

EXECUTIVE STRATEGIES FOR RISK MANAGEMENT BY STATE DEPARTMENTS OF TRANSPORTATION

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Executive Strategies for Risk Management by State Departments of Transportation

FINAL RESEARCH REPORT

Prepared for

NCHRP PROJECT 20-24(74)
Administration of Highway and Transportation Agencies

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ABSTRACT

The objective of this study is to describe how Department of Transportation (DOT) leadership currently uses risk management techniques in the conduct of their business and to identify executive strategies that may be useful to DOT leadership for enterprise-wide risk management. Achieving this objective requires DOT leadership to be aware of current risk management strategies implemented by DOTs at the *enterprise, program and project levels*. Therefore, this research study presents a thorough review of transportation, planning, business management and organizational strategy research to identify current risk management practices, emerging methods, and trends. The study presents a comprehensive survey with responses from 43 of the 52 DOTs to identify the risk management strategies currently implemented. The findings from the literature and survey were validated through interviews with top DOT management from three agencies that were considered currently most advanced in risk management based on the survey submissions. This study concludes with a summary of current strategies and recommended techniques that are promising for DOTs. Recommendations relate to leading the development of policies and communication; supporting the integration of the risk management process throughout the DOT; appointment of an executive risk manager; and participation in national enterprise risk management efforts.

EXECUTIVE SUMMARY

Introduction

State departments of transportation (DOTs) function in an environment that is extremely complex and fraught with uncertainty. Administrators, planners, engineers and construction managers must coordinate a multitude of human, organizational and technical resources. Managing risks and planning for contingent liabilities are essential components of a holistic DOT management strategy. Departments of transportation have unique challenges relating to enterprise risk management. It is incumbent upon Chief Executive Officers (CEOs) and DOT administrators to identify and manage risk.

The results of a single negative event can erode public trust with citizens and stakeholders that took years to develop.

This report describes how DOT executives are using risk management today. It is based on the results of a comprehensive literature review, national survey and structured interviews with DOT executives sponsored by the National Highway Research Program (NCHRP). The study identified transferrable strategies that may be useful to DOT leadership for enterprise-wide risk management. Broader understanding and adoption of these executive strategies, leading to enterprise-wide risk management, brings added value and enhances overall DOT performance.

While most DOT personnel would say that they inherently identify and manage risk in their day-to-day activities, this study found only 13 DOTs that have formalized enterprise risk management programs and an even fewer number that have a comprehensive approach encompassing risk management at the enterprise, program, and project levels (see Figure 1). In total, representatives from 43 state DOTs completed the survey for this study. The respondents from 35 of the 43 state DOTs (81%) claimed that their DOT has formal, published risk management policies and procedures. However, none of these respondents felt that their agency was always successful at applying appropriate risk management strategies at the various levels of the enterprise. Twenty-six respondents (62%) felt that they *frequently* apply the appropriate strategies, nine (21%) felt that they *seldom* applied the appropriate strategy, and seven (17%) felt that they *never* apply the appropriate strategies.

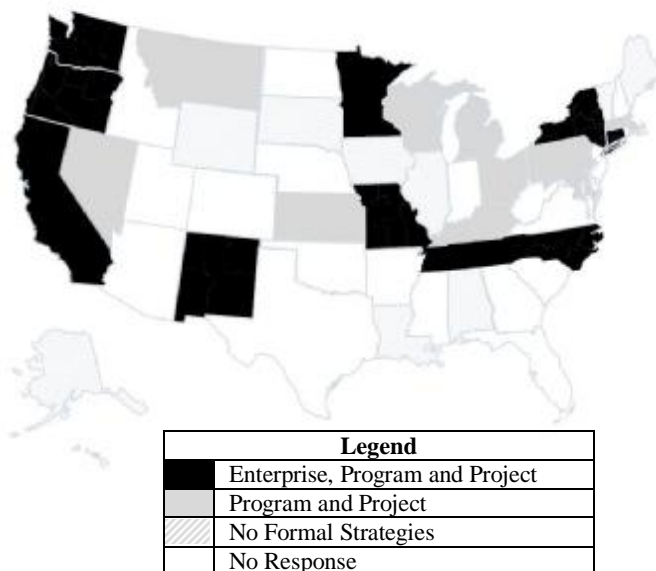


Fig. E.1 DOT Risk Management Practices

This study also found that formal risk management tools exist and are adding value to those DOTs that are using them. Pockets of excellence in enterprise risk management exist throughout the country but its use is not yet consistent or pervasive. While it is impossible to avoid every risk event, CEOs have a responsibility to acknowledge that risk and uncertainty exist and to develop formalized procedures to manage it throughout the DOT enterprise.

What is risk management?

In its broadest terms, risk is anything which could be an obstacle to achieving goals and objectives. Risk management is a process of analytical and management activities that focus on identifying and responding to the inherent uncertainties of managing a complex organization and managing capital facilities. The international standard ISO 31000 defines risk management as “*the effects of uncertainty on objectives.*” Figure 2 describes the iterative steps in the risk management process as described by ISO 31000 and other management organizations.

There are multiple levels at which to manage risks. The highest level is the enterprise. Enterprise risks relate to those uncertainties that can affect the achievement of the DOT’s strategic objectives (e.g., public opinion, declining revenues). Enterprise risk management is the consistent application of techniques to manage the uncertainties in achieving DOT strategic objectives. Therefore, enterprise risk management is not a task to complete but a process to consistently apply and improve.



Fig. E.2 Cyclical Nature of the Risk Management Process (after ISO 31000)

Risk management at the program level involves managing risk across multiple projects (e.g., risk of material price escalation, design standard changes, etc. on a DOT program). Finally, some risks may be unique to a specific project. Project risk management occurs with staff that is familiar with the specifics of that project (e.g., utility relocation coordination, right-of-way purchase delays, etc.). Though the focus of this report is on enterprise risk management, techniques implemented to manage program and project risks are also discussed as they are related to the enterprise. Figure 3 illustrates the relationship between enterprise, program, and project risk management.

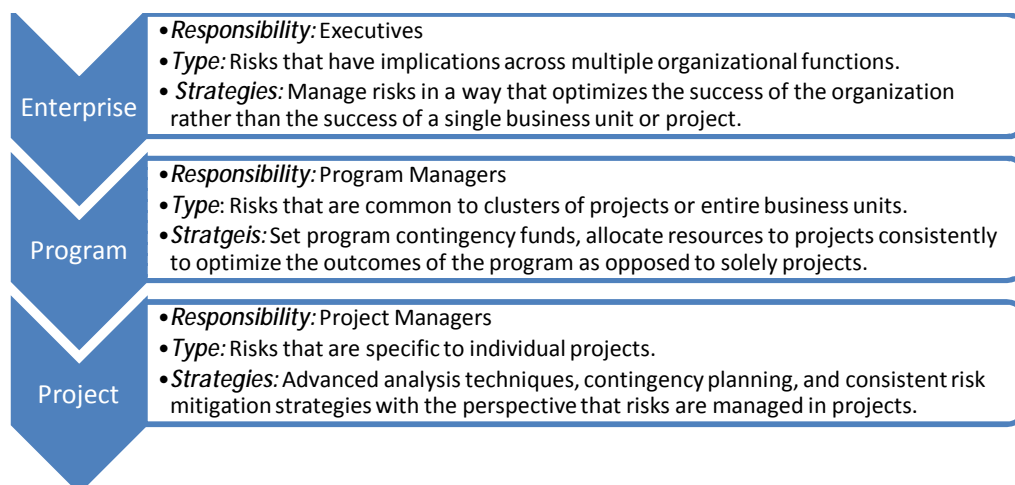


Fig. E.3 Relationship between Enterprise, Program, and Project Risk Management

Why invest in risk management?

The largest public and private organizations in the world have begun to actively employ enterprise risk management in the last two decades. DOTs are not exempt from the need to employ these approaches and, in fact, may be more susceptible to risk and uncertainty than other large organizations. The number, diversity and complexity of risks that DOTs face have grown over the last two decades. External risks have been created by the acceleration of technological advances, political uncertainty and economic volatility. Internal risks have been created by the retirement of key staff and reorganization of traditional DOT functions. In the face of these risks, formal risk management procedures can provide a positive return on investment and help CEOs avoid risk events that can erode public confidence and future funding.

Risk Management practices can help with cooperation, communication, resource constraints, and resistance to change.

–State DOT Executive

Risk management at any level requires an investment of time and resources. However, the avoidance of one significant risk event can prove the value of the investment in risk identification, treatment and monitoring processes. The DOTs surveyed and the literature reviewed in this study found the following added value from comprehensive risk management.

Enterprise Risk Management

- Valuable data that enhances the ability to make objective decisions.
- Decisions that consider the risks associated with political environment and diverse stakeholder expectations.
- Improved strategic planning and performance measurement.

Program Risk Management

- Better understanding of the program development process, including timelines, phasing, procedural requirements, and potential obstacles.
- Ability to develop appropriate contingency funds, potential program cost overruns and schedule delays.

Project Risk Management

- More realistic estimates of individual component costs and durations, thereby allowing more reasonable expectations of total project cost and duration.
- Better understanding of what the project contingencies are, whether they are sufficient, and for what they may need to be used.

Risk management, whether formal or informal, requires an individual be designated to those duties and provided the time and resources to address those needs. That individual needs to work closely with the agency director or the director's office in order to apply risk management to all levels of the organization.

–State DOT Executive

What constitutes a comprehensive approach?

DOT managers and executives have recognized that their agencies are facing new, high magnitude risks due to a variety of internal and external pressures. Though most DOTs have some level of formal or informal risk assessment in place, this study showed that few have the comprehensive approach to risk management needed to optimize resources. According to literature and the results of surveys and interviews with DOT managers and executives, a comprehensive risk management program at the enterprise level may include:

1. Executive commitment to enterprise risk management;
2. Designation of a risk executive;
3. An enterprise risk management culture, which promotes accountability throughout the organization;
4. Engagement of stakeholders;
5. Transparency of the risk communication process;
6. Integration of financial and operation risk information;
7. Use of formal risk assessment methods;
8. Constant identification of new risks; and
9. Focus on leveraging risk as opposed to mitigation.

These nine enterprise risk management attributes apply to DOTs as well as any major public or private organization.¹ In its Risk Management Guide for Project Development, the New York State DOT cites that *three key elements* are essential for successful risk management at the program-level in transportation organizations. These three elements echo the findings of the survey and interviews in this study.

1. A strong commitment in the organization, beginning with senior management, for developing and maintaining a risk management program and culture;
2. Open communication and teaming among project development and industry partners in order to promote successful implementation; and
3. Being proactive in implementation to improve performance and outcomes.

What are the challenges to implementation?

Research shows that two obstacles to enterprise risk management are competing priorities and insufficient resources. The challenge of establishing consensus among decision makers can also prove to be difficult. Another challenge of enterprise risk management implementation is changing the thinking of all members of the organization from *considering only their function's objectives to considering how decisions can affect the entire agency*. Though it may be relatively simple to understand how risk management practices can impact one DOT function, applying this perspective to the enterprise level can prove difficult. Consequently, developing enterprise risk

Risk management cannot mean public agencies overstressing administrative procedures, regulatory controls and action avoidance, but should mean being able to systematically assess circumstances, being prepared to make informed judgments about policy, operations, financial, and political situations, and being willing to act.

-NYSDOT Risk Management Guide for Project Development

¹ Adapted from Aon's Global Enterprise Risk Management Survey of more than 200 companies.

management into a living process and not just an annual task can prove difficult for many organizations.

A final challenge in enterprise risk management implementation is the organization having the ability to quantify all risks. However, many of the larger risks that an enterprise risk management program will look to address (e.g., human resource risks and political uncertainty) may not need or be able to be quantified and are better served by simply having a mitigation strategy. Numerous methods for quantifying and analyzing risks (e.g., Monte Carlo Analysis) are available and many frameworks suggest quantification strategies that fit within the framework. The research report that accompanies this executive summary discusses several quantification strategies.

What can and should a CEO do?

This research has shown that strong support from senior management is critical to successful implementation of enterprise risk management. The CEO should set the vision for enterprise risk management and provide the resources for successful implementation. The CEO should also support the risk management planning process. The roles and responsibilities table (Table 1) has been adapted from the Federal Highway Administration as one example of where a top DOT administration integrates into the process. The roles and responsibilities should be tailored to the goals of the risk management process and each individual DOT organizational structure. Table 1 provides one example of how an agency could approach the process. While many structures can be successful, leadership involvement is critical to successful implementation.

Table E.1. Example Roles and Responsibilities

Process Tasks	Role and Responsibility		
	CEO or Chief Risk Executive	Program Manager	Project Managers
Identify & Define Transportation Problems, Opportunities and Potential Risks	L	A	
Risk Management Planning	S	A	L
Risk Identification and Refinement	S	A	L
Qualitative / Quantitative Risk Analysis		A	L
Risk Determination and Mitigation Planning		A	L
Risk Monitoring and Control		A	L
Final Risk Performance Reporting	A	L	S

Legend:

L – Lead role

S – Support role

A – Approval authority

Developing a culture of risk management throughout the DOT is essential to the effective implementation of enterprise risk management. Representatives from 13 of the agencies that responded to this survey indicated that their organization had formal enterprise risk management techniques and were confident that they could answer questions about their agencies. These DOT representatives identified the following communication and organizational management strategies.

Enterprise Risk Management

- Appoint a chief risk executive with authority and resources to implement the program.
- Communicate risk management issues through formal memoranda and public communications.
- Develop state policies and procedures.
- Participate in the development of national policies and standards.

Program Risk Management

- Provide training and education for risk management implementation.
- Develop business plans with performance measures and regularly monitor progress.

Project Risk Management

- Maintain project risk registers and regularly monitor progress.
- Conduct regular project status meetings.
- Develop personnel performance measures relating to risk management.

Mainstreaming enterprise risk management is essential and training process must be ingrained within the corporate culture. Terminology needs to be clear and understood by all employees and employees need to understand their role in the enterprise risk management process. As one DOT executive risk manager states, “the risk management program office should consistently manage the enterprise risk management processes, techniques, tools, workshops, training, and develop a sense of community around enterprise risk management.”

Recommendations

Though this study has shown that many agencies are considering enterprise risk management, enterprise risk management is truly in its formative stages in the United States. National guidance through Transportation Research Board research initiatives and American Association of State Highway Transportation Official knowledge transfer will be essential to the long-term success of risk management in the highway sector. An efficient and effective enterprise risk management program can be a powerful tool for state DOTs. The benefits of such a program are both quantitative, such as better controls over costs and delivery schedules, and qualitative, such as less likelihood of negative public relations issues. While each state likely has a different level of maturity, this study has identified a set of common recommendations that DOT executives can take to advance enterprise risk management in their state and throughout the country.

1. **Take a leadership role** in developing state risk management policies and communicate the importance of the program.

2. ***Support the integration of enterprise risk management*** into strategic planning, department controls and department performance measures.
3. ***Appoint a chief risk executive*** and provide the individual with the resources for implementing the enterprise risk management program.
4. ***Participate in the development of national policies and standards*** to support the enterprise risk management process.
5. ***Provide resources*** for risk management tools, training and workshops.

