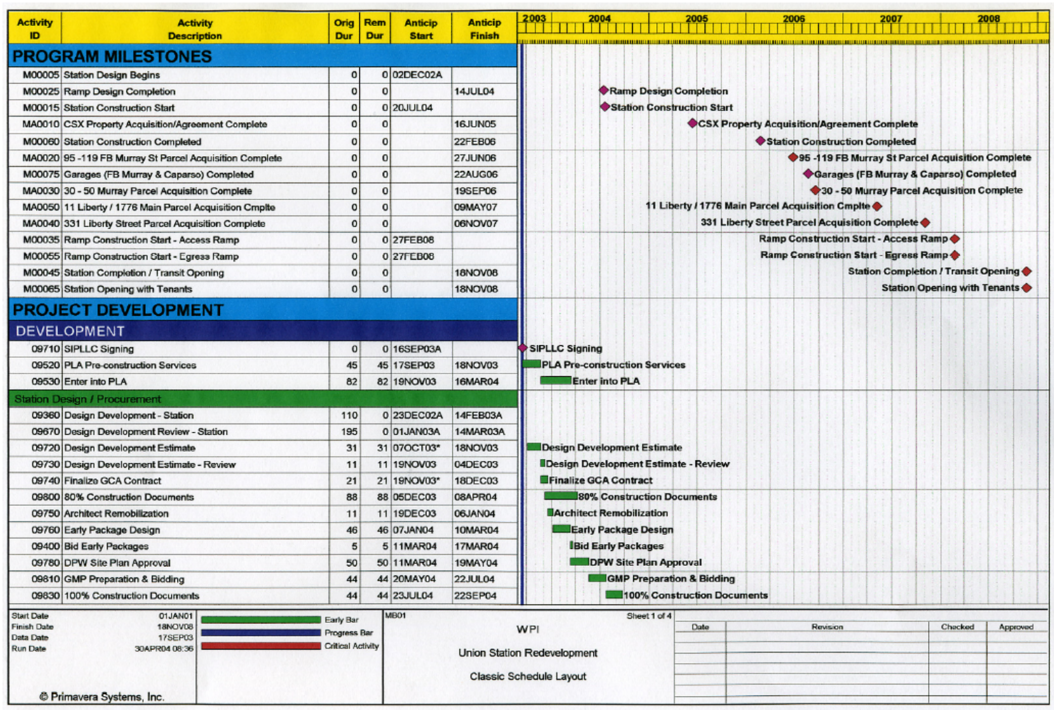


Sheet 4 of 6


Activity ID
Activity Description
Orig Dur
Rem Dur
Early Start
Early Finish
2003
2004
2005
2006
SRA Satisfaction of Taking Conditions
Property Acquisition Negotiation
SRA Authorization Eminent Domain
Initiate 21E Process
Relocation Period (120 calendar days)
21E Complete / Price Settlement
Property Acquisition Closing
Site Access Date for Demolition
CSX Property Acquisition
CSX Acquisition
Review Appraisals
Negotiations with CSX
Estimate of Just Compensation
Consult with FTA as necessary
Construction Agreement with CSX
Complete Title Search
Purchase and Sales
Access and Use Agreement - CSX/Amtrak
Easement Agreement
Closing with CSX and Amtrak
Initiate 21E Process
Construction Structural Mntce Cost Estimate
DESIGN, BID and CONSTRUCTION - BUSWAY
Busway Design
Busway Preliminary Work
CSX Procurement - Signal Bungalow
Western MA Electric Power Relocation
CSX Construction - Signals
Busway Design
Commence Final Design Access Ramp
Busway Access Ramp Design
60% Submittal to PVTA
Busway Design to 90%
60% Review - CSX/Amtrak
90% Submittal to PVTA and In-House
90% Review - CSX/Amtrak
PS&E Bid Set Ramp Design
PS&E Review - CSX/Amtrak
Busway Bid
Bid - Busway Ramps
Sheet 5 of 6

