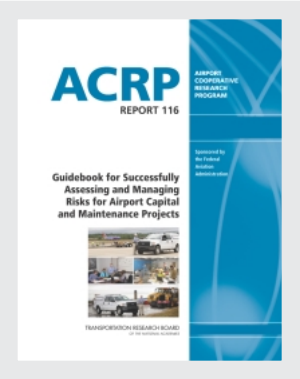

Guidebook for Successfully Assessing and Managing Risks for Airport Capital and Maintenance Projects

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 116

Guidebook for Successfully Assessing and Managing Risks for Airport Capital and Maintenance Projects

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Pickerington, OH

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

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FOREWORD

By Marci A. Greenberger
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ACRP Report 116: Guidebook for Successfully Assessing and Managing Risks for Airport Capital and Maintenance Projects provides a step-by-step process for evaluating and managing risk for capital and maintenance projects that can be scaled depending on the complexity of the project. Each step of the process is explained, allowing the user to understand the step and its relationship to the entire process. Chapter 8 is structured to be a quick user's guide. Employees at all levels that have any responsibility for safety and risk management will find this guidebook useful.

Risk is usually thought of in terms of what bad things can happen to people and property (although it should also be looked at as being able to identify and capitalize on opportunities). Airports, prior to the emerging requirement for some to have a safety risk management process, have been conducting risk assessments and management functions informally as part of their overall safety programs. But there are other types of risks that airports are prone to, such as operational, financial, reputational, and political. Project risk management assessment and the management of those identified risks are becoming more common at airports to help minimize, mitigate, transfer, or eliminate risk to help control costs, respond to changing regulations, and assist in doing the right thing.

Airports engage in many capital and maintenance projects that, by their sheer nature, involve uncertainties, and uncertainties imply risk. Under ACRP Project 01-22, Direct Effect Solutions, Inc., was tasked with developing guidance that airport management and line employees could use when planning capital and maintenance projects regardless of their scope and complexity. Their approach to the research included interviews and focus groups, and they developed this guidebook to be useful to airports of all sizes, geographic locations, and governance structures. As with any two entities, different airports are going to have different risk tolerances, and their approaches to project risk management may differ. But the process of identifying, prioritizing, and managing project risks will be the same, and this guidance explains each step in the process.

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PART 1

Project Risk Management: Overview

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Part 1 Objectives

The chapters in this part address the following questions:

- What is project risk management?
- When is project risk management performed?
- Who performs project risk management?

CHAPTER 1

Introduction

1.1 Background

All projects involve risk. No matter how small, large, simple, or complex a project, some uncertainties will likely remain that, if realized, could affect the project budget, schedule, or scope. As a result, projects often exceed initial cost estimates, extend beyond their scheduled completion dates, or experience some other unwelcome complications toward meeting their goals.

Although airports often undertake significantly complex projects that can be laden with uncertainty, the literature suggests that they are not unique in facing risks and consequences during project development and delivery. For example, a 2002 study of 167 transportation infrastructure projects constructed over the previous 70 years found that large capital projects were initially underestimated by an average of 20%, with a small percentage of projects even being overestimated (Flyvbjerg et al., 2003). Poor predictions of project performance can in turn lead to other negative consequences, including:

- Poor planning of design requirements and project deliverables that can result in scope, schedule, and budget changes;
- Underestimating costs, which can result in project teams having to make changes to project scope, which results in changes to schedule and budget;
- Changes to design efforts causing changes to phasing of project deliverables, which can result in resource conflicts, schedule impacts, and, ultimately, budget changes; and
- Impacts to quality and timely completion of project work.

Sources of poor project performance are often tied to the following general risk sources:

- Cost risk: Will the initial cost estimates prove accurate as the project progresses?
- Funding risk: Will the funding profile remain constant throughout the life of the project?
- Schedule risk: Will scheduled milestones and completion date be met?
- Scope or technical risk: Will the technology needed to complete the project mature at the expected time?

Lost opportunities are also a risk due to poor project planning. An aspect of project risk management is also to look at the opportunities available to increase the benefit of project activities through responses such as to capitalize, accept, grow, or enhance an activity. Each of the previous bullet points can also have an opportunity associated to them, such as:

- Cost opportunity: Can costs be reduced by leveraging buying power from multiple projects simultaneously?
- Funding opportunity: Can year-end timing of available funding be taken advantage of to ask for more and do more as a result?

- Schedule opportunity: Can similar activities be combined in order to be completed in a more expedient way?
- Scope or technical opportunity: Are there aspects of the scope that could lead to additional opportunities to complete enhancements for other projects?

Figure 1.1 depicts these general project risk sources and associated common risks.

1.1.1 What Is Project Risk?

Project risk or opportunity is an uncertain future event or condition that, if it occurs, has a positive or negative effect on achieving the project objectives of cost, schedule, scope, or quality. To fully define risk, three elements are needed:

- A future event, which, if eliminated or corrected, would prevent a potential consequence from occurring.
- A probability (or likelihood) assessed at the present time of that future event occurring.
- The impact (or effect) of that future event.

Typical project risk categories are summarized in Table 1.1.

1.1.2 Project Risk Management Overview

Implicit in the previous definition of project risk is the concept that risks are *future* events; that is, they are potential problems creating uncertainty in the project's success. (In contrast, *issues* are problems that have already occurred and require resolution.)