CHAPTER 1. INTRODUCTION

1.1 Background

Risk in an organization can be described as the effect of uncertainty on objectives (ISO 2009). Transportation organizations can be especially fraught with uncertainty from internal and external factors and influences. Risk management is the term used to describe a sequence of analytical and management activities that focus on creating a response to the inherent uncertainties of managing a complex organization and managing capital facilities. Various agencies such as the Project Management Institute (PMI), the Association for the Advancement of Cost Engineering International (AACEI), the International Organization for Standardization (ISO), and the US Department of Energy (DOE) use very similar steps for risk management (PMI 2004; AACEI 1998; ISO 2009; DOE 2003), which are described in Chapter 2 of this report.

There are multiple levels in which risks may be managed. Risks may be grouped and managed at the enterprise level when they are inherently connected to multiple functions within the DOT or when the responsibility to recognize and respond to the risks lie with upper management. Risks may also be managed at the program level when they are shared among multiple projects (e.g., material price escalation, funding allocations, asset management, and design standard changes). Finally, some risks may be unique to a specific project. Project risk management occurs with staff that is familiar with the specifics of that project (e.g., utility relocation coordination, right-of-way purchase delays, funding, politics, and injuries). Though the focus of this report is on enterprise risk management, techniques implemented to manage program and project risks are also discussed as they are germane to enterprise risk management.

1.2 Research Objectives

The objectives of this project are to describe how DOT leadership use risk management currently in the conduct of their business and to identify executive strategies that may be useful to DOT leadership for enterprise-wide risk management. The sub-objectives include:

- Conducting a comprehensive literature review of current enterprise, program, and project risk management research;
- Identifying the current state-of-practice for DOT risk management applications through a comprehensive survey of state DOT personnel;
- Interviewing selected DOT management personnel to validate and discuss the literature and survey findings; and
- Documenting the results of this research in a concise and comprehensive research report.

1.3 Target Audience

The target audience for this report is DOT chief executive officers (CEOs), administrators, and upper-level managers within state DOTs who have competency, capability and responsibility for managing the DOT enterprise.

1.4 Research Tasks

The research team conducted four tasks as required by NCHRP to complete the objectives of this study.

Task 1. The research team met with the NCHRP project panel via teleconference to discuss the work plan, design of the survey to be conducted in Task 3 and other details of the project's technical scope, including significant opportunities for panel-member contributions to the research.

Task 2. The research team prepared a literature review of risk-management approaches applicable to state DOTs. The review described the types of risks such agencies face and considered how such risks are managed by large organizations in the private and public sectors. It described how various types of risk are addressed within a context of enterprise-wide risk management. The research team developed an annotated bibliography (see Appendix A).

Task 3. The research team conducted a survey of state DOTs to (a) identify management's perceptions of risk and risk-management approaches used in these agencies and (b) describe how these approaches influence the agency's strategic management. The team identified perceived benefits of uses of risk management and organizational impediments to implementing risk-management methods.

Task 4. The team prepared an executive summary and this report documenting the research and presenting the results of preceding tasks.

1.5 Report Outline

The report outline presents the basic definitions, tools and techniques for enterprise risk management in DOTs. It then provides detailed descriptions of successful strategies relating to enterprise, program and project risk management. The remainder of this report is organized in the following chapters and appendices.

- Chapter 2. Data Collection and Analysis
- Chapter 3. General Risk Management Strategies
- Chapter 4. Enterprise Risk Management
- Chapter 5. Program Risk Management
- Chapter 6. Project Risk Management
- Chapter 7. Conclusions, Recommendations and Future Research
- Appendix A. Annotated Bibliography
- Appendix B. Online Research Questionnaire
- Appendix C. State DOT Risk Management Policies
- Appendix D. Interview Protocol and Questionnaire

CHAPTER 2. DATA COLLECTION AND ANALYSIS

2.1 Data Collection Approach

In order to investigate and document the state-of-the-practice for enterprise, program and project risk management in state DOTs, a survey of upper-level managers within each DOT was conducted. Surveys were selected as the primary mode of data collection and interviews were selected as the primary validation method.

Surveys:

The research team utilized surveys for data collection because they allowed for a breadth of data to be collected in a timely fashion. The objectives of the survey questions were to: (1) identify management's perceptions of risk and risk management approaches used in these agencies; (2) describe how these approaches influence the agency's strategic management; and (3) identify perceived benefits of uses of risk management and organizational impediments to implementing risk management methods.

The research team surveyed members of the American Association of State Highway Transportation Officials (AASHTO) and the Transportation Research Board (TRB) committees that were deemed to be most relevant to this study, and that could provide a diverse sense of program, project and enterprise level risk practices. These members represent their states at a national level and have been chosen for this role because of their expertise and broad interest in the field. The following committees were surveyed:

AASHTO Committees

- Standing Committee on Finance and Administration
- Administrative Subcommittee on Fiscal Management and Accounting
- Administrative Subcommittee on Transportation Finance Policy
- Subcommittee on Construction
- Subcommittee on Design
- Highway Subcommittee on Maintenance (SCOM)
- Standing Committee on Performance Management
- Subcommittee on Organizational Management
- Standing Committee on Planning
- Subcommittee on Asset Management

TRB Committees

- ABC10 Strategic Management
- ABC20 Management and Productivity
- ABC30 Performance Measurement
- ABC40 Transportation Asset Management
- ABE10 Taxation and Finance
- SC005 Subcommittee on Planning and Policy Review

The final database included more than three hundred contacts, with all 52 DOTs represented by at least two individuals. An online survey was used and respondents were contacted through email. The online survey was organized into four sections: demographics, enterprise risk management, program risk management, and project risk management. The survey was set up to allow respondents to answer in their area of expertise. The online questionnaire is included as Appendix B to this report.

2.2 Summary Data Analysis

In total, 78 representatives from 43 state DOTs completed the survey. Of these 43 DOTs, multiple responses were obtained from 29. Collecting data from multiple representatives in the state DOTs ensured that the data were as complete as possible. The responses from multiple DOT representatives were combined and/or aggregated. The demographics of the respondent group are provided in Table 2.1.

Table 2.1 Demographics of Survey Respondents

	CEO	Deputy Director	Risk/Safety Mgr	Maint Director	Planning/Const Engineer	Contract Admin/Program Mgr.
Number	2	24	12	6	25	9
Percentage	3%	31%	15%	8%	32%	11%

This study found that 13 DOTs have formalized enterprise risk management programs and found that a smaller number of DOT's have a comprehensive approach encompassing risk management at the enterprise, program, and project levels (see Figure 2.1).² The respondents from 35 of the 43 state DOTs (81%) claimed that their DOT has formal, published risk management policies and procedures. However, none of these respondents felt that their agency was always successful at applying appropriate risk management strategies at the various levels of the enterprise. Twenty-six of the 43 states responding (62%) felt that they *frequently* apply the appropriate strategies, nine (21%) felt that they *seldom* applied the appropriate strategy, and seven (17%) felt that they *never* apply the appropriate strategies.

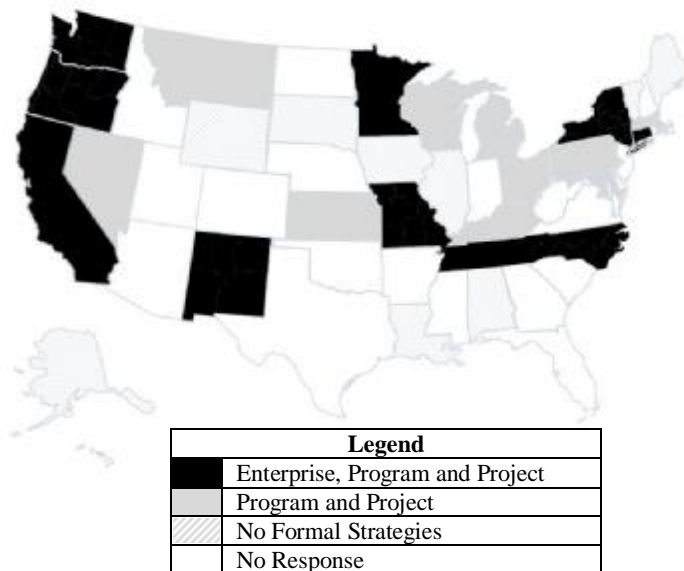


Fig. 2.1 DOT Risk Management Practices

After completing the survey and analyzing the data, three DOTs with exemplary enterprise risk management practices were chosen for follow-up interviews. High-level administrators and risk

² The map in Figures 2.1 was based upon whether the respondents identified a specific risk identification process in each of the enterprise, program and project levels. Please refer to questionnaire in Appendix B of this report.

managers were selected from each of these states. Multiple perspectives within the state will allow replications of results and ensure internal validity. Each of these three agencies shared formal risk management plans and protocols from the organization. The results of these interviews provided additional support for the survey results. Interviews are the source of quotes that have been provided in the research report.

2.3 Conclusions on Data Collection

With survey responses from 43 DOTs and interviews with three DOTs, the research team successfully met its goals for data collection. This chapter summarizes the overall results of the data collection. Appendix B contains the online survey questionnaire. Appendix C contains the information on online locations of state DOT risk management policies if this information was provided in the questionnaire. Appendix D contains the interview protocol and questionnaire. Additional survey results are provided throughout this report in the appropriate chapters to support the literature review and discussion.

CHAPTER 3. GENERAL RISK MANAGEMENT STRATEGIES

There are several risk management strategies that apply to risk management in all levels of the DOT. Although this study separates enterprise, program and project risk management, the methods of risk identification, assessment, response and management are applicable regardless of the levels in which the risks are managed. The following discussion provides a brief overview of general risk management techniques as they apply to DOT projects.

Risk management involves several well defined steps (see Figure 3.1). The Project Management Institute, ISO and others each have similar steps. This report outlines five steps which have proven to be effective in managing risk: (1) identification, (2) assessment, (3) analysis, (4) mitigation and planning and, (6) monitoring and updating (Molenaar et al. 2006). Additionally, as shown in Figure 3.1, the risk management process should be iterative. This means that the steps must be repeated over time. As risk mitigation and planning efforts are implemented, some risks no longer apply but new risks may be identified.



Fig. 3.1 Cyclical Nature of the Risk Management Process

3.1 Risk Identification

The objective of risk identification is two-fold. First, risk events that may impact organizational success must be identified and categorized. The risk identification process should be rigorous and completed by an experienced, qualified and diverse team. Second, common risks should be classified to ensure optimal efficiency in their management. Each DOT, and often sub-units of the DOT, should develop their own unique risk classifications to fit their unique needs. Some common classifications include technical, economic, environmental, management, legal, and construction risks (California Department of Transportation 2003).

Risks can be identified from many different sources. At the enterprise level, risks can be identified in strategic plans, long-range plans, funding documents, performance reports, or existing policies and procedures. At the project and program levels, risks are often identified in cost estimates, schedules, project plans and specifications. In addition to the examination of documents by the risk identification team, numerous risk identification strategies have been developed to aid in the process. For example, brainstorming, “what-if?” scenarios and external expert consultation are a few commonly used methods (Chapman 1998). The Delphi technique is another method in which experts are used to provide anonymous data through the course of multiple rounds of surveys in an effort to reach consensus. This technique allows for equal participation by all team members, and also helps to spark new risk identification among participants (Expert Program Management 2010).

Once identified and classified, risk events can be stored in a risk register to be used throughout the risk management process. The risk register serves multiple purposes. Upon risk identification, it can be used as a “repository of a corpus of knowledge,” and to initiate the analysis and associated management steps. As discussed later in this chapter, risk registers are also used for risk assessment, monitoring and control.

Some organizations create risk checklists and databases to identify recurring risks and to expedite the process by using lessons-learned from previous efforts. Checklists and databases can be helpful, but stakeholder experience and subjective analysis will almost always be required to identify the full spectrum of risks. Risk checklists can be useful at the end of the risk identification process to ensure that no common risks have been overlooked, but checklists should not be the sole tool for risk identification.

3.2 Risk Assessment

Risk assessment involves quantifying the magnitude of risks that have been identified. In order to quantify the magnitude of the risk, there are two risk characteristics of the event that need to be considered: the frequency (or likelihood) of occurrence and the severity (or impact) should that event occur. A complete risk assessment considers risk both qualitatively and quantitatively (Altenbach 1995). Qualitative risk assessment is useful for the prioritization of risks and development of mitigation strategies. It also provides the input for quantitative risk analysis as described in the next section. A common method of qualitative risk assessment is to create a probability-impact matrix. Using this method, risks are rated for both their impact and likelihood as very low, low, medium, high and very high. Risks then are classified as low, medium or high (Ward 1999). Figure 3.2 illustrates an example of a probability-impact matrix.

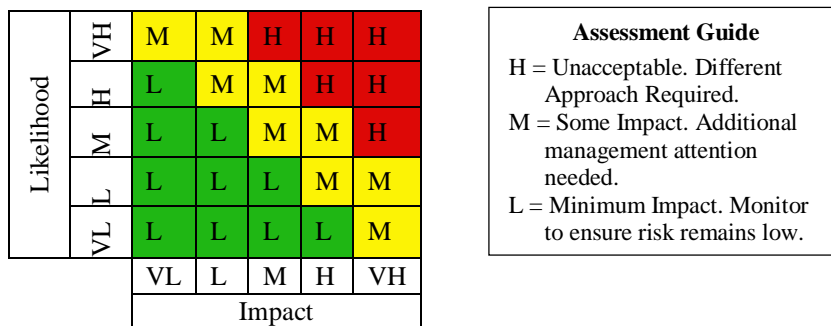


Fig. 3.2 Probability-Impact Matrix

3.3 Risk Analysis

Many risks will warrant further investigation after they are assessed. The methods available for risk analysis vary widely. Traditional methods such as the use of historical probability distributions are useful in developing a cost contingency by multiplying estimated cost by risks factors (Molenaar et al. 2006). The primary benefit of such a system is its simplicity. A wide variety of personnel can use this approach. However, the use of more advanced methods such as analytical methods, influence diagrams and simulation models are becoming more common in both private and public sector construction (Bedford et al. 2001).

3.3.1 Monte Carlo Simulation

Simulation methods, also known as Monte Carlo analyses, allow a DOT to simulate the risk events in an agency or on a project thousands of times through random number generation. The output of such a simulation gives important information to the user such as the mean cost increase or mean schedule delay caused by risk events and the distribution of the outcomes. The distribution can then allow the agency to choose a contingency based on their risk appetite. This method also allows for inputs to be adjusted when further information becomes available and for sensitivity analyses to be conducted in order to find out which risks have the greatest effect on an outcome (Hacura et al. 2000). Monte Carlo analysis has proven useful in meeting the unique needs of state DOTs for projects but has yet to see widespread use at the program or enterprise levels. Hacura et al. (2000) conducted a study that showed Monte Carlo analysis can help managers to decide whether to proceed with a project or not. Research has also shown that Monte Carlo analysis can be applied to construction risks to estimate upper and lower bounds for schedule both accurately and efficiently (McCabe 2003; Xing-xea et al. 2009). One of the tools that is most popular for conducting this type of analysis is the @Risk program, which works within Microsoft Excel and can run thousands of simulations of a scenario in minutes (Palisade 2010).