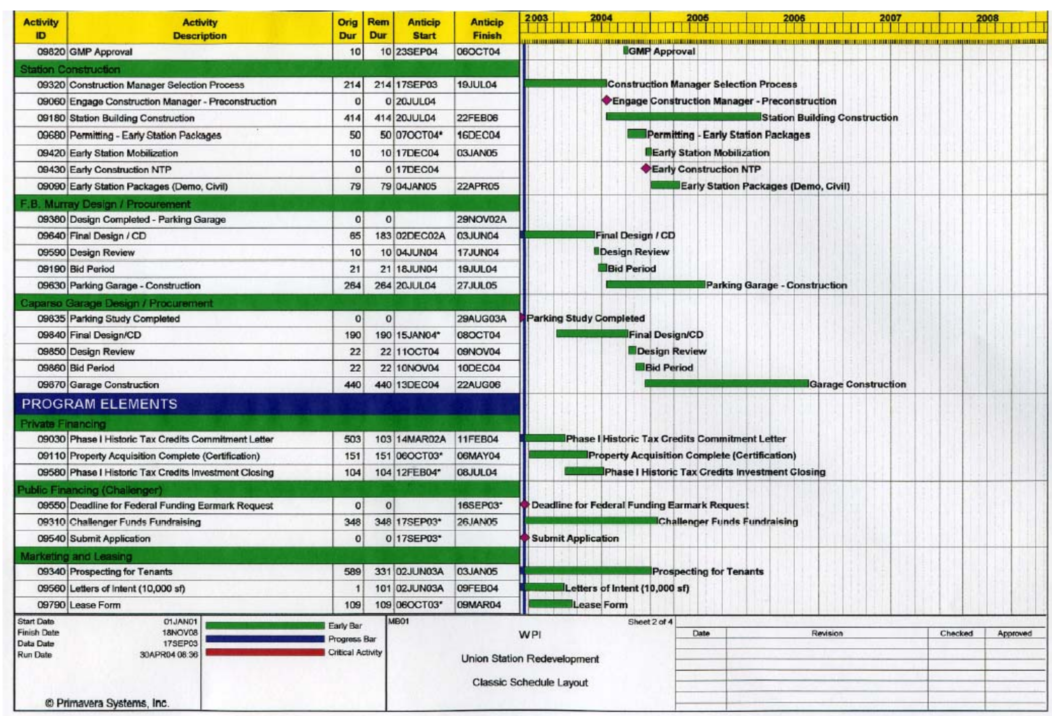

Activity ID
Activity Description
Orig Dur
Rem Dur
Early Start
Early Finish
2003
2004
2005
Award / Mobilization
Busway Access Ramp Construction
Construction - Busway Access Ramp
Construction - Busway Concrete Slab
Busway Egress Ramp Construction
Construction - Busway Egress Ramp / Finish Work
STATION OPENING
Open New Station and Busway
Sheet 6 of 6