3.3.2 Sensitivity Analysis

The purpose of a sensitivity analysis is to understand how a model reacts when the value of an input variable is changed (i.e., how “sensitive” the model is to a change in that parameter). Conducting a sensitivity analysis on a risk model is important because it creates confidence in the model and brings the model closer to becoming requisite. A requisite model has considered

all the non-overlapping alternatives, and parameters. Two applications of sensitivity analysis are to bring a model closer to accurately depicting real world, empirical results and to play out “what-if?” scenarios before an event (Middleton 2010). A popular method to display sensitivity analysis results is in a tornado diagram, which shows the impact ranges of a variable (see Figure 3.3).

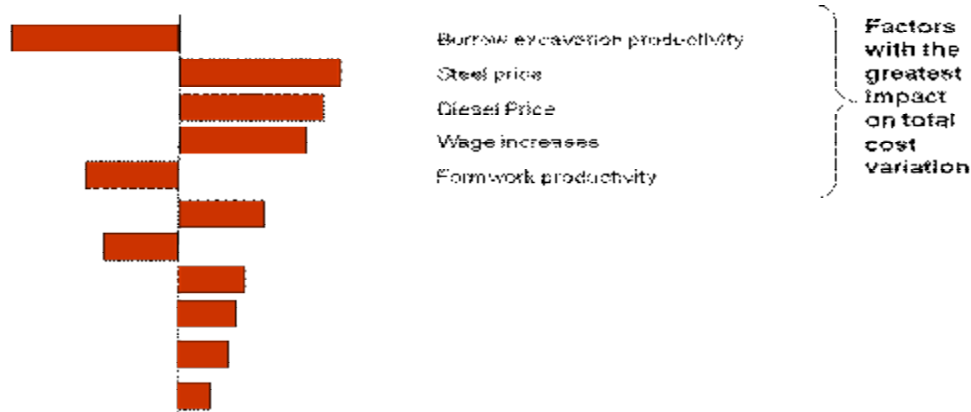


Fig. 3.3 Example Tornado Diagram Output from a Monte Carlo Analysis

3.3.3 Decision Trees

The decision tree method of analysis creates a graphical representation of expected value. Decision trees are particularly useful when analyzing a sequence of risk events and decisions that will occur in a known order. Decision trees are composed of three different node types: (1) decision nodes, which represent variables controlled by the decision maker; (2) chance nodes, which are events out of the decision maker’s control; and (3) terminal or end nodes that denote the outputs of the model. In order to solve a decision tree, the probabilities of each chance event must be known. A decision tree is constructed from left to right, starting at the root node and with successive risk events and decisions branching forward. Decision trees are then solved from right to left by calculating the expected values at each node until the user reaches the root node (de Ville 2006).

3.4 Risk Mitigation and Planning

Once the impacts of the risks are understood, strategies and plans can be put in place to mitigate negative impacts or exploit potential opportunities. Risk mitigation and planning ensures that every risk identified for a project has a response strategy and the individual or group responsible for carrying out the response strategy has been identified. The following are the four basic responses that an organization can take to a risk:

1. **Avoid** - The team chooses to change the project plan in order to eliminate the possibility of the risk occurring or the project suffering the event’s impact.
2. **Transfer** - A risk can be transferred by the work being contracted to another party who is more capable of mitigating and managing the risk. This protects the organization from the impact of the risk.
3. **Mitigate** - The team develops a plan(s) or strategy(ies) to decrease either the likelihood a risk occurs, the impact of the risk, or both. Mitigation strategies will often have

additional upfront costs (i.e., an investment to lower probability or impact), however they protect against greater risk impacts to the project.

4. **Accept** - A risk is accepted when none of the three preceding strategies is taken. The team accepts the risk and allows for the risk to have the same likelihood and consequences. If the risk occurs, then the team will deal with it at that time or implement a predetermined response strategy.

3.5 Monitoring and Updating

The monitoring and updating phase of the project risk management process is critical to ensure that new risks are identified and existing risks are tracked and updated. The risk register can serve a secondary process during this step because it facilitates the constant improvement and updating of relevant data. Information included in the risk register typically includes a risk description, status, owner, probability and impact or rating, mitigation or response strategy and when the risk's status was last updated. Numerous other pieces of information are often included in the risk register and one of its strengths is that it is scalable based on project, program, or enterprise size (Patterson et al. 2002). Some DOTs such as Caltrans have set policies that dictate the level of detail needed in the risk register based on project cost.

Risk registers can be created in Microsoft Excel, although web based software are now being used by some agencies. Web-based versions allow team members to access the most up-to-date version of the register from anywhere with an internet connection. Most importantly, the risk register serves as a communication tool for the project or risk management team and creates discussion around project risk (Patterson et al. 2002). Figure 3.4 shows a sample of a project risk register and Figure 3.5 show a sample of a program risk register.

Project: Ballard St. Widening		Manager:	JoAnn Smith		Date Created:	7/1/10
Proj Number:	2010-008	Telephone:	555-867-5309		Last Updated:	8/1/10
Owner:	DOT	Email:	smith@xyzdot.gov			
Risk Description	Status	Risk Trigger	Owner	Prob/Imp Rating	Mitigation Strategy	Last Update
Unexpected Soil Conditions	Active	Too few borings	Contractor	Medium	Transfer	7/15/10
Right of Way Dispute	Active	Land owner unwilling to sell	DOT	Low	Mitigate	7/15/10
Lack of Funding	Retired	Budget Cuts	DOT	High	Accept	7/15/10

Fig. 3.4 Sample Project Risk Register

Program Components	Risk Factors	Unit with Primary Responsibility	Frequency of Exposure (High, Medium or Low)	Likelihood of Risk Event/Occurrence (High, Medium, Low)	Impact (High, Medium or Low)	Tolerance	Risk Prior to Control (High, Medium, or Low)	Stewardship and Oversight Controls	Post Control Risk (High Medium, or Low)
Program Management									
Program Funding Allocations	Accuracy, Timeliness, Interception, Many players. Loss of ability to timely obligate funds.	HQ	L	L	L	M	L	Reviewed by 3rd party. Separation of duties. Reconciliation. Project cost tracking.	L
Program Oversight Delegations of Authority	Misuse of funds. Breakout of activities pending Recent Audit issues have brought attention to this	HQ	H	H	H	L	H	Stewardship agreements and controls	H
Planning & Programming									
Bridge Management Systems	Congressionally mandated. SMS, PMS under development. Bridge Mngmt Sys in place. poor data collection/data mining	HQ, P&P, TS PMS	M	M	L	M	M	Many under development	L
Selection of Projects	Not much political fallout. Agency sometimes involved in Project Selection.	P&P	M	M	L	H	M	Under development via mgmt systems	L
Roadway Inventory Program	Cost, Data Integrity, Data Access, Schedule Delays	Tech Serv	H	M	L	H	M	Agency Collects Data (NPS), QC/OA of digital data	L
Bridge Inspection Program	Tort Claims, Safety Issues, Loss of service which can be an adverse event if structural failure results in loss of life->hence low tolerance	Bridge	H	L	H	L	M	Agency Collects Data biennially and evaluates bridge condition when critical. Projects added/reviced to Program at annual Program Meetings. Bridge inspections are conducted every 2- years, except for structures that are new or have low risk of deterioration, e.g. concrete which are then visited every 2- yrs & inspection reports developed every 4th yr. Struc. experiencing distress are monitored frequently, e.g. ever yr until rehabilitation or replacement occurs.	L

Fig. 3.5 Sample Program Risk Register

3.6 Conclusions on General Risk Management Strategies

This chapter has outlined several risk management steps that apply to risk management in all levels of the DOT. Although the steps can vary by DOT, the five common steps are risk: (1) identification; (2) assessment; (3) analysis; (4) mitigation and planning; and (6) monitoring and updating (Molenaar et al. 2006). Although this study separates enterprise, program and project risk management, the methods of risk identification, assessment, response and management are applicable regardless of the levels in which the risks are managed.

CHAPTER 4. ENTERPRISE RISK MANAGEMENT

4.1 Role and Importance

There are two broad methods for an organization to manage risk. The first method focuses on managing one risk at a time, often known as the silo method. The second, enterprise risk management, involves strategically considering risks together (Nocco et al. 2006). Berry and Phillips (1998) define enterprise risk management as the “consistent application of techniques to manage the uncertainties surrounding the achievement of an organization’s objectives.” Therefore, by definition, enterprise risk management cannot be viewed as a task to complete but as a process that is constantly utilized and improved within the organization (Angelina 2008).

The need for enterprise risk management has grown over the past two decades due to several factors. The number, diversity, and complexity of risks have grown due to the acceleration of technological advances and globalization, which has contributed to the need for organizations to manage all risks consistently. External pressures are being applied to organizations due to public disapproval of projects following recent failures (Causality Actuarial Society 2003). DOTs face similar pressures and more specialized external risks such as those associated with public opinion, declining or insufficient revenues and closures of transportation facilities due to infrastructure failure, accidents and incidents or weather-related events. There is a growing tendency of DOTs to use formal risk analysis procedures because of their positive return on investment. A positive return on investment is achieved when cost savings are greater than the funds spent on planning and risk management. This has resulted in the need to consistently assess and manage risks so that they may be aggregated in financial analyses and other primary organizational functions.

Aon’s Global Enterprise Risk Management Survey is the most recent study on the implementation of enterprise risk management by large organizations around the world (McDonald 2010). The study aimed to uncover the level of enterprise risk management implementation by more than 200 organizations based on the following nine characteristics of a successful enterprise risk management program:

1. Board-level commitment to enterprise risk management;
2. Employment of a risk executive;
3. An enterprise risk management culture, which promotes accountability throughout the organization;
4. Engagement of stakeholders;
5. Transparency of the risk communication process;
6. Integration of financial and operation risk information;
7. Use of formal risk assessment methods;
8. Constant identification of new risks; and
9. Focus on leveraging risk as opposed to mitigation.

Based on these nine characteristics, firms were broken into five levels of enterprise risk management implementation: initial, basic, defined, operation, and advanced. Only seven percent of those surveyed were found to have advanced enterprise risk management programs and 40 percent only had a defined set of policies for handling risk from identification to

monitoring. Thus, very few organizations are receiving the maximum benefits of an enterprise risk management program (Sandrick 2010).

4.1.1 Risk Exposures

Enterprise risk management has several potential benefits to an organization resulting from the elimination of the inherent disadvantages with the traditional silo approach. The use of enterprise risk management helps to avoid risks from being managed multiple times by different functions within the department. Though managing risks individually may help to reduce the volatility of each individual risk, the enterprise risk management approach helps reduce the volatility of an organization's entire risk portfolio (Hoyt et al. 2008). In the silo approach, the interdependencies of risks are not considered and related risks are rarely aggregated. The ability to understand the interdependencies among risks and the full risk profile of an organization allows for more objective resource allocation (Meulbroek 2002).

In addition to considering the interdependencies between risks, an enterprise risk management program also forces an agency to consider highly improbable and external risks (Sandrick 2010). Though the quantification of such risks may be difficult or impossible, consideration of such risks forces an organization to consider "what-if?" scenarios and develop plans or mitigation strategies for potential events. These considerations could prove important to DOT's as projects and programs become more interconnected and complicated. Enterprise risk management programs also allow for the consideration of strategic risks defined by Slywotzki et al. (2005 pp. 80) as "the array of external events and trends that can devastate a company's growth trajectory and shareholder value." Strategic risks for private businesses could be events such as new technological changes or sudden shifts in consumer preferences (Slywotzki et al. 2005). In the case of a DOT, a significant mandate change, such as the need to meet specific greenhouse gas requirements; a dramatic increase in fuel prices that increases the demand for and political pressure to deliver transit services; or a lack of sufficient or stable resources to make needed infrastructure improvements and that could lead to the failure of important transportation infrastructure if not considered on an enterprise level

4.1.2 Corporate Culture

A successful enterprise risk management culture also helps to ensure that policies and procedures for managing risk are applied consistently throughout an organization (Pitt 2010). This concept is important because project planners typically perform initial risk evaluations while executives are ultimately responsible for decision making. An organization with an enterprise risk management culture and successful framework will ensure that managers consider all risks that may impact the organization's objectives. Successful enterprise risk management frameworks typically include performance evaluations and rewards based on a manager's decision making in the context of the organizations total risk (Nocco et al. 2006). Such a system not only helps to reinforce the enterprise risk management culture within an organization but also to give managers a greater sense of worth and value to the organization.

Perhaps the most important part of developing an effective and efficient enterprise risk management program within an organization is the development of a culture of risk management. For enterprise risk management to be successful, organizational units must shift their mindset from a project-level risk management approach to an organization-wide strategy.

This unification allows for consistency of risk management across the organization (Meulbroek 2002). Though the coordination of the different organizational units is a hallmark of a successful program, the units and individual managers must still have the power to take initiative and be flexible in their decision making (CAS 2003).

4.1.3 Assignment of Responsibility

A major consideration of enterprise risk management is who will be responsible for the enterprise risk management strategy. It is important that the sponsor of the program is a member of senior management because creating buy-in and making enterprise risk management a part of the culture is a deciding factor in success (CAS 2003). Senior managers can show their support for the enterprise risk management program in the following four ways:

1. Be familiar with the organization's risk philosophy and be consistent with the overall risk attitude of the organization;
2. Be inquisitive about the risk management processes that are taking place and have an understanding of the current status of the enterprise risk management program;
3. Be knowledgeable about the organization's most significant risks; and
4. Be willing to spend time reviewing and assessing the enterprise risk management program and make sure that the enterprise risk management program fits within the strategic objectives of the organization (Sandrick 2010).

This research has shown that strong support from senior management is critical to successful implementation of enterprise risk management. The CEO should set the vision for enterprise risk management and provide the resources for successful implementation. The CEO should also support the risk management planning process. The roles and responsibilities table (Table 4.1) has been adapted from the Federal Highway Administration as one example of where a top DOT administration integrates into the process. The roles and responsibilities table provides a suitable format to summarize the goals of the risk management process to a DOT organizational structure. Table 4.1 provides one example of how an agency could approach the process. While many structures can be successful, leadership involvement is critical to successful implementation.

Table 4.1 Example Roles and Responsibilities

Process Tasks	Role and Responsibility		
	CEO or Chief Risk Executive	Program Manager	Project Managers
Identify & Define Transportation Problems, Opportunities and Potential Risks	L	A	
Risk Management Planning	S	A	L
Risk Identification and Refinement	S	A	L
Qualitative / Quantitative Risk Analysis		A	L
Risk Determination and Mitigation Planning		A	L
Risk Monitoring and Control		A	L
Final Risk Performance Reporting	A	L	S

Legend:

L – Lead role

S – Support role

A – Approval authority

4.1.4 Challenges

Gates (2006) found that two obstacles to the implementation of enterprise risk management by organizations were competing priorities and insufficient resources. While these two represent temporary setbacks, the challenge of establishing consensus among decision makers can also prove to be difficult and may stop the process. Since it has been shown that strong support from senior management is critical to successful implementation of an enterprise risk management, this may be a crucial element of the enterprise risk management program (CAS 2003).

Another challenge of enterprise risk management implementation is to change the thinking of all members of the organization from considering only their tasks objectives to considering how decisions can affect the entire organization. Overcoming this challenge requires a common understanding of an enterprise risk management vocabulary, examples of successes and demonstrated leadership, at a minimum. Understanding that the risks one group encounters can impact the entire agency is conceptually simple. However, applying this concept to practice can prove difficult (Meulbroek 2002). If senior managers can instill a sense of shared responsibility within their organization, whereby different members recognize their response to risk affects their co-workers and the overall health of the organization, a successful enterprise risk management program is more likely to take hold.

A final challenge in enterprise risk management implementation is the organization's ability to quantify all risks. However, as previously discussed, many of the larger risks that an enterprise risk management program will look to address may not need, or be able to be quantified and are better served by simply having a mitigation strategy (e.g., political and human resources).

However, many of the risks identified in an enterprise risk management program will need to be quantified. Numerous methods for quantifying risks are available and many frameworks suggest quantification strategies that fit within the framework (Gates 2006). Several quantification strategies are discussed in detail in the project risk management portion of this report (see Chapter 3.3). These strategies are important because many are applicable at the program and enterprise levels as well.

4.1.5 General Implementation

Two previous studies were conducted to quantify the proportion of organizations that implement or plan to implement enterprise risk management. A survey of 1,400 CEO's worldwide conducted by PricewaterhouseCoopers (2004) found that 38 percent of CEO's felt that they had effective enterprise risk management programs in place with an additional 35 percent planning to improve upon or initiate an enterprise risk management program. A separate study of 271 organizations around the world found similar results with 32 percent of the organizations having enterprise risk management plans and an additional 53 percent either preparing an enterprise risk management plan or aware of the need for an enterprise risk management plan. Fewer than 14 percent of respondents had neither considered enterprise risk management nor had decided against the idea (Gates 2006). The following section describes the state of practice for enterprise risk management for state DOTs as reported by upper managers in response to the survey conducted for this study.

4.2 DOT State-of-Practice

The survey of DOTs conducted for this study provided similar results to the PricewaterhouseCoopers and Gates studies previously discussed. Of the 43 state DOTs that had upper-level managers and executives who responded to the survey, representatives from 13 indicated that their organization had formal enterprise risk management techniques and were confident that they could answer questions about their agencies enterprise risk management program development, procedures, analysis techniques, and lessons learned.

When asked how agencies developed their enterprise risk management framework, five (14%) indicated that they adopted an enterprise risk management framework from outside of the agency, 11 (31%) developed their framework in-house; one (3%) adopted their framework from another state DOT, and one (3%) adopted their framework from another industry. Several respondents expanded by noting that their framework was effectively developed by including input from Bureau Chiefs, Chief Engineers, and other DOT executives over the course of many years. Another respondent indicated that effective integration of an enterprise risk management program requires that it be spread through the organization through training, formal documents, and workshops, and that its implementation be facilitated by executives and upper-level managers.

Respondents were also asked how enterprise risks are identified within the agency. Twelve of the respondents indicated that they have formal enterprise risk identification procedures that include brainstorming. Of these, (67%), standard checklists (58%), risk breakdown structures (25%), scenario planning (50%), expert interviews (25%), and the Delphi method (17%).

The survey also asked respondents to identify common enterprise risks in their agency. Risks were identified in the following areas:

- Project delivery
- Financial management
- Compliance in many areas
- Staffing and resources
- Third-party agreements
- Constructability
- Project improvement reviews
- Cultural resource protection
- Value engineering
- Safety
- Project development risks such as utility relocations
- Right of way acquisition
- Environmental permitting
- Public relations
- Fleet management

Seventeen of the responding agency representatives indicated that they have formal enterprise risk analysis techniques. Of these agencies, eight (47%) utilize qualitative risk assessment techniques, seven (41%) use statistical analyses of historical data, four (24%) use Monte Carlo or other simulation methods, and three (18%) build decision trees.

As previously indicated, developing a culture of risk management throughout the enterprise is essential to the effective implementation of enterprise risk management. When asked to describe how the agency develops an enterprise risk management culture that supports the consistent application of the enterprise risk management framework throughout the organization, the following communication and organizational management strategies were identified:

- Formal communications
- Memoranda
- Policies
- Training
- Agency performance measures
- Personnel performance measures
- A business plan with performance measures is updated regularly to monitor progress
- Designers are taught to follow DOT policies and procedures as well as national standards such as AASHTO publications
- Weekly project status meetings are held

One agency with a mature enterprise risk management program expanded upon this topic. They have centralized enterprise risk management in their Office of Policy Analysis, Research and Innovation (PARI). This office oversees the enterprise risk management program throughout the organization and facilitates enterprise risk management processes, techniques, tools, workshops,

training, and develops a sense of community around enterprise risk management within the agency.

4.2.1 Lessons Learned

As a part of the online survey, respondents were asked to identify lessons-learned from their experiences in developing an enterprise risk management program. The results are summarized below.

4.2.1.1 Streamlining and training

Multiple respondents believed that the enterprise risk management process must be ingrained within the corporate culture, streamlined as an integral component of all organizational functions, and have associated training, especially for new hires. Executives also believed strongly that the associated terminology needs to be clear and understood by all employees and that all employees need to know what their role is with respect to enterprise risk management.

4.2.1.2 Consistency in implementation and employee involvement

When establishing an enterprise risk management program it is important that there is a common understanding of the goals, expectations and resources. Additionally, it is critical to have employees involved throughout the entire enterprise risk management process as each employee has competencies and knowledge that add value. Additionally, one executive believed that:

“risk management practices can help with cooperation, communication, resource constraints and resistance to change. Because risk management will be new to the department, education needs are high in the area. Initially, most folks will over simplify risk assessments and create non-dynamic worksheets and/or will not forecast on timeframes in the future. It will be nice to have a risk management expert that has actually practiced facilitating workshops and answered difficult modeling questions. Reading a book will only get you so far. The most will be learned by doing.”

The literature verifies the importance of having an experienced risk management expert to help propagate risk management throughout the organization.

4.2.1.3 Leadership priority

Executives believed that enterprise risk management must be a priority of leadership that receives attention in all aspects of organization management. In fact, one respondent indicated that:

“enterprise risk management plans need to be taken seriously and provided the attention they deserve. Education and training are critical in order to obtain accurate risk assessments that yield good data. Time has to be budgeted into the process for a great deal of follow-up with managers and analysts who are new to risk assessments or internal control testing.”

4.2.1.4 Allocation of appropriate time for implementation

Finally, executives concurred that the implementation of an effective risk management program throughout an enterprise took considerable time and took several years to develop. To this point, one DOT representative stated:

“It has taken several years but enterprise risk management and risk management is finally not looked at as the management ‘flavor of the month.’ We are still moving in the direction of having a complete culture of risk management and language that is used.” Another stated that their, “overall risk management program is in-flux. We are constantly looking at some of the better more refined programs.”

4.3 Emerging Strategies

Based on interviews with three states that have begun to implement risk management strategies, the research team found that these agencies have begun to implement enterprise risk management strategies have committed a small staff in an effort to effectively foster the enterprise risk management program during its formative year. This staff has responsibilities that include managing only the top-level risks, supporting DOT divisions and functional groups in their risk management operations, and providing training throughout the organization on the need for risk management as well as the proper use of the tools provided for risk management. This suggests that enterprise risk management staffs at DOTs are actively working to build the culture needed for successful risk management practices, as suggested by literature.

In order to become more accurate and streamlined in their use of risk management practices, one DOT enterprise risk management group is currently completing a three-year project in order to build a risk portfolio for the entire agency. The creation of this risk portfolio is being completed using a bottom-up approach, with “baseline” risk data being collected from the project levels and then being passed up and aggregated throughout the process. Ultimately, the gathering of this baseline risk data could be used to build a risk breakdown structure for the organization. This structure would allow for the clear assignment of risk responsibility at all levels of the organization. The collection of this baseline data is paralleled by the development of software to aid the organization in creating a common language, risk data input methods, and risk assessment output.

4.4 Conclusions on Enterprise Risk Management

An effective enterprise risk management program can be a powerful tool for any agency. The benefits of such a program are both quantitative, such as less volatility in project programming, and qualitative, such as a better understanding of the risk profile of the organization. The implementation of an enterprise risk management program is an attainable step for an agency that already implements risk management on a project scale. The risk management process is scalable from the project to the enterprise and the benefits likewise scale from project gains to enterprise gains. It is critical to identify uncertainties, reduce the potential impacts of risks, and manage events that can trigger the potential risks. Unfortunately, most agencies have yet to start an enterprise risk management program. The implementation of an enterprise risk management program presents many challenges for an organization. Nevertheless, these setbacks can be overcome with appropriate support from senior management and buy-in from all levels of the organization.

CHAPTER 5. PROGRAM RISK MANAGEMENT

5.1 Role and Importance

Opportunities for program risk management abound at State DOTs. For example, there is the operations program, which manages a broad array of risk including emergency and special event response. There is the safety program, which recommends strategies in response to safety risks. State transportation improvement programs (STIP) are an obvious application for program risk management.

State transportation improvement programs represent similar or sequential projects that can be managed as a program. A program of projects can be defined as “a temporary organization constituted by an ensemble of projects or activities, which are managed together to achieve higher order strategic goals not delivered by the individual project management” (Turner et al. 2003). Risk management for a program must consider higher order risks (i.e., systemic risks that affect multiple projects) and must complement the strategic management of the entire organization. Consequently, program risk management serves as a foundation for enterprise risk management. Program risks are different from project risks in that they can be an aggregation of many project risks and may be more effectively dealt with by program managers (vs. project managers). Therefore, aggregated risks must be more closely considered when dealing with a program than with an individual project.

Currently, many program managers are relying on project management techniques to manage program risks. Though this may be effective for small programs, these strategies alone are not sufficient for large-scale programs, especially considering the broad array of DOT program areas. Government agencies such as DOTs typically have hundreds of projects within their program. For example, a DOT with a program for renewing existing infrastructure under their jurisdiction could have a wide variety of projects within the program for the manager to consider (Zacharias et al. 2008). The use of risk management at a program level will allow for better project and enterprise risk management.

The Project Management Institute (PMI) recently published *The Standard for Program Management*. The recommendations in this document are focused on managing smaller programs consisting of similar projects. This is an important step toward providing program managers with information concerning organizational objectives in the framework of managing a program. PMI identified six activities for managing program risk in order to consider higher order issues (PMI 2006):

1. Identify and analyze inter-project risks;
2. Verify project risk response plans whose actions could affect other projects;
3. Determine root causes;
4. Propose specific solutions to risk escalated by project managers;
5. Implement response mechanisms, which benefit more than one project; and
6. Manage program contingency reserves (in terms of cost and time).

An adaptation of project risk management is needed for effective management of large-scale programs. Recently, there has been a growing consensus that risk breakdown structures are an effective method for establishing a framework for program risk management. The use of a risk

breakdown structure for project risk management covers the three themes cited by PMI (2006) that are keys to a program’s success, which include benefits management, program stakeholder management and program governance. Though program risk management does draw significantly from the strategic management concepts on the organizational level, some project management tools can be used or adapted for the program level. For example, joint program risk registers, created by the risk management teams, can be adapted to include which projects are affected or how it affects the different participants (Fussell et al. 2005). The needs of the program of projects will determine which project risk management tools are appropriate. Figure 5.1 shows an example of a program risk breakdown structure.

Level 0	Level 1		Level 2		Level 3		
PROGRAM RISKS	A	Management	I	Organizational Mgmt	1	Accounting	
					2	HR	
					3	Org. Structure	
					4	Culture	
			II	Program Mgmt	1	Experience	
					2	Equipment Resources	
			3	Contingency Budget			
	B	Projects Implementation	I	Planning	1	Right of Way	
					2	Project Type	
					3	Design	
					4	Technology Available	
			II	Contracting	1	Clarity and Completeness	
					2	Penalties	
					3	Risk Allocation	
					4	Payment Process	
			III	Construction	1	Safety	
					2	Quality	
					3	Schedule	
					4	Budget	
			IV	Operation	1	Project Turnover	
2					Maintenance		
C			External	I	Political	1	Laws and Regulations
						2	International Relationships
	3	Governmental Change					
	II	Environmental		1	Endangered Species		
				2	Wetlands		
				3	Natural Disaster		
	III	Social		1	Public Disapproval		
				2	Labor Availability		
				3	Interest Groups		

Fig. 5.1 Example Program Risk Breakdown Structure

5.2 DOT State of Practice

Program risk management in state DOTs is especially important because projects are often grouped due to various funding schemes. Such programs may include risks that are common to all projects within the program, which are most effectively managed at the program level (e.g., material price escalation or human resources). The survey solicited information regarding program risk management strategies implemented within state DOTs. Of the 43 states responding to the survey, 11 DOT representatives indicated that their agency has formal program risk management and were capable of providing data.

DOT representatives identified that brainstorming (82%), checklists (64%), risk breakdown structures (27%), scenario planning (55%), expert interviews (45%), and the Delphi method (18%) were used to identify program risks. Analysis techniques for identified risk included qualitative risk assessment (70%), statistical analysis of historical data (60%), Monte Carlo simulation (20%), and decision trees (30%).

5.2.1 Lessons Learned

Those DOTs with more mature methods of program risk management shared several lessons learned. For example, one respondent indicated that, “Risk management, whether formal or informal, requires an individual be designated those duties and provided the time and resources to address those needs. That individual needs to work closely with the agency Director or the Director’s Office in order to apply risk management to all levels of the organization. In other words, they need to be involved in all the processes to some degree.” Another respondent felt that there is a need to emphasize that everyone in the organization is a risk manager and that everyone must take ownership of the risk that are in their control. Finally, one DOT executive believed that, “The data has to be available to executives so they can push a button and check without having programs filter the info. When staff knows the executive and other upper-level managers are reading the data this way, they get serious about data quality.”

5.4 Conclusions on Program Risk Management

Though there is significant research on project risk management and enterprise risk management, guidance for program risk management is lacking. Much of the literature available on program risk management is contained as only a small or tangential component. The need for program risks to be managed differently than both project and enterprise risks, however, is gaining increased attention. The survey responses indicate that there are several program risk identification and analysis strategies that are being implemented. However, one of the strategies that has been shown to be most effective, risk registers, is used by only one of the 43 DOTs responding. Use of risk registers helps assess program risk management more accurately and efficiently and helps with organizational learning.

CHAPTER 6. PROJECT RISK MANAGEMENT

6.1 Role and Importance

Much is known about effective project risk management. The majority of the knowledge developed about risk management summarized in Chapter 3 stems from research on project risk management. For example, risk analysis strategies like Monte Carlo simulation, decision trees, and sensitivity analyses were all developed for and implemented on projects. The use of risk registers are also common for project risk management and are now being used for program and enterprise risk management. Consequently, those DOTs and private contractors who employ risk management tend to have more mature and effective means of managing project risks than program and enterprise risks. The following summary discusses the results of the project risk management component of the benchmarking survey.