APPENDIX D – Case Study_Schedule Regenerated for Risk Analysis Study



Activity ID	Activity Description	Orig Dur	Rem Dur	Anticip Start	Anticip Finish
PROGRAM MILESTONES					
M00005	Station Design Begins	0	0	02DEC02A	
M00025	Ramp Design Completion	0	0		14JUL04
M00015	Station Construction Start	0	0	20JUL04	
MA0010	CSX Property Acquisition/Agreement Complete	0	0		16JUN05
M00060	Station Construction Completed	0	0		22FEB06
MA0020	95 -119 FB Murray St Parcel Acquisition Complete	0	0		27JUN06
M00075	Garages (FB Murray & Caparso) Completed	0	0		22AUG06
MA0030	30 - 50 Murray Parcel Acquisition Complete	0	0		19SEP06
MA0050	11 Liberty / 1776 Main Parcel Acquisition Cmplte	0	0		09MAY07
MA0040	331 Liberty Street Parcel Acquisition Complete	0	0		06NOV07
M00035	Ramp Construction Start - Access Ramp	0	0	27FEB08	
M00055	Ramp Construction Start - Egress Ramp	0	0	27FEB08	
M00045	Station Completion / Transit Opening	0	0		18NOV08
M00065	Station Opening with Tenants	0	0		18NOV08
PROJECT DEVELOPMENT					
DEVELOPMENT					
09710	SIPLLC Signing	0	0	16SEP03A	
09520	PLA Pre-construction Services	45	45	17SEP03	18NOV03
09530	Enter into PLA	82	82	19NOV03	16MAR04
Station Design / Procurement					
09360	Design Development - Station	110	0	23DEC02A	14FEB03A
09670	Design Development Review - Station	195	0	01JAN03A	14MAR03A
09720	Design Development Estimate	31	31	07OCT03*	18NOV03
09730	Design Development Estimate - Review	11	11	19NOV03	04DEC03
09740	Finalize GCA Contract	21	21	19NOV03*	18DEC03
09800	80% Construction Documents	88	88	05DEC03	08APR04
09750	Architect Remobilization	11	11	19DEC03	06JAN04
09760	Early Package Design	46	46	07JAN04	10MAR04
09400	Bid Early Packages	5	5	11MAR04	17MAR04
09780	DPW Site Plan Approval	50	50	11MAR04	19MAY04
09810	GMP Preparation & Bidding	44	44	20MAY04	22JUL04
09830	100% Construction Documents	44	44	23JUL04	22SEP04

Start Date 01JAN01
Finish Date 18NOV08
Data Date 17SEP03
Run Date 30APR04 08:36
Early Bar
Progress Bar
Critical Activity
MB01
Sheet 1 of 4
WPI
Union Station Redevelopment
Classic Schedule Layout
Date | Revision | Checked | Approved



Activity ID	Activity Description	Orig Dur	Rem Dur	Anticip Start	Anticip Finish
09820	GMP Approval	10	10	23SEP04	06OCT04
Station Construction					
09320	Construction Manager Selection Process	214	214	17SEP03	19JUL04
09060	Engage Construction Manager - Preconstruction	0	0	20JUL04	
09180	Station Building Construction	414	414	20JUL04	22FEB06
09680	Permitting - Early Station Packages	50	50	07OCT04*	16DEC04
09420	Early Station Mobilization	10	10	17DEC04	03JAN05
09430	Early Construction NTP	0	0	17DEC04	
09090	Early Station Packages (Demo, Civil)	79	79	04JAN05	22APR05
F.B. Murray Design / Procurement					
09380	Design Completed - Parking Garage	0	0		29NOV02A
09640	Final Design / CD	65	183	02DEC02A	03JUN04
09590	Design Review	10	10	04JUN04	17JUN04
09190	Bid Period	21	21	18JUN04	19JUL04
09630	Parking Garage - Construction	264	264	20JUL04	27JUL05
Caparso Garage Design / Procurement					
09835	Parking Study Completed	0	0		29AUG03A
09840	Final Design/CD	190	190	15JAN04*	08OCT04
09850	Design Review	22	22	11OCT04	09NOV04
09860	Bid Period	22	22	10NOV04	10DEC04
09870	Garage Construction	440	440	13DEC04	22AUG06
PROGRAM ELEMENTS					
Private Financing					
09030	Phase I Historic Tax Credits Commitment Letter	503	103	14MAR02A	11FEB04
09110	Property Acquisition Complete (Certification)	151	151	06OCT03*	06MAY04
09580	Phase I Historic Tax Credits Investment Closing	104	104	12FEB04*	08JUL04
Public Financing (Challenger)					
09550	Deadline for Federal Funding Earmark Request	0	0		16SEP03*
09310	Challenger Funds Fundraising	348	348	17SEP03*	26JAN05
09540	Submit Application	0	0	17SEP03*	
Marketing and Leasing					
09340	Prospecting for Tenants	589	331	02JUN03A	03JAN05
09560	Letters of Intent (10,000 sf)	1	101	02JUN03A	09FEB04
09790	Lease Form	109	109	06OCT03*	09MAR04