6.2 Methods Implemented

Of the 43 DOTs responding to the survey, 11 have formal project risk management strategies and the representatives felt confident in answering questions related to their agencies practices. When asked to identify which risk identification techniques were implemented at the project level, representatives noted that brainstorming (64%), checklists (82%), risk breakdown structures (45%), scenario planning (55%), expert interviews (55%), and the Delphi method (27%) were implemented. Interestingly, only two DOTs stated that they used risk registers to organize and categorize identified risks. One of these DOTs updated their risk registers every one to two years and the other updates theirs twice a year.

The risk analysis techniques implemented at the project level followed a similar distribution as program and enterprise risk management, which indicates a degree of consistency in risk analysis throughout the organization. For project risk analysis, qualitative risk assessment techniques (83%), statistical analysis of historical data (67%), Monte Carlo simulation (58%), and decision trees (42%) were implemented. Only 4 DOT representatives indicated that their agency uses formalized risk allocation during contract administration.

Since project risk management is relatively mature with state DOTs when compared to enterprise and program risk management, representatives were asked to identify how their project risk analysis procedures change depending on specific project characteristics. Respondents indicated that their risk analysis procedures change depending on project size (89%), project value or dollar amount (78%), project complexity (89%), and project phase (e.g., planning, program, design) (56%). Respondents also noted that certain projects may be unique in their risks and, therefore, may be managed differently through risk transfer in the contract. Also, one executive mentioned that, "The level of effort for analyzing risk will depend on the amount of information available related to the project scope, as well as the significance of the project within the overall program. In addition, increased project complexity in general can generate higher levels of risk that should be managed actively to control the project development schedule and project costs."

6.2.1 Lessons Learned

Some survey and interview respondents offered lessons learned based upon their experiences with project risk management. Some of these lessons are provided below:

- Project risk management needs a "Champion" and support from the top of the organization.

- Once a project team successfully implements and sees the benefit in risk management, it then becomes RM's greatest advocate! Then it spreads.
- Evaluate the processes used by other states and compare your program to theirs to determine the appropriate level of effort for your program.
- Evaluate the ability and availability of the staff that will be doing the risk management and be sure that your proposed process will meet their needs without creating an unreasonable amount of extra work. You need them to accept the process in order to have it be successful.
- Try to make the new process similar to other, familiar processes, and make it complement current project management efforts.
- Focus on significant issues.
- Keep the system user-friendly.
- Follow standard processes.

In its Risk Management Guide for Project Development, the New York State DOT cites that *three key elements* are essential for successful risk management at the program-level in transportation organizations. These three elements echo the findings of the survey and interviews in this study. The three elements are:

1. A strong commitment in the organization, beginning with senior management, for developing and maintaining a risk management program and culture;
2. Open communication and teaming among project development and industry partners in order to promote successful implementation; and
3. Being proactive in implementation to improve performance and outcomes.

6.4 Conclusions on Project Risk Management

This study found that project risk management is a key supporting element of a comprehensive enterprise risk management program. The literature review and the findings of the data collection in this study show that risk management tools apply to enterprise and program risk management.

CHAPTER 7. FINDINGS, CONCLUSIONS, AND FUTURE RESEARCH

7.1 Findings

The literature review, supported by the results of the survey undertaken in this study and the follow-up interviews with three state DOTs, shows that developing a culture of risk management throughout the DOT is essential to the effective implementation of enterprise risk management. This research has identified the following communication and organizational management strategies as critical to risk management program success.

Enterprise Risk Management

- Appoint a chief risk executive with authority and resources to implement the program.
- Communicate risk management issues through formal memoranda and public communications.
- Develop state policies, procedures and performance measures.
- Participate in the development of national policies and standards.

Program Risk Management

- Provide training and education for risk management implementation.
- Develop business plans with performance measures and regularly monitor progress.

Project Risk Management

- Maintain project risk registers and regularly monitor progress.
- Conduct regular project status meetings.
- Develop performance measures relating to project risk management.

Mainstreaming of enterprise risk management is essential and training process must be ingrained within the corporate culture. Terminology needs to be clear and understood by all employees and employees need to understand their role in the enterprise risk management process. As one DOT executive risk manager states, “the risk management program office should consistently manage the enterprise risk management processes, techniques, tools, workshops, training, and develop a sense of community around enterprise risk management.”

Risk management at any level requires an investment of time and resources. However, the avoidance of one significant risk event can far outweigh the risk identification, treatment and monitoring processes. The DOTs surveyed and the literature reviewed in this study found the following added value from comprehensive risk management.

Enterprise Risk Management

- Valuable data that enhances the ability to make objective decisions.
- Decisions that consider the risks associated with political environment and diverse stakeholder expectations.
- Improved strategic planning and performance measurement.

Program Risk Management

- Identify and analyze inter-project risks and propose specific solutions to risk escalated by project managers.
- Better understand the program development process, including timelines, phasing, procedural requirements, and potential obstacles.
- Implement response mechanisms, which benefit more than one project and help to manage program contingency reserves (in terms of cost and time).
- Ability to develop appropriate contingency funds, potential program cost overruns and schedule delays.

Project Risk Management

- More realistic estimates of individual component costs and durations, allowing more reasonable expectations of total project cost and duration.
- Better understanding of what the project contingencies are, whether they are sufficient, and for what they may need to be used.

Research shows that two chief obstacles to enterprise risk management are competing priorities and insufficient resources. The challenge of establishing consensus among decision makers can also prove to be most difficult. Another challenge of enterprise risk management implementation is changing the thinking of all members of the organization from *considering only their function's objectives to considering how decisions can affect the entire agency*. Though it may be relatively simple to understand how one unit within the DOT may affect the enterprise as a whole, applying this perspective to the entire organization can prove difficult. Further, developing enterprise risk management into a living process and not just an annual task can prove difficult for many organizations.

A final challenge in enterprise risk management implementation is the organization having the ability to quantify all risks. However, many of the larger risks that an enterprise risk management program will look to address may not need or be able to be quantified and are better served by simply having a mitigation strategy. Numerous methods for quantifying risks are available and many frameworks suggest quantification strategies that fit within the framework. This research report includes a discussion of several quantification of these strategies.

7.2 Conclusions

Though this study has shown that many agencies are participating, enterprise risk management is truly in its formative stages in the United States. An efficient and effective enterprise risk management program can be a powerful tool for state DOTs. The benefits of such a program are both quantitative, such as better controls over costs and delivery schedules, and qualitative, such as less likelihood of negative public relations issues. While each state likely has a different level of maturity, this study has identified a set of common actions that DOT executives can take to advance enterprise risk management in their state and throughout the country.

1. **Take a leadership role** in developing state risk management policies and communicate the importance of the program.
2. **Support the integration of enterprise risk management** into strategic planning, department controls and department performance measures.

3. ***Appoint an executive risk manager*** and provide the individual with the resources for implementing the enterprise risk management program.
4. ***Participate in the development of national policies and standards*** to support the enterprise risk management process.
5. ***Provide resources*** for risk management tools, training and workshops.

7.3 Future Research

As the survey results revealed, risk management is evolving in U.S. highway agencies. The fact that none of the survey respondents felt their agency was always successful at applying appropriate risk management strategies at the various levels of the enterprise is a solid indicator that more research is needed. Only 26 of the 43 states responding (62%) felt that they *frequently* apply the appropriate strategies, nine (21%) felt that they *seldom* applied the appropriate strategy, and seven (17%) felt that they *never* apply the appropriate strategies.

The need for future research and guidance is clear. National guidance through Transportation Research Board research initiatives and American Association of State Highway Transportation Official knowledge transfer will be essential to the long-term success of risk management in the highway sector. This study identifies a number of areas to immediately address. The following are suggestions to propagate effective risk management strategies throughout highway agencies.

- **Guidebook on Enterprise Risk Management Strategies, Methods and Tools:** A comprehensive NCHRP guidebook on risk management strategies, methods and tools will have perhaps the greatest impact on the propagation of consistent and effective enterprise risk management across the country. NCHRP guidebooks are comprehensive and can speak to multiple levels of DOT personnel. A guidebook on enterprise risk management should: (1) speak to DOT executives through a discussion on *strategies* for implementation; (2) guide chief risk executives and program managers on *methods* for developing programs and measuring their effectiveness; and (3) provide staff with *tools* to implement these programs. This would be the most significant research study and could encompass some of the following research topics.
- **Risk Management Tool Development and Deployment:** The present research study identified a number of risk management tools in the literature and in practice. The most commonly used tool at all levels of risk management is the *risk register*. Highway agencies would benefit from a standard format and training for risk registers. Other tools cited in this report deal with risk identification, risk categorization, risk assessment, risk analysis and risk communication. If these tools cannot be developed comprehensively through an NCHRP guidebook as previously described, they could be developed through individual research efforts.
- **Risk Management Performance Measures:** Although this research study identified the need for performance measures, it did not identify specific examples. The identification of existing performance measures, the development of new performance measures and the testing of both will provide for the measurement and improvement of risk management programs. Ideally, this research could identify a performance measures at the project, program and enterprise level that support current performance measurement program structures (and strategic goals) of DOTs across the country.

- **Risk Management Maturity Model:** The development of a risk management maturity model will help DOT executives determine priorities for investment in their evolving risk management programs. A maturity model could also be tied to the performance measures and national standards to help propagate consistency of programs across the country. The research would likely need to look at maturity models from other industries as a source of knowledge to support what currently exists in the highway sector.
- **Risk Management Case Studies:** Case studies may be the best research tool to demonstrate the “observed benefits” of enterprise risk management programs. Clear demonstration of these benefits could entice more DOT’s to formally adopt such programs. Detailed case studies of how enterprise risk management has helped DOT’s deal with significant uncertainties such as a decrease in available resources, changing regulations or design standards, or failure of a major artery would provide transportation executives with a demonstration of tangible benefits. An investment in a research effort to develop risk management case studies is a logical next step.

REFERENCES

- Altenbach, T.J. (1995). "Comparison of risk assessment techniques from qualitative to quantitative." *ASME, Pressure Vessels and Piping Division*, 296: 15-28.
- Angelina, M. (2008). "Special Blend." *Best's Review*, 108(12): 88-91.
- Association for the Advancement of Cost Engineering International (1998). *Professional Practice Guide #2: Risk*. Michael W. Curran, Editor, AACE International, Morgantown, WV.
- Bedford, T. and Cooke, R. (2001). *Probabilistic Risk Analysis: foundations and methods*. Cambridge University Press, Cambridge, U.K.
- Berry, A. and Phillips, J. (1998). "Enterprise Risk Management: Pulling it Together." *Risk Management*, 45(9): 53-58.
- California Department of Transportation. (2003). *Project Risk Management Handbook*. Report of the California Department of Transportation, Office of Project Management Process Improvement, Sacramento, CA.
- (CAS) Enterprise Risk Management Committee. (2003). "Overview of Enterprise Risk Management." *Causality Actuarial Society*.
- Chapman, R.J. (1998). "The effectiveness of working group risk identification and assessment techniques." *International Journal of Project Management*, 16(6): 333-343.
- de Ville, B. (2006). "Decision Trees – What are they?" *Decision Trees for Business Intelligence and Data Mining: Using SAS Enterprise Miner*, SAS Publishing, Cary, N.C., 1-16.
- Expert Program Management. (2010). "Risk management: risk identification." Expert Program Management, < <http://www.expertprogrammanagement.com/2010/01/how-to-identify-risks/>> (July 31, 2010).
- Fussell, L., and Field, S. (2005). "The Role of the Risk Management Database in the Risk Management Process." 18th International Conference on Systems Engineering, Las Vegas, Nevada.
- Gates, S. (2006). "Incorporating Strategic Risk into Enterprise Risk Management: A Survey of Current Corporate Practice." *Journal of Applied Corporate Finance*, 18(4): 81-90.
- Hacura, A., Jadamus-Hacura, M., and Kocot, A. (2001). "Risk analysis in investment appraisal based on Monte Carlo simulation technique." *The European Physical Journal B*, 20: 551-553.

- Hoyt, R.E., Moore, D.L., and Liebenberg, A.P. (2008). "The Value of Enterprise Risk Management: Evidence from the U.S. Insurance Industry. Society of Actuaries, Schaumburg, Illinois.
- International Organization for Standardization (ISO) (2009). ISO 31000 Risk Management -- Principles and Guidelines, Geneva, Switzerland.
- McCabe, B. (2003). "Monte Carlo Simulation for Schedule Risks." *Proceedings of the 2003 Winter Simulation Conference*, New Orleans, Louisiana, USA, December 7-10.
- McDonald, C. (2010). "Few firms see themselves as 'Advanced' on use of enterprise risk management." *National Underwriter: Property & Casualty*, <<http://www.property-casualty.com/Issues/2010/April-26-2010/Pages/Few-Firms-See-Themselves-As-Advanced-On-Use-Of-Enterprise-Risk-Management.aspx?k=few+firms+see+themselves+as+'advanced'>> (July 15, 2010).
- Middleton, M. (2010). "Sensitivity Analysis using excel." Treeplan, <http://treeplan.com/chapters/02_decan_20071029_1042.pdf> (August 16, 2010).
- Molenaar, K.R., Diekmann, J.E. and Ashley, D.B. (2006). "Guide to Risk Assessment for Highway Construction Management." *Report FHWA-PL-06-032*, U.S. Department of Transportation, Washington, D.C.
- Meulbroek, L.K. (2002). "A Senior Manager's Guide to Integrated Risk Management." *Journal of Applied Corporate Finance*, 14(4): 56-70.
- Nocco, B.W. and Stulz, R.M. (2006). "Enterprise Risk Management: Theory and Practice." *Journal of Applied Corporate Finance*, 18(4): 7-20.
- Palisade Corporation. (2010). "@Risk: a new standard in risk analysis." Palisade, <<http://www.palisade.com/risk/>> (August 16, 2010).
- Patterson, F.D. and Neailey, K. (2002). "A risk register database system to aid the management of project risk." *International Journal of Project Management*, 20: 365-374.
- Pitt, H. (2010). "Risk of failing to understand ERM failures." *Compliance Week*, 7(74).
- PricewaterhouseCoopers. (2004). "Survey Data: ERM Trends." *NC State University College of Management, Enterprise Risk Management Initiative*, <<http://www.mgt.ncsu.edu/erm/index.php/articles/entry/survey-erm-trends/>> (April 2, 2010).
- Project Management Institute. (2004). *A guide to project management body of knowledge (PMBOK Guide)*. Project Management Institute, Newton Square, PA.
- Project Management Institute. (2006). *The Standard for Program Management*, PMI, Newton Square, PA.

- Sandrick, K. (2010). "Threat Assessment: enterprise risk management helps hospitals prepare for the unexpected." *Trustee*,
<http://www.trusteemag.com/trusteemag_app/jsp/articledisplay.jsp?dcrpath=TRUSTEEMAG/Article/data/05MAY2010/1005TRU_coverstory&domain=TRUSTEEMAG> (July 15, 2010).
- Slywotzky, A.J., and Drzik, J. (2005). "Countering the Biggest Risk of All." *Harvard Business Review*, April 2005: 78-88.
- Turner, J.R. And Muller, R. (2003). "On the nature of the project as a temporary organization." *International Journal of Project Management*, 17(3): 1-8.
- U.S. Department of Energy. (2003). *Project Management Practices: Risk Management*. U.S. Department of Energy, Office of Management, Budget and Evaluation, Office of Engineering and Construction Management, Washington, D.C.
- Ward, S. C. (1999). "Assessing and managing important risks." *International Journal of Project Management* 17(6): 331-36.
- Williams, Terry. (1994). "Using a risk register to integrate risk management in project definition." *International Journal of Project Management* 12(1): 17-22.
- Xing-xia, W. and Jian-wen, H. (2009). "Risk analysis of construction schedule based on Monte Carlo simulation." *International Symposium on Computer Network and Multimedia Technology*, Wuhan, China, January 18-20.
- Zacharias, O., Panopoulos, D., and Askounis, T.D.. (2008). "Large Scale Program Risk Analysis Using a Risk Breakdown Structure." *European Journal of Economics, Finance and Administration Sciences*, 12: 170-181.

APPENDIX A ANNOTATED BIBLIOGRAPHY

Abdou, O.A. (1996). "Managing construction risks." *Journal of Architectural Engineering*, March: 3-10.

In this paper the author examines the common risks present on a construction project. The focus is on the risk identification process and how risks are allocated under the traditional design-bid-build contractual arrangement. The merits of risk identification and categorization checklists are a key concepts presented.

Abrams, C., von Kanel, J., Muller, S., Pfitzmann, B., Ruschka-Taylor, S. (2002). "Optimized Enterprise Risk Management." IBM Research GmbH, Switzerland.

This report provides a definition of enterprise risk management and a discussion of different levels of implementation. It then gives an in depth explanation of the enterprise risk management program at the IBM corporation. The different layers of the enterprise risk management framework and their interactions are explained. Finally, the report outlines the steps that IBM took in order to successfully implement their framework.

Aguilar, M.K. (2010). "Choosing the right risk-management framework." *Compliance Week*, <<http://www.complianceweek.com/article/5828/choosing-the-right-risk-management-framework>> (July 15, 2010).

This article lists several of the predominant enterprise risk management frameworks that are being used by organizations. Much attention is paid to the COSO framework. Also discussed is how the different frameworks address government regulations in various countries, including the United States.

Akintoye, A.S., and MacLeod, M.J. (1997). "Risk analysis and management in construction." *International Journal of Project Management*, 15(1): 31-38.

This paper provides the results of a survey of contractors in the U.K. on their use of risk management techniques. The findings show that most contractors are risk averse and that contractors typically use intuition, judgment, and experience to manage risk as opposed to more formal techniques. The paper finds that while formal risk management techniques have been shown to be financially beneficial the majority of contractors are still resistant to its implementation.

Altenbach, T.J. (1995). "Comparison of risk assessment techniques from qualitative to quantitative." *ASME, Pressure Vessels and Piping Division*, 296: 15-28.

In this report, the author examines various qualitative and quantitative risk assessment techniques and explains when each technique is appropriate. The paper provides in depth descriptions of the probability-impact matrix method as both a quantitative and qualitative technique and provides the author's top ten reasons for not quantifying a risk.

American Consulting Engineers Council (ACEC) and Associated General Contractors of America (AGC). (1992). *Owner's Guide to Saving Money by Risk Allocation, Report to the American Consulting Engineers Council and Associated General Contractors of America*. Authored by Robert J. Smith, Wickwire Gavin, P.C., American Consulting Engineers Council, Washington, D.C.

This guide states that contract documents alone do not provide risk allocation for a construction project. The lack of clarity in the contract documents is the leading cause of litigation in the construction industry. This document attempts to provide project owners with strategies to avoid litigation through the use of appropriate allocation techniques.

Angelina, M. (2008). "Special Blend." *Best's Review*, 108(12): 88-91.

This article discusses how enterprise risk management has evolved and some of the reasons for its evolution. It then discusses how enterprise risk management adds strategic value to an organization and the objectives of an enterprise risk management program. Finally, the importance of a change in corporate culture and a phased implementation are stressed.

Anquillare, M. (2010). "ERM helps risk managers cross barriers within, outside company." *National Underwriter: Property & Casualty*, < <http://www.property-casualty.com/Issues/2010/April-26-2010/Pages/ERM-Helps-Risk-Managers-Cross-Barriers-Within-Outside-Company.aspx>> (July 15, 2010).

This is a brief article from the April 2010 edition of *National Underwriter: Property & Casualty* that touches on reasons that enterprise risk management programs fail at organizations. For each of the reasons for failure discussed some methods for avoiding pitfalls.

Berry, A. and Phillips, J. (1998). "Enterprise Risk Management: Pulling it Together." *Risk Management*, 45(9): 53-58.

This paper gives a brief overview of enterprise risk management. Published in the September 1998 issue of *Risk Management*, the main purpose of this paper is to introduce the reader to the idea of enterprise risk management and some of its key issues. The paper describes who to involve and how to launch an enterprise risk management process.

Bedford, T. and Cooke, R. (2001). *Probabilistic Risk Analysis: foundations and methods*. Cambridge University Press, Cambridge, U.K.

This book is entirely dedicated to the methodology behind probabilistic risk analysis. The book contains explanations and methodology for many techniques including decision trees, expert opinions, and software use as well as the statistical theory used to support them. The final section of the book is completely devoted to decision-making theory including multi-attribute decision-making.

Breierova, L. and Choudhari, M. (2001). "An introduction to sensitivity analysis." *Massachusetts Institute of Technology, Cambridge, MA.*

<<http://sysdyn.clexchange.org/sdep/Roadmaps/RM8/D-4526-2.pdf>> (August 15, 2010).

This guide supplies the basic information needed to conduct a sensitivity analysis and provides examples in order to make the concepts more applicable. The authors state that the merits of sensitivity analysis are in the building and evaluation of a model. The guide uses STELLA software to display the results of the examples.

Buchanan, L. (2004). "Watch Your Back." *Harvard Business Review*, February 2004: 19-20.

This article placed the enterprise risk management concept as part of the *Harvard Business Review* list of breakthrough ideas for 2004. It discusses the increasing need for enterprise risk management because of the rapidly-changing modern business environment. It also sites increasing government regulations on public organizations that are requiring enterprise risk management.

California Department of Transportation. (2003). *Project Risk Management Handbook*. Report of the California Department of Transportation, Office of Project Management Process Improvement, Sacramento, CA.

This is California Department of Transportation's guide to risk and risk management. It describes the basic concepts and processes that guide risk management planning and implementation during project development.

California Department of Transportation (2007). "Caltrans Risk Register Excel Document." California Department of Transportation, State of California.

<http://www.dot.ca.gov/hq/projmgmt/guidance_prmhb.htm>. (October 25, 2009).

The California DOT risk register excel document is the template that was until recently used to help manage risk for all transportation projects in the state of California. The excel document uses macros and drop downs to make the document extremely user friendly and provides a good example of thorough and requisite risk register.

Champion, D., Kaplan, R.S., Mikes, A., Simons, R., Tufano, P., Hoffman, M. (2009). "Managing Risk in the New World." *Harvard Business Review*, October 2009: 69-75.

This article is an interview with a *Harvard Business Review* senior editor and five experts in the field of enterprise risk management. The discussion revolves around enterprise risk management principles and practices and their application in current economic events. How enterprise risk management could have helped to avoid the current economic crisis and how its broader application will hopefully help to avoid such a crisis from occurring again are key topics of discussion.

Chapman, R.J. (1998). "The effectiveness of working group risk identification and assessment techniques." *International Journal of Project Management*, 16(6): 333-343.

This paper compares the effectiveness three risk identification techniques used in the construction industry: (1) brainstorming; (2) nominal group technique and; (3) the Delphi technique. The strengths and weaknesses of all three methods are considered and summaries are provided for the different elements needed to make each technique effective.

de Ville, B. (2006). "Decision Trees – What are they?" *Decision Trees for Business Intelligence and Data Mining: Using SAS Enterprise Miner*, SAS Publishing, Cary, N.C., 1-16.

This resource is the first chapter in a book on the use decision tree software program. This first chapter outlines why and when decision trees can be useful and effective. The book describes decision trees as a simple, but powerful form of multi-criteria decision analysis and outlines how to construct a decision tree.

Enterprise Risk Management Committee. (2003). "Overview of Enterprise Risk Management." *Causality Actuarial Society*, <<http://www.casact.org/research/erm/overview.pdf>> (April 1, 2010).

This document was the most in depth review of enterprise risk management that was read during the literature review process. The report begins with the history of enterprise risk management and definitions of key enterprise risk management terms. Enterprise risk management framework, methods and tools are then given a thorough discussion. Finally, the use of case studies throughout the document and the practical implications portion help to provide context for the theory discussed in the rest of the document.

Expert Program Management. (2010). "Risk management: risk identification." *Expert Program Management*, <<http://www.expertprogrammanagement.com/2010/01/how-to-identify-risks/>> (July 31, 2010).

This resource states that project risk management is a best practice in successful project delivery. Brainstorming, the nominal group technique, and the Delphi methods of risk identification are all described. Additionally, procedures for completing these three techniques are provided.

Fussell, L., and Field, S. (2005). "The Role of the Risk Management Database in the Risk Management Process." 18th International Conference on Systems Engineering, Las Vegas, Nevada.

This article promotes the use of a risk register as an important tool in the risk management process. The authors state that the use of risk registers creates a better understanding of project risks as well as serving as an important communication tool for all involved parties. Also stressed is the need for the risk register to be tailored to the needs of the project.

Gates, S. (2006). "Incorporating Strategic Risk into Enterprise Risk Management: A Survey of Current Corporate Practice." *Journal of Applied Corporate Finance*, 18(4): 81-90.

This article provides a background of the need to consider strategic organizational risks in enterprise risk management framework. Commonly faced strategic risks are outlined in grouped into seven major classifications. The report then provides case studies of several organizations at different levels of enterprise risk management implementation. With each case, a different consideration of enterprise risk management is inspected such as implementation obstacles and enterprise risk management ownership.

Hacura, A., Jadamus-Hacura, M., and Kocot, A. (2001). "Risk analysis in investment appraisal based on Monte Carlo simulation technique." *The European Physical Journal B*, 20: 551-553.

The paper describes how Monte Carlo analysis can be used to decide whether or not to pursue a project based on the risk analysis. Net present value of the project is used as the deterministic factor in the decision whether to proceed or not. The use of Monte Carlo methodology and development of a model are also described.

Higuera, P.R., Gluch, P.D., Dorofee, J.A., Murphy, L.R., Walker, A.J., and Ray, C.W., (1994). "An introduction to team risk management." Pittsburgh, Software engineering institute, Carnegie Mellon University.

This article uses the situation of a software development project to discuss the principles and concepts of team risk management. The authors present nine principles necessary of team risk management and how each of the principles can be successfully achieved. These principles are based on a combination of risk management and teamwork principles that have been shown to be effective.

Hillson, D. (2003). "Using a risk breakdown structure in project management." *Journal of Facilities Management*, 2(1): 85-97.

According to the author, the most effective way to deal with a long list of risks after the identification process is to create a risk breakdown structure. A risk breakdown structure has a hierarchal structure of the risks faced on a project. The author sites the benefits of using a risk breakdown structure including providing a framework for cross project risk reporting and a tool for post mortem lessons learned.

Hillson, D. (2008). "Towards Program Risk Management." PMI Global Congress Proceedings, Denver, Colorado.

The author describes program risk management and compares the three most common definitions currently on the topic and how program risks can evolve from project risks or an aggregation of project risks or be delegated from the organizational level. Also described are the challenges faced with implementing risk management on the program level.

Hoyt, R.E., Moore, D.L., and Liebenberg, A.P. (2008). "The Value of Enterprise Risk Management: Evidence from the U.S. Insurance Industry. Society of Actuaries, Schaumburg, Illinois.

This report aimed to measure the extent to which firms have implemented enterprise risk management and from that point assess the value the program has produced for the organization. The article showed the growth of the use of enterprise risk management by U.S. Insurance companies from 2000 to 2005. The initial evidence from the study is that the use of enterprise risk management has added value to the insurance companies that have implemented programs.

Hubbard, D. (2009). *The Failure of Risk Management: Why it's broken and how to fix it*. Wiley, John & Sons, Incorporated, Hoboken, NJ.

According to the author of this book there are many reasons why risk management processes have not been as effective as they could and should be. He suggests methods for fixing the risk management process. Much of the book is written in the context of the financial crisis that began in 2008.

Khamooshi, H., and Cioffi, D.F. (2009). "Program Risk Contingency Budget Planning." *IEEE Transactions on Engineering Management*, 56(1): 171-179.

This paper builds upon other papers researching the use and estimation of contingency budgeting in the risk management process. In this paper procedures and algorithms are developed in order to accurately estimate an appropriate contingency budget, even at 99% confidence. According to the authors, this research shows that assigning an arbitrary percentage for contingency is no longer justifiable.

Kwan, T.W., and Leung, H.K.N. (2009). "Measuring Risks within a Program Consisting of Multiple Interdependent Projects," International Conference on Computational Intelligence and Software Engineering, 2009. CiSE 2009, Wuhan, China, 1-7, 11-13

This paper proposes risk metrics for correlated risks within programs. The paper found that when managing program risks, risks can be divided into two categories: (1) program risks and; (2) project risks. Program management techniques were found to yield several benefits for managers on the project level including better communication between projects and that related risks could be better managed together.

Li, C. and Sun, A. (2008). "The research of economic evaluation project risk based on Monte Carlo simulation." *4th International Conference on Wireless Communications, Networking and Mobile Computing*, Dalian, China, October 12-14.

In this paper the authors use Monte Carlo simulation techniques to provide economic evaluations of construction projects. The model is then used to predict the net present value and the internal rate of return for construction projects. This research is intended to

help contractors find the estimate yield and profit for a project and, therefore, make more informed decisions on which projects to pursue.

Lindorff, D. (2010). "The Current State of ERM." *Treasury & Risk*, June 2010: 16-17.

This article focuses on the external risks that organizations must consider and how the enterprise risk management process works to protect against these risks. They argue that the quantification of high impact, low probability events is unnecessary. The author argues that the focus for such events should be on contingency plans.

Lycett, M., Rassau, A., and Danson, J. (2004). "Programme management: a critical review." *International Journal of Project Management*, 22: 289-299.

This paper includes critical problems with current program management strategies, which can also be applied to program risk management strategies. The authors found that the two most common mistakes made in program management are the assumption that program management is a scaled-up version of project management and that a 'one size fits all' approach can be applied to program management.

McCabe, B. (2003). "Monte Carlo Simulation for Schedule Risks." *Proceedings of the 2003 Winter Simulation Conference*, New Orleans, Louisiana, USA, December 7-10.