Start Date 01JAN01
Finish Date 18NOV08
Data Date 17SEP03
Run Date 30APR04 08:36
Early Bar
Progress Bar
Critical Activity
MB01
Sheet 2 of 4
WPI
Union Station Redevelopment
Classic Schedule Layout
Date | Revision | Checked | Approved

Activity ID	Activity Description	Orig Dur	Rem Dur	Anticip Start	Anticip Finish
09370	Tenant Criteria	88	88	04NOV03*	09MAR04
09570	Tenant Leases 25%	217	217	04NOV03	08SEP04
09610	Tenant Leases 50%	130	130	09SEP04	14MAR05
09620	Tenant Leases 75%	133	133	15MAR05	15SEP05
09770	Tenant Leases 100%	130	130	16SEP05	16MAR06
Property Management					
09460	Negotiate Transit Leases	317	207	14MAR02A	08JUL04
09330	Finalize Stage One Operating Budget	197	197	24NOV03*	31AUG04
09690	Phase in Property Staffing	67	67	28NOV05*	28FEB06
09700	Opening of Transit	0	0		28FEB06
PROPERTY ACQUISITION					
01010	331 Liberty Street Property Acquisition	729	729	20JAN05	06NOV07
10145	11 Liberty / 1776 Main St Property Acquisition	600	600	20JAN05	09MAY07
10245	95-119 FB Murray Street Property Acquistion	374	374	20JAN05	27JUN06
10335	30 - 50 Murray Property Acquistion	434	434	20JAN05	19SEP06
CSX Property Acquisition					
CSX Acquisition					
09115	Negotiations with CSX	45	300	30JUL03A	16NOV04
09085	Review Appraisals Completed	0	0		29AUG03A
09095	Estimate of Just Compensation	10	10	17SEP03	30SEP03
09125	Construction Agreement with CSX	22	22	01OCT03	30OCT03
09135	Purchase and Sales	66	66	31OCT03	04FEB04
09155	Access and Use Agreement - CSX/Amtrak	43	43	17NOV04	19JAN05
09165	Easement Agreement	20	20	20JAN05	16FEB05
09195	Closing with CSX and Amtrak	86	86	17FEB05	16JUN05
DESIGN, BID and CONSTRUCTION - BUSWAY					
Busway Design					
Busway Design					
00635	Commence Final Design Access Ramp	0	0	09JUL01A	
00065	Busway Access Ramp design	373	300	10JUL01A	16NOV04
00595	60% Submittal to PVTA	0	0	13DEC02A	
00615	Busway Design to 90%	55	0	13DEC02A	30JUN03A
00785	60% Review - CSX/Amtrak	120	31	13DEC02A	29OCT03

Start Date 01JAN01
Finish Date 18NOV08
Data Date 17SEP03
Run Date 30APR04 08:36

Early Bar
Progress Bar
Critical Activity

MB01

Sheet 3 of 4

WPI

Union Station Redevelopment

Classic Schedule Layout

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur	Rem Dur	Anticip Start	Anticip Finish
00605	90% Submittal to PVTA and In-House	0	0		30JUN03A
00455	90% Review - CSX/Amtrak	90	90	30OCT03	08MAR04
00795	PS&E Bid Set Ramp Design	90	90	09MAR04	14JUL04
00805	PS&E Review - CSX/Amtrak	30	30	15JUL04	25AUG04
00810	PS&E Review - PVTA & In-House	30	30	15JUL04	25AUG04
Busway Bid					
00110	Bid - Busway Concrete Slab	60	60	26AUG04	17NOV04
00100	Award / Mobilize Concrete Slab	60	60	18NOV04	14FEB05
00075	Bid - Busway Access/Egress Ramps	60	60	07NOV07	29JAN08
00095	Award / Mobilization Ramps	20	20	30JAN08	26FEB08
Busway Access Ramp Construction					
00145	Construction - Busway Concrete Slab	170	170	15FEB05	10OCT05
00085	Construction - Busway Access Ramp	190	190	27FEB08	18NOV08
Busway Egress Ramp Construction					
00125	Construction - Busway Egress Ramp / Finish Work	141	141	27FEB08	10SEP08
STATION OPENING					
00255	Open New Station	0	0		18NOV08