This author uses Monte Carlo probabilistic simulation methods to translate project characteristics into schedule risk boundaries. The model uses Primavera Project Planner and Primavera Monte Carlo and reviewed over 2000 scheduled activities on an infrastructure project. The research showed that upper and lower limits for project schedule could be accurately estimated using probabilistic methods.

McDonald, C. (2010). "Few firms see themselves as 'Advanced' on use of enterprise risk management." *National Underwriter: Property & Casualty*, < <http://www.property-casualty.com/Issues/2010/April-26-2010/Pages/Few-Firms-See-Themselves-As-Advanced-On-Use-Of-Enterprise-Risk-Management-.aspx?k=few+firms+see+themselves+as+'advanced'>> (July 15, 2010).

This resource is a report from *National Underwriter* that highlights the results of Aon's 2010 Global Enterprise Risk Management Survey. It describes the criteria for the study and then the results.

Middleton, M. (2010). "Sensitivity Analysis using excel." Treeplan, <http://treeplan.com/chapters/02_decan_20071029_1042.pdf> (August 16, 2010).

This chapter gives step by step instruction for using Microsoft Excel to conduct a sensitivity analysis when posed with a decision. The manual describes how to conduct sensitivity analysis for one and two-variable situations. Methods of finding the upper and lower bounds for each of the models are also described.

Molenaar, K.R., Diekmann, J.E. and Ashley, D.B. (2006). "Guide to Risk Assessment for Highway Construction Management." *Report FHWA-PL-06-032*, U.S. Department of Transportation, Washington, D.C.

In 2004, a team of representatives from the Federal Highway Administration, State highway agencies, industry, and academia visited Canada, Finland, Germany, the Netherlands, Scotland, and the United Kingdom. The purpose of this International Technology Scanning Program study was to identify practices that might be evaluated and applied in the United States to improve construction management.

Meulbroek, L.K. (2002). "A Senior Manager's Guide to Integrated Risk Management." *Journal of Applied Corporate Finance*, 14(4): 56-70.

Because upper management support is critical to the success of an enterprise risk management program, this guide serves to inform senior managers of the benefits of the enterprise risk management. The report describes the different way in which enterprise risk management can add value to a firm and uses examples from industry to strengthen the argument. The authors concluded by discussing some of the tools and mechanisms needed for success.

Nocco, B.W. and Stulz, R.M. (2006). "Enterprise Risk Management: Theory and Practice." *Journal of Applied Corporate Finance*, 18(4): 7-20.

These authors discuss enterprise risk management from the viewpoint of finance and banking organizations. The importance of determining an organizations risk appetite and why an enterprise risk management program creates value dominates the first half of the document. The second half focuses on the implementation of enterprise risk management and why an enterprise risk management protects an organization from risk exposures that other risk management methods do not.

Palisade Corporation. (2010). "@Risk: a new standard in risk analysis." Palisade, <<http://www.palisade.com/risk/>> (August 16, 2010).

This is the website for @Risk software, created by the Palisade corporation. It contains a description of the features of the software as well as customer support and purchasing options.

Pate-Cornell, M.E., and Dillon, R.L. (2004). "Success factors and future challenges in the management of faster-better-cheaper space missions." *IEEE Trans. Eng. Manage.*, 48(1): 25-35.

This paper conducts case studies on four recent NASA programs in order to investigate the strengths and weaknesses of the new faster-better-cheaper management style for unmanned space missions. One of the major findings that risks and uncertainties within the programs need to be better accounted for.

Patterson, F.D. and Neailey, K. (2002). "A risk register database system to aid the management of project risk." *International Journal of Project Management*, 20: 365-374.

This authors provide an outline for the proper use of a risk register. The role of a risk register is discussed. The paper then builds upon the concept of a risk register by creating a risk register database. The risk register database system combines the risk register with risk assessment tools, which according to the authors, provided more salient details for the risks.

Pellegrinelli, S. (1997). "Programme management: organising project-based change." *International Journal of Project Management*, 15(3): 141-149.

This paper identifies how program management abilities can have a positive impact on project level management. The author examines how risk management considerations on the program level can be applied to the project level to create value. The author argues that the program management strategies that can be applied to project management to create value are strategic management and benchmarking techniques.

Pitt, H. (2010). "Risk of failing to understand ERM failures." *Compliance Week*, 7(74).

This article uses a National Security Agency's example to emphasize the importance of an EMR program. Basic enterprise risk management framework and processes are discussed. The most unique portion of this article is the lessons learned for corporations portion based on the NSA case presented in the first half of the article.

PricewaterhouseCoopers. (2004). "Survey Data: ERM Trends." *NC State University College of Management, Enterprise Risk Management Initiative*, <<http://www.mgt.ncsu.edu/erm/index.php/articles/entry/survey-erm-trends/>> (April 2, 2010).

This site contains the summarized results of a survey conducted by PricewaterhouseCooper. The survey was completed by over 1400 CEOs worldwide and focused on perceived organizational threats, risk appetite and enterprise risk management use and implementation.

Princeton University. (2001). "Definition of Probability." *Webster's Online Dictionary*, <<http://www.websters-online-dictionary.org/definitions/probability?cx=partner-pub-0939450753529744%3Av0qd01-tdlq&cof=FORID%3A9&ie=UTF-8&q=probability&sa=Search#922>> (August 28, 2010).

This is the site for Webster's online dictionary which provides definitions for words. This particular link leads to the definition of probability.

Project Management Institute. (2006). *The Standard for Program Management*, PMI, Newton Square, PA.

This document provides a standard for managing multiple projects beyond the techniques used for individual project management. The guide provides information for program managers on achieving organizational goals as well as the goals for the individual projects within the program.

Project Management Institute. (2004). *A guide to project management body of knowledge (PMBOK Guide)*. Project Management Institute, Newton Square, PA.

This document is widely recognized as the standard for project management around the world. The document contains concepts, techniques and methods for the management of project integration, scope, time, cost, quality, human resources, communications, risk and procurement. The guide breaks project management processes into five basic groups: initiating, planning, execution, monitoring and controlling and closing.

Rahman, M. and Kumaraswamy, M. (2002). "Joint risk management through transactionally efficient relational contracting." *Construction Management and Economics*, 20(4): 44-54.

This paper states that the appropriate contracting methods and documents of a construction project are dependent on the characteristics of the project. The paper claims that relational contracting and joint risk management are two methods to decrease costs and make projects ultimately more successful.

Sanchez, H., Robert, B., Bourgault, M., and Pellerin, R. (2008). "Risk Management applied to projects, programs and portfolios." *International Journal of Managing Projects in Business*, 2(1): 14-35.

This paper serves as a literature review for risk management practices on the project, program and portfolio (enterprise) levels. The researchers found that there is significant research on project risk management compared to program or portfolio risk management especially in the development of methodologies and tools. The paper cites and summarizes many important resources for risk management research.

Sandrick, K. (2010). "Threat Assessment: enterprise risk management helps hospitals prepare for the unexpected." *Trustee*,
<http://www.trusteemag.com/trusteemag_app/jsp/articledisplay.jsp?dcrpath=TRUSTEEMAG/Article/data/05MAY2010/1005TRU_coverstory&domain=TRUSTEEMAG> (July 15, 2010).

This primary focus of this article is the application of enterprise risk management principles in the American health care industry, specifically at hospitals. The article discusses the COSO framework for enterprise risk management and specific ways for high-level executives to support an enterprise risk management program. Finally the article cites examples of hospitals that have successfully applied enterprise risk management principles.

Schmitt, A.J. (2009). "Quantifying supply chain disruption risk using Monte Carlo and discrete event simulation." *Proceedings of the 2009 Winter Simulation Conference*, Austin, Texas, USA, December 13-16.

This paper uses Monte Carlo analysis to determine the risk of significant supply chain disturbance. The authors then worked to develop mitigation strategies to avoid such occurrences. The paper provides insights into the risks that are faced by global supply chains, which applies to virtually every organization working in the United States economy.

Schuyler, J. (2001). *Risk and decision analysis in projects*, 2nd ed. Project Management Institute, Newton Square, PA.

This book provides information for numerous topics within risk and decision analysis. Some of the topics include multi-criteria decision-making, decision trees, Monte Carlo analysis and sensitivity analysis among others. The book provides both conceptual and practical frameworks for the use of these techniques and methods. The book is designed as a textbook for a class devoted to risk and decision analysis.

Skorupka, D. (2008). "Identification and initial risk assessment of construction projects in Poland." *Journal of Management in Engineering*, 24(3): 120-127.

This paper analyzes the Polish construction market with specific attention paid to the use of risk identification and risk assessment techniques that are used in Poland. Several Polish construction companies were analyzed for the level of risk assessment that they complete in various categories or risk such as operational, political, economic and legal.

Slywotzky, A.J., and Drzik, J. (2005). "Countering the Biggest Risk of All." *Harvard Business Review*, April 2005: 78-88.

This *Harvard Business Review* article discusses the concept of strategic risk for an organization and how enterprise risk management is the primary mode for countering it. The first half of the article defines strategic risks and the enterprise risk management process. The second half of the article outlines commonly faced strategy risks and their countermeasures.

Turner, J.R. And Muller, R. (2003). "On the nature of the project as a temporary organization." *International Journal of Project Management*, 17(3): 1-8.

This paper examines project management from the perspective of organizational theory. The roles of project participants such as the project manager and the project owner are considered from this perspective. The authors delineate between projects, programs, and organizational portfolios using organizational theory.

U.S. Department of Energy. (2003). *Project Management Practices: Risk Management*. U.S. Department of Energy, Office of Management, Budget and Evaluation, Office of Engineering and Construction Management, Washington, D.C.

This document is used for all Department of Energy projects in order to ensure successful projects. The document stresses that risk management must be an iterative and continuous process. All DOE risk management responsibilities processes, and documentation procedures are outlined. Additionally, guidelines are provided for tailoring the policies for individual projects. The attachments of the document include templates for risk documentation including a Risk Breakdown Structure and a Risk Register.

Van Gelder, P., van Noortwijk, J.M., Duits, M.T. (1999). "Selection of probability distributions with a case study on extreme order river discharges." *Safety and Reliability*, 2: 1475-1480.

This paper examines Baye's Factor Method and Tang's Method for choosing a probability distribution to estimate risk in civil engineering problems. The authors used Monte Carlo analysis to apply the methods to a cases study and determined that Baye's Factor was more effective in choosing a probability distribution.

Wanhua, Z., and Ruiyu, L. (2008). "Study on engineering project investment risk measure based on Monte Carlo method." *Proceedings of the International Conference on Information Management, Innovation Management and Industrial Engineering*, Taipei, Taiwan, December 19-21, 407-411.

This paper uses Monte Carlo analysis to determine the economic risk of engineering projects with net present value as the deterministic output. The authors concluded that the Monte Carlo method was an effective method for determining such risk because of ease of use and it's ability to supply decision makers with more statistical information.

Ward, S.C., Chapman, C.B., and Curtis, B. (1991). "On the allocation of risk in construction projects." *International Journal of Project Management*, 9(3): 140-147.

According the authors, a organization's willingness to take on a risk in a construction project is based on their ability to charge a premium for that risk. The paper shows what some of the implications of risk allocation are and outlines the four response options for a party bearing a risk. The authors argue that appropriate risk allocation leads to better overall project risk management and therefore more successful projects.

Ward, S. C. (1999). "Assessing and managing important risks." *International Journal of Project Management* 17(6): 331-36.

This paper looks at the shortcomings of only assessing risks using probability impact matrices. The author states that while this method is useful in ranking risks it gives no absolute meaning to the risk. Outlined are the important considerations that should be

taken in the assessment and identification phase of the risk management process. The paper concludes with a list of items that should be included in a risk register.

Wideman, R.M. (1992). *Project and Program Risk Management: A guide to managing project risk and opportunities*. Project Management Institute, Newton Square, PA.

This handbook is published as part of the Project Management Body of Knowledge. It provides an understanding to the nature of risk and provides methods for reducing a project's risk exposure. The handbook includes tools and techniques for risk identification, risk assessment, contingency management and risk mitigation.

Williams, T.M. (1994). "Using a risk register to integrate risk management in project definition." *International Journal of Project Management* 12(1): 17-22.

This paper found that the risk register was becoming central to any successful risk management program. The paper describes an integrated risk analysis and management framework that is based around the use of a risk register. This framework assists managers by making the risk register a tool in making decisions for risk management plans and risk transference.

Xing-xia, W. and Jian-wen, H. (2009). "Risk analysis of construction schedule based on Monte Carlo simulation." *International Symposium on Computer Network and Multimedia Technology*, Wuhan, China, January 18-20.

This paper looks specifically at duration risk in construction projects. The authors use Monte Carlo analysis to estimate a project's duration and the duration risk faced by the proposed construction schedule. The authors found that Monte Carlo analysis could accurately and efficiently predict the duration of individual project activities and of the overall project duration.

Zacharias, O., Panopoulos, D., and Askounis, T.D.. (2008). "Large Scale Program Risk Analysis Using a Risk Breakdown Structure." *European Journal of Economics, Finance and Administration Sciences*, 12: 170-181.

This paper examines program risk management, specifically looking at large-scale programs include hundreds of projects and are typically management by governmental agencies. The authors find that there is little research on effective techniques to manage risk for such programs. Team-based risk management and the use of a risk breakdown structure are the two techniques that are found to be effective and are given thorough discussion.

APPENDIX B ONLINE RESEARCH QUESTIONNAIRE

**Online Survey for NCHRP Project 20-24(74)
Executive Strategies for Risk Management by State
Departments of Transportation**

Page 1 - Heading

NCHRP Project 24-20 Executive Strategies for Risk Management by State Departments of Transportation
 You are being invited to participate in a study of executive risk management strategies for state departments of transportation (DOT) by the National Cooperative Highway Research Program (NCHRP). The objectives of this research are to describe how DOT leadership use risk management in the conduct of their business and to identify executive strategies that may be useful to DOT leadership for enterprise-wide risk management. The University of Colorado is teaming with ICF International to perform a scan of current risk management practices in practice by DOTs across the country. While the study focuses on identifying effective risk management strategies for DOT leaders, it is also striving to collect data from all sectors of the transportation industry as a means of comparison and to generate new ideas. Your individual privacy will be maintained in all published and written data resulting from this study. We expect the project to benefit you by providing a summary of current methods of enterprise risk management implemented by DOTs across the country. You will receive no compensation for your participation. Completing the questionnaire will take approximately 20 minutes.

Page 1 - Question 1 - Choice - Multiple Answers (Bullets)

I understand the above information and voluntarily consent to participate in the research project entitled NCHRP 20-24 Executive Strategies for Risk Management by State Departments of Transportation

- Yes
- No

Page 2 - Question 2 - Open Ended - One or More Lines with Prompt

Please fill in the following information (Note: we are collecting names only to avoid duplication when aggregating results. Your individual privacy will be maintained in all published and written data):

- @ First Name _____
- @ Last Name _____
- @ Organization _____
- @ Organizational Unit and/or Job Title _____
- @ State in which you are employed _____

Page 2 - Question 3 - Choice - Multiple Answers (Bullets)

We are asking for your email so we may contact you with the results of this effort or for additional questions.

- Please do not contact me with the results
- I am available for additional questions
- Email Address: _____

Page 3 - Question 4 - Choice - Multiple Answers (Bullets)

Please check the answer which best describes your organization.

- State Department of Transportation
- Other - please describe

Page 3 - Question 5 - Choice - Multiple Answers (Bullets)

Please check your organization's primary construction sector.

- Highway
- Transit
- Other - please explain

Page 3 - Question 6 - Open Ended - One Line

Organization's approximate annual program expenditures (include all sources federal, state, etc.). Answer in approximate \$/yr in expenditures (\$xxx,xxx,xxx).

Page 4 - Question 7 - Yes or No

Does your organization have a formal, published management policies or procedures?

- Yes
- No

Page 4 - Question 8 - Choice - Multiple Answers (Bullets)

If your organization's risk management policies or procedures are available in electronic form, can you share them with us via email or via the Web?

- Not Available
- Policies and Procedures will be emailed to keith.molenaar@colorado.edu
- Web Address for policies and procedures

Page 5 - Heading

This questionnaire will address risk management at the enterprise, program and project level. You can answer questions in one of these areas or all of these areas by answering positively to the next question and similar questions that follow.

Page 5 - Heading

This study defines Enterprise Risk Management as the consistent application of techniques to manage the uncertainties surrounding the achievement of an organization's objectives.

Page 5 - Question 9 - Choice - Multiple Answers (Bullets)

Are you able to answer questions about Enterprise Risk Management?

- Yes [Skip to 6]
- No [Skip to 9]

Page 6 - Question 10 - Choice - Multiple Answers (Bullets)

How was your organization's Enterprise Risk Management framework developed?

- Using an established framework, developed outside of the DOT (e.g. International Standards Organization (ISO) or Committee of Sponsoring Organizations (COSO))
- Framework was developed in house
- Framework adapted from another DOT
- Framework adapted from another industry/private industry
- Other - please explain

Page 6 - Question 11 - Open Ended - Comments Box

Optional - Please expand on Question 10. Describe when the process was developed, who was involved (i.e. job titles of individuals), and any other relevant information surrounding the development of the Enterprise Risk Management framework.

Page 6 - Question 12 - Open Ended - Comments Box

Please describe the risks (or general nature of the risks) that your organization manages using Enterprise Risk Management techniques.

Page 6 - Question 13 - Open Ended - Comments Box

Please describe if and how your organization works to develop an Enterprise Risk Management culture so that policies and procedures are applied consistently at all levels of the organization.

Page 7 - Question 14 - Choice - Multiple Answers (Bullets)

Does your organization use any of the following formal risk identification techniques as part of your Enterprise Risk Management Program? Please check all that apply.

- Brainstorming
- Standard Checklists
- Risk Breakdown Structures
- Scenario Planning
- Expert Interviews
- Delphi Method
- N/A, the organization does not conduct formal risk identification.
- Other - please explain other risk identification techniques

Page 7 - Question 15 - Choice - Multiple Answers (Bullets)

Please indicate which of the following formal risk management techniques are applied as part of your Enterprise Risk Management program? Please check all that apply.

- Qualitative risk assessment techniques (e.g., engineering judgment, categorization of probability and impact).
- Statistical analysis of historic data (e.g. assigning costs to risks, or probability of risk events occurring)
- Monte Carlo or simulation methods
- Probability or decision trees
- N/A, the organization does not conduct formal risk assessment.
- Other - please explain other formal quantitative or qualitative assessment techniques

Page 8 - Question 16 - Open Ended - Comments Box

To what extent is a risk register used to manage organizational risks (e.g. financial, human resources, political, etc)?

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.....

Page 8 - Question 17 - Open Ended - One Line

If a risk register is used for organizational risks, how frequently are risks updated?

.....

Page 8 - Question 18 - Open Ended - Comments Box

Can you share any brief lessons learned concerning enterprise risk management that might benefit other state agencies?

.....

.....

.....

.....

Page 9 - Heading

A program is a group of projects (e.g. a state transportation improvement program) that are managed together to achieve higher order strategic goals not delivered by individual project management.

Page 9 - Question 19 - Choice - Multiple Answers (Bullets)

Are you able to answer questions about Program Risk Management?

- Yes [Skip to 10]
- No [Skip to 13]

Page 10 - Question 20 - Open Ended - Comments Box

Please describe the risks that your organization manages on the program level (i.e. risks that are managed for multiple projects).

Page 10 - Question 21 - Open Ended - Comments Box

How do the risks identified in the previous question differ from risks that are managed on the enterprise level?

Page 10 - Question 22 - Open Ended - Comments Box

How do the risks identified in the two previous questions differ from risks that are managed on the organizational level?

Page 11 - Question 23 - Choice - Multiple Answers (Bullets)

Does your organization use any of the following formal risk identification techniques on the program level? Please check all that apply.

- Brainstorming
- Standard Checklists
- Risk Breakdown Structures
- Scenario Planning
- Expert Interviews
- Delphi Method
- N/A, the organization does not conduct formal risk identification.
- Other - please explain other risk identification techniques

Page 11 - Question 24 - Choice - Multiple Answers (Bullets)

Does your organization have any formal quantitative or qualitative risk assessment or analysis techniques for program risk management? Please check all that apply.

- Qualitative risk assessment techniques (e.g., engineering judgment, categorization of probability and impact).
- Statistical analysis of historic data (e.g., for assigning costs to risks, or probability of risk events occurring)
- Monte Carlo or simulation methods.
- Probability or decision trees
- N/A, the organization does not conduct formal risk assessment.
- Other- please explain other formal risk assessment techniques

Page 12 - Question 25 - Open Ended - Comments Box

To what extent is a risk register used to manage program risks?

Page 12 - Question 26 - Open Ended - One Line

If a risk register is used for program risks, how frequently is the risk register updated?

Page 12 - Question 27 - Open Ended - Comments Box

Can you share any brief lessons learned concerning program risk management that might benefit other state agencies?

Page 13 - Heading

Project risk management is a structured process that allows individual risk events and overall project risk to be understood and managed proactively, optimizing project success by minimizing threats and maximizing opportunities.

Page 13 - Question 28 - Choice - Multiple Answers (Bullets)

Are you able to answer questions about Project Risk Management?

- Yes [Skip to 14]
- No [Skip to 18]

Page 14 - Question 29 - Open Ended - One or More Lines with Prompt

Does your organization conduct formal risk analyses in any of the following areas? If yes, please approximate the percentage of projects for which formal risk analyses are conducted.

- @ Project Scope (%):
- @ Project Schedule (%):
- @ Project Cost (%):
- @ Contracting Risk (%):
- @ Other - please explain
- @ Other - please explain
- @ Other - please explain

Page 14 - Question 30 - Choice - Multiple Answers (Bullets)

Does your risk analysis process change for any of the following areas? Please check all that apply.

- Project Size or Scale
- Project Value or Dollar Amount
- Project Complexity
- Project Phase (i.e. planning, programming, design)
- N/A
- Other - please explain other instances for which the risk analysis process is changed

Page 14 - Question 31 - Open Ended - Comments Box

If you answered positively to any of the items on the previous question, please explain here?

.....

.....

.....

.....

Page 15 - Question 32 - Choice - Multiple Answers (Bullets)

Does your organization use any of the following formal risk identification techniques on the project level? Please check all that apply.

- Brainstorming
- Standard Checklists
- Risk Breakdown Structures
- Scenario Planning
- Expert Interviews
- Delphi Method
- N/A, the organization does not conduct formal risk identification
- Other - please explain other formal risk identification techniques

Page 15 - Question 33 - Choice - Multiple Answers (Bullets)

Does your organization have any formal quantitative or qualitative risk assessment or analysis techniques for project risk management? Please check all that apply.

- Qualitative risk assessment techniques (e.g., engineering judgment, categorization of probability and impact)
- Statistical analysis of historic data (e.g., for assigning costs to risks, or probability of risk events occurring)
- Monte Carlo or simulation methods.
- Probability or decision trees
- N/A, the organization does not conduct formal risk assessment
- Other - please explain other formal risk assessment techniques

Page 16 - Question 34 - Open Ended - Comments Box

To what extent is a risk register used to manage project risks?

Page 16 - Question 35 - Open Ended - One Line

If a risk register is used for project risks, how frequently is the risk register updated?

Page 17 - Question 36 - Yes or No

Does your organization use any formalized risk allocation techniques in drafting contract provisions?

- Yes
- No

Page 17 - Question 37 - Open Ended - Comments Box

If yes to the previous question, please describe.

Page 17 - Question 38 - Open Ended - Comments Box

Can you share any brief lessons learned concerning project risk management that might benefit other state agencies?

[Skip Unconditionally to 18]

Page 18 - Question 39 - Choice - Multiple Answers (Bullets)

In your opinion, how often is your organization successful at applying the appropriate risk management strategies at the organizational level for which your role is most responsible for?

- Always
- Frequently
- Seldom
- Never
- N/A

Thank You Page

Thank you for participating in this research. Your contribution is invaluable to the study.

If you would be willing to discuss your answers further or answer more questions on the topic please email keith.molenaar@colorado.edu.

APPENDIX C STATE DOT RISK MANAGEMENT POLICIES

A question in the online survey asked if DOT's risk management policies or procedures were available in electronic form on the web. The following is a listing of links that were provided by the survey respondents.

State DOT	Link Provided
CALTRANS	http://www.dot.ca.gov/hq/projmgmt/guidance_prmhb.htm
CODOT	http://www.coloradodot.info/about/governmentrelations
IADOT	http://www.iowadot.gov/pol_leg_services/index.htm
ILDOT	http://www.dot.il.gov/desenv/demanuals.html
MoDOT	http://gomdot.com/Divisions/AdministrativeServices/Resources/APA/Home.aspx
OHDOT	http://portal.dot.state.oh.us/Groups/policies/default.aspx
TXDOT	http://www.dot.state.tx.us/about_us/internal_compliance.htm
UDOT	http://www.udot.utah.gov/main/f?p=100:pg:0:::T,V:2662,
WSDOT	http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/ http://www.wsdot.wa.gov/Publications/Manuals/M72-01.htm http://www.wsdot.wa.gov/Projects/ProjectMgmt/#execord

Note: Links provided in August and September of 2010.

APPENDIX D INTERVIEW PROTOCOL AND QUESTIONNAIRE*Salient Interview Protocol Details*

Interview Characteristic	Protocol	Justification
Number of Cases	3	Examining three DOTs will allow the team to gather both a variety of responses and find common risk management practices.
Unit of Analysis	State DOT or Other Public Transit Organization	Will allow for easy initial organization of interview and data collection results
Interviewees	≥ 2 representatives, from different management levels, will be consulted.	Multiple perspectives will allow replications of results and ensure internal validity.
Other Sources of Data	Formal risk management plans and protocols from the organization, survey results	Inclusion of these documents allows for triangulation of results and creates construct validity.
Data Organization	Will be in two levels, first by organization and second by level of risk management (e.g. enterprise, project)	While data will initially be organized by organization for ease it will later be organized by level of risk management in order to make the data more suitable for writing the final report
Organization Selection	Select those organizations that have demonstrated a clear understanding of the different levels of risk management and have formal procedures and policies.	These organizations will be able to provide the largest data set and provide information relevant to the objectives of the final report.

Case Protocol & Steps

1. Create set of standard interview questions
2. Identify potential organizations based on previous research and contacts.
3. Identify potential organizations based on survey results and responses.
4. Contact identified organizations and find candidates to interview for research.
5. Conduct each case:
 - a. Request formal risk management plans and procedures and any other pertinent documents for research teams review from each participating organization.
 - b. Review risk management plans, procedures and documents.
 - c. Create questions specific to organization based on review of the organization's plans, procedures and documents.
 - d. Conduct interviews
6. Review all interview results
7. Ask any follow up questions to individuals or individual organizations based on results from all cases.

Interview Questions

Demographics

1. What organization are you employed by?
2. What is your primary job title?
3. Approximately how many people does your organization employ?
4. What is your organization's primary sector of construction?
5. What is your organization approximate annual program expenditure?
6. What level of the risk management process are you responsible for at your organization (e.g. enterprise, project, program)?
7. What levels of the risk management process at your organization are you familiar with?

Definition

1. How does your organization define risk?
2. How does your organization define risk management?

Structure

1. Who is involved in the RM process at the level for which you are responsible?
2. What inputs does your level of RM receive from other levels of the RM program? Who is responsible for giving and receiving these inputs?
3. What inputs does your level of RM pass along to other levels of the RM program? Who is responsible for giving and receiving these inputs?
4. Is there a specific team of individuals responsible for managing different levels of risks? (e.g. Enterprise, Program)
5. Is there a specific team of individuals responsible for managing different types of risks? (e.g. budgetary, technical, scheduling, resource allocation)
6. Is there a specific team of individuals responsible for different portions of the RM process? (e.g. identification, assessment)

7. Does your organization utilize a risk breakdown structure in order to determine RM responsibilities?
8. Does your organization have a risk breakdown structure or RM hierarchy that you could share with us?

Policies

1. How was the RM program developed (e.g. in house, another organization)?
2. When was the current RM program developed? Who was involved in its development?
3. Where did the impetus for the RM program come from?
4. How frequently is the RM program reviewed and revised?
5. How does your organization ensure that all its members have the same understanding of risks?
6. How does your organization ensure that all of its members manage risks according to organizational policies and procedures?
7. How has your organization created a mindset of risk management as an integral part of operations?

Procedures

1. What processes do you use to identify risks? Who is involved in these processes?
2. What processes do you use to assess risks? Who is involved in these processes?
3. When are risks identified? Assessed?
4. What tools are used to catalogue risks?
5. What response options does your organization consider when managing risks?
6. How are appropriate response strategies determined?
7. How frequently are previously identified risks reviewed and their status revised?
8. Does your organization have a set of written policies or procedures that you could share with us?

Costs/Resources

1. What do you believe are the primary costs and or resources associated with implementing a RM program within an organization?
2. What resources are required for the RM program to be carried out?
3. Can you give any specific examples or documentation of the costs or resources that your organization allocates to risk management?

Barriers

1. What do you believe are the primary barriers to the implementation of a RM program within a comparable organization?
2. Can you give any specific examples of methods that your organization has used to successfully overcome some of these barriers?
3. What other methods could be used to overcome these barriers?
4. Are there any barriers that your organization is currently working against to make the RM program more effective or efficient?

Benefits

1. What do you believe are the primary benefits to the implementation of a RM program within a comparable organization?

2. Can you give any specific examples or success stories of your organization's RM program benefitting the organization?
3. If you were selling the implementation of a RM program to a comparable organization, what would be the business case for such a program? Do you have any examples?

Advice to Peer DOTs

1. What advice would you give a peer DOT attempting to implement a RM program similar to your organization's program?
2. What steps do you think a peer DOT should take in order to make their RM program more efficient?
3. What steps do you think a peer DOT should take in order to make their RM program more effective?