Start Date 01JAN01
Finish Date 18NOV08
Data Date 17SEP03
Run Date 30APR04 08:36

Early Bar
Progress Bar
Critical Activity

MB01

Sheet 4 of 4

WPI

Union Station Redevelopment

Classic Schedule Layout

Date	Revision	Checked	Approved

APPENDIX E - Sample Risk Analysis Workshop Feedback Questionnaire

Springfield Union Station Intermodal Redevelopment Project
Risk Assessment Workshop Feedback Questionnaire
WPI Risk Analysis Study Group, 2004

The risk assessment workshop was conducted on April 27, 2004 at the PVTA offices in Springfield. On behalf of WPI we would like to thank you for the opportunity to be involved in this challenging project. Utilizing a “real” project provided us an invaluable opportunity and learning experience.

To further our study for academic purposes, your comments and advice would be crucial. You may have a look at a couple of questions below or send us any comment or advice you would like to offer.

1. Do you think the format we utilized in the workshop was helpful to making critical project decisions? Why?

2. What did you find is most helpful or how did it assist bringing to light project issues?

We do really appreciate any advice and suggestion from you. And thank you very much for the time and consideration!

APPENDIX F - Workshop Questionnaire Feedback

From Pioneer Valley Transit Authority (PVTA):

1) Do you think the format we utilized in the workshop was helpful to making critical project decisions? Why?

[Sandra Sheehan] Yes, because it was an opportunity to get everyone around the table to address all the possible issues.

2) What did you find is most helpful or how did it assist bringing to light project issues?

[Sandra Sheehan] The issue of CSX. How the assessment brought about all the risk and issues that go along with CSX. What will be helpful is a breakdown of both present and future costs and exposure.

From FTA –Mr. Matthew Keamy, Region One Office:

- A Risk Assessment should have been done about a year earlier in the project development.
- On larger projects, two or three days would be needed for the workshop.
- I would recommend a format or agenda be followed but still allow for a free exchange of ideas during the workshop.
- A 20-minute presentation on "What is a Risk Assessment" should kickoff a workshop.

From DMJM+HARRIS, Inc. – Ms. Jeannette Skoropowski and Mr. Michael Hunter:

> *The workshop was extremely helpful in making PVTA realize what they were up against and the minimal chance they had of advancing the project the way it currently developed because of CSX.*

APPENDIX G – FTA Risk Analysis Program Question Feedback

Feedback (I): <Bhattacharya, Saptarshi, Office of Program Management, FTA, Washington D.C.>

1) How many projects does FTA have on yearly basis? And what are their sizes and complexities? How many of them do you conduct formal Risk Assessment workshops?

   [Bhattacharya, Saptarshi (TPM)] We do about 6-10 projects in a year. They range from $400 Million to $4 Billion. They are simple to complex. All projects performing Risk Assessments run formal workshops.

2) What are the criteria to have a Risk Assessment, and when to conduct the risk assessment?

   [Bhattacharya, Saptarshi (TPM)] The criteria vary but normally all projects requesting FFGA are required to perform the Risk Assessment.

3) To what extent the "initial risk assessment" studies conducted in Los Angeles, Pittsburgh and Charlotte projects resemble the one we conducted in Springfield Union Station project?

   [Bhattacharya, Saptarshi (TPM)] The basic parameters you followed in your Risk Assessment are similar to what we do in our Risk Assessment studies. The only difference is that ours are much more detailed specially the simulation portion and the analysis on Cost, Schedule and Contingency.

Feedback (II): <Keamy, Matthew, Region One Office, FTA, Cambridge, MA>

1) If a project is authorized a Full Funding Grant Agreement, does the "$400milliion" become a criterion for implementing a formal risk analysis? Then how many projects authorized FFGAs are not conducted a formal risk analysis on a year basis?

   [Keamy, Matthew (TRO-01)] Projects with greater than $25 million in New Starts funds require an FFGA. All this started in FY03. All FFGA projects now require a Risk Assessment. Keep in mind that New Starts is only one type of FTA Federal Funding. There may be more Federal Funds in the project.

2) I reviewed the annual reports and project profiles which include all the projects FTA has funded. I did not find Springfield Union Station Project. As I know, the Springfield project has received $14.5 million from TEA-21 in 1999 and totally $26.5 million by 2003. Does this meet the "$25 million or more" criterion for being authorized a FFGA? Will the Springfield project enter a Full Funding Grant Agreement with the federal?

   [Keamy, Matthew (TRO-01)] There are no New Starts funds in Springfield Union Station. No FFGA is expected.

3) How many projects which are funded by the federal but not authorized FFGAs on a year? Do you implement a (informal) risk analysis for this type of projects and what is the risk analysis methodology if any?

   [Keamy, Matthew (TRO-01)] FTA was experimenting with the Risk Analysis for Springfield Union Station. To my knowledge, we have not tried this before.

APPENDIX H - FTA Risk Classification Breakdown

Federal Transit Administration Risk Classification
I. Project Feasibility
A. Technical feasibility
B. Long-term viability
C. Political circumstances
II. Funding
A. Sources of funding
B. Inflation and growth rates
C. Accuracy of cost and contingency analysis
D. Cash flow
E. Exchange rates
F. Appropriation
III. Planning
A. Scope
B. Complexity of the project
C. Technical constraints
D. Sole source material or service providers
E. Constuctability
F. Milestones (schedule)
G. Tune to complete (schedule)
H. Synchronization of work and payment schedules
IV. Engineering
A. Design and performance standards
B. Unreliable data
C. Complexity
D. Completeness of design
E. Accountability for design
F. System integration
V. Type of Contract
A. Lumpsum
B. Unit price
C. Cost plus
VI. Contracting Arrangement
A. Turnkey

B. Joint venture
C. Single prime contractor
D. Several prime contractors
E. Innovative procurement methods
VII. Regional and Local Business Conditions
A. Number of bidders
B. Unemployment rate in construction trades
C. Workload of regional contractors
VIII.Contractor Reliability
A. Capability
B. Capacity
C. Credit worthiness
D. Personnel experience
IX. Owner Involvement
A. Management of project
B. Supplying of material
C. Testing and inspection
D. Safety programs
E. Communications and problem solving
F. Partnering
G. Start-up operations
X. Regulatory Conditions
A. Licenses, permits, approvals
B. Environmental regulations and requirements
C. Patent infringement
D. Taxes and duties
E. DBE (Disadvantaged Business Enterprise) involvement
XI. Acts of God
A. Storm
B. Earthquake
C. Flood
D. Fire
E. Impact of site location on any of the above
XII.Site
A. Access

B. Congestion
C. Underground conditions
* Soil conditions (rock vs soil, etc.)
* Water
* Utilities (existing and new)
* Archeological finds
* Hazardous wastes
D. Noise, fume, dust
E. Abutting structures
F. Security
G. Disruption to public
XIII.Labor
A. Productivity
B. Strikes
C. Minority representation
D. Sabotage
E. Availability
F. Work ethics
G. Wage scales
H. Substance abuse
I. Local rules
J. Unions
K. Material wastes
L. Workman's compensation
XIV.Loss or Damages
A. Owner's responsibility
B. Contractor's responsibility
C. Engineer's responsibility
D. Vandalism, sabotages
E. Accidents
F. Third Party Claims
XV.Guarantees
A. Schedule
B. Performance
C. Consequential losses
D. Liquidated damages

APPENDIX I – Generic Risk Checklist

GENERIC RISK CHECKLIST FOR TRANSPORTATION PROJECTS
A. Planning and Selection Risks
1. Inadequate project planning.
2. Inappropriate or inefficient project delivery system
3. Inappropriate or inadequate contract award process
4. Inappropriate or inadequate pricing
5. Poor client selection.
6. Assembling primary design and construction team
7. Subcontractor and supplier selection.
B. Financial Risks
1. Major participant insolvency.
2. Bankruptcy of a major participant.
3. Insufficient unencumbered value in project for mechanic's lien recovery.
4. Funding Risks (Government Contract Funding, Allocations).
5. Loss or damage incurred by third parties.
6. Regulatory Exposures (IRS, FASB).
7. Interest Rate Changes (Credit Risks, Bonding).
8. Lender, surety, or insurer insolvency.
9. Labor and Material Costs (FTE's, Contract, Outsourced).
10. Earnings Volatility (Revenue Recognition, EPS Growth).
11. Currency Fluctuation (Foreign Exchange, Arbitrage).
C. Contractual Risks
1. Illegal contracts: Agreements in violation of statutory or regulatory law
2. Miscommunications and ambiguities in the contract formation process.
3. Disappointed expectations with respect to contract award: Use of alternates in competitive bidding.
4. Subcontractor disappointment over award process: Bid shopping.

5. Bid chiseling.
6. Doing business with foreign suppliers: Application of international law to domestic contracts.
7. Confusing public and private work: Suretyship and sovereign immunity issues.
8. Refusal of prime contractor to honor its bid: The bid bond.
9. Warranties (Express, Implied)
10. Liquidated, Consequential and Punitive Damages Clauses.
11. Project labor agreements.
12. Design Responsibility (Design Delegation, Assumption of Risk).
D. Organizational Risks
1. Inadequate corporate form.
2. Risk of personal liability: Piercing the corporate veil.
4. Doing business with sole proprietors: Workers' compensation risks.
5. Doing business without proper license.
6. Ill-conceived joint ventures.
7. Inadequate safety programs: Civil and criminal liability.
8. Inadequate quality management procedures.
9. Inadequate internal financial controls.
10. Generational changes in ownership: The bane of the family-run construction business.
E. Site Risks
1. Site availability: Failure to obtain ownership, easement or right-of-way.
2. Zoning and land use regulation.
3. Limitations on access: Remote sites and problems with government approvals.
4. Underground utilities.
5. Poor soils.
6. Poor drainage.
7. Congestion.
8. Underground water.

9. Security problems.
10. Inadequate site investigation.
11. Insufficient time or access to perform adequate investigation.
12. Site investigation impracticable or impossible.
13. Latent conditions in existing construction.
14. Lack of readily available power and/or other utilities.
15. Navigable waterways: Application of admiralty law to construction projects.
F. Resource Risks
1. Unavailability of sufficient amounts of skilled labor.
2. Labor unrest and strikes.
3. Managerial/ supervisory inadequacy or inefficiency.
4. Injuries to employees.
5. Injury to non-employee workers.
6. Material shortages or damage to stored materials.
7. Equipment availability or damage to equipment.
G. Environmental Risks
1. Asbestos.
2. Underground storage tanks.
3. Lead paint.
4. Contaminated soils.
5. Wetlands.
6. Projects in coastal zone areas.
7. Brownfields.
8. Endangered species.
9. Sedimentation & storm water runoff.
10. Disposal of construction waste.
11. Polychlorinated Biphenyls (PCBs) and other hazardous materials.

12. Importation by construction team of hazardous materials.
13. Growing risks from indoor pollution.
14. Environmental remediation contracts.
15. Native American remains.
H. Technology Risks
1. Unwillingness to acquire the right software and inconsistent use of software or use of different software across projects
2. Novel or unproven designs.
3. Incorporation of new products or new uses of existing products.
4. Complex building materials: Compatibility problems.
5. Complex building materials: Constructability problems.
6. Design professional's reliance on supplier information.
7. Systems performance requirements or guarantees.
8. Patent liability.
9. Copyright liability.
10. Inadequate IT facilities.
I. Communication Risks
1. Different languages.
2. Cultural differences.
3. Doing business with Indian tribes.
4. Ambiguous contract documents.
5. Poorly coordinated contract documents.
6. Vague, indefinite or ambiguous contract or work scopes.
7. Contract documents fail to accurately describe project conditions.
8. Confusion over the responsibility for taxes, duties and fees: Tax exempt and federal projects.
9. Confusion over the shop drawing process.
10. Ill-defined costs.
11. Failure or delay in giving notice of material information.

12. Claim notice requirements: Problems with enforcement and compliance.
13. Confusion over scope of authority.
14. Failure to clearly delineate design responsibilities of contracting team.
15. Scope of contractor's obligation to comply with all laws and regulations.
16. Personality conflicts between member participants.
17. Tortuous communications: Defamation risks.
18. Confusion regarding measurements for unit-price items.
J. Waiver Risks
1. Waiver of right to terminate.
2. Waiver in shop drawing approval process.
3. Waiver through acceptance of defective work.
4. Waiver of impact costs.
5. Waiver of insurance rights.
6. Waiver of claims through the execution of change order release language.
7. Waiver in course of executing settlement agreements.
8. Waiver of completion date.
9. Waiver of written change order requirements.
10. Waiver of notice requirements.
11. Waiver in the bid process.
12. Waiver of cost guarantees.
13. Waiver of exculpatory provisions.
K. Expectation Risks
1. Owner’s reliance upon inaccurate cost estimates.
2. Unanticipated site conditions.
3. Contractor’s failure to accurately cost the work.
4. Unusually high performance or quality expectations.
5. Expectation disagreements over quality: The role of industry standards and course of dealing.

6. Unreasonable completion schedule.
7. Failure of recoverable damages to meet injured party’s expectations.
8. Unexpected recovery bars: Relatively short statutes of limitation and repose.
9. Frustrated profit motive.
10. Unrealistic risk allocations.
11. Disappointed value engineering expectations.
12. Unrealistic claim pricing: Establishing the existence and amount of loss.
L. Completion Risks (Time Schedule)
1. Delays to design work.
2. Delays in transmittal/ submittal process.
3. Delays in issuing and responding to requests for information or interpretation (RFIs).
4. Completion delay not within parties' control.
5. Completion delay within one or more of the parties’ control.
6. Concurrent delay.
7. Liquidated damages.
8. Untimely inspection and testing.
9. Multiple primes/coordination failures.
10. Delay responding to and giving direction in face of changed conditions or changed work.
M. Completion Risks (Cost)
1. Cost escalation of critical labor, materials or equipment.
2. Cost overruns within contractor’s control.
3. Voluntary owner changes.
4. Involuntary changes in scope of work.
5. Increase in work units.
6. Unproductive/ disrupted work conditions.
7. Accelerated and/or out-of-sequence work.
8. Overly burdensome inspection and testing requirements.

9. Improper or inefficient construction means and methods.
10. Constructability problems.
N. Completion Risks (Quality)
1. Inadequate or insufficient plans and specifications.
2. Specification and/or use of unsuitable products.
3. Defective construction.
4. Nonconforming work.
5. Inadequate warranties/remedies.
6. Failure to achieve performance requirements.
7. Inadequate inspection and testing.
8. Nonconforming or defective goods.
O. Project Administration Risks
1. Inadequate record-keeping procedures.
2. Inadequate policies and procedures to ensure effective communication.
3. Inefficient dispute resolution procedures.
P. Force Majeure Risks
1. Unusually severe weather, e.g., rain, snow, heat or cold.
Q. Political Risks
1. War, terrorism or hostilities.
2. Strike or lockout or other industrial action by workers not due to fault of any construction participant.
3. Changes in law that adversely affect the project.
4. Government refusal to issue permits or licenses necessary for project.
5. Expropriation.
6. Repudiation of necessary governmental approvals or agreements.
7. Governmental orders and penalties adversely impacting construction.
8. Import/export restrictions.
9. Local courts or administrative bodies failing to recognize choice of law, venue and dispute resolution choices made by the parties.

10. Inability to gain entry for key personnel.
11. Threats to in-country management.
12. International taxation.
R. Currency Risks
1. Inconvertibility of currency.
2. Transfer risk.
3. Devaluation risk.