Figure 1.1. General project risk sources.

Table 1.1. General project risk categories.

Technical	Operational	External	Organizational	Commercial
Scope definition	Safety	Customer	Resources	Contractual terms and conditions
Requirements	Security	Political	Dependencies	Suppliers and vendors
Design	Interfaces	Public relations	Financial capacity	Procurement process
Quality	Site conditions	Market conditions		Contractors
Complexity		Weather		
Site conditions		Environmental		
		Property acquisition		
		Permitting		
		Regulatory changes		

The focus of project risk management is therefore not just on eliminating risk, but rather on managing it—through the iterative steps of project risk management planning, identification, analysis, response planning, and monitoring and control—to cost-effectively keep risk exposure at an acceptable level.

Note that project risk can also relate to opportunities that may help the project team deliver the project with lower costs, shortened schedules, or enhanced scope or quality. Where risk management seeks to understand what might negatively affect a project, the focus of opportunity management is on what could be done to capitalize on additional aspects of the project scope, schedule, or budget that could be beneficial to the organization as a result of the project. Realizing midway through a project that a superior alternative exists is not useful since it is typically too late at that point to act on the opportunity.

The process of managing risk at the project level has been described by various organizations, such as the Project Management Institute (2008) for generic projects, the U.S. Department of Energy (2008) for nuclear plant operation and construction, the U.S. Department of Defense (2006) for defense system acquisition, and the Federal Highway Administration projects (Molenaar et al., 2010 and Ashley et al., 2006) for transportation construction. Despite the diversity in the types of projects these organizations pursue, their general approach to project risk management closely follows the cyclical process depicted in Figure 1.2, with differences limited primarily to industry-specific terminology and common risks.

The steps of the project risk management process are described in Table 1.2.

1.1.3 Benefits of Project Risk Management

The need for a formal project risk management process arises from the nature of risk and the typical complexity of projects. The numerous risks that may arise in a typical project are often interrelated and change organically during the course of the project. A formal, repeatable approach allows project teams to sort through numerous risk events; identify the risks, opportunities, and their interrelationships; pinpoint those that are the most critical; and identify cost-effective ways to reduce those risks or capitalize on those opportunities, consistent with the overall project goals.

Project risk management is an integral part of the overall project delivery process. When a disciplined, comprehensive risk management program is implemented throughout a program's

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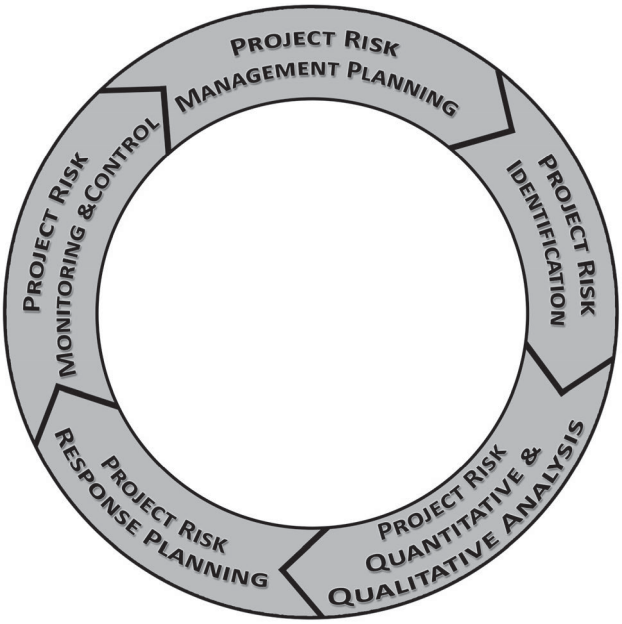

Figure 1.2. Project risk management process.

life cycle, critical program risks are properly identified and suitable handling plans are developed and implemented. A well-executed life-cycle risk management process is essential for balancing cost, schedule, and performance goals, especially for programs with designs that approach or exceed the state-of-the-art.

A structured process can facilitate project management by defining a consistent approach by which risk and opportunity can be assessed, handled, monitored, and communicated to stakeholders. Having a systematic process helps provide a reliable way to ensure objectivity and minimize any unwarranted optimism, bias, or self-interest.

The project risk management process helps project sponsors and project teams make informed decisions regarding alternative approaches to achieving their objectives and the relative risks involved in each in order to increase the likelihood of success in meeting or exceeding the most important objectives (e.g., time), sometimes at the expense of other objectives (e.g., cost). Risk management encourages the project team to take appropriate measures to:

- Realistically plan the project activities given the desired scope, schedule, and budget;
- Realize potential conflicts in resource utilization early to avoid conflicts proactively;
- Maximize opportunities to improve the project's objectives with lower cost, shorter schedules, enhanced scope, and higher quality; and
- Establish consistent project practices and communication strategies to create predictability in project activities and minimize management by crisis.

Project risk management is primarily performed to improve the chance of projects achieving their goals. Benefits include:

- Providing better information to support decisions regarding project direction and the setting of schedule and cost targets and contingencies.
- Identifying actions that can be taken to help improve technical, schedule, and cost performance.
- Creating a credible foundation for each project by showing it is possible, or, alternatively, demonstrate that the project is not feasible so that it can be avoided or transformed.

Table 1.2. Project risk management process steps and description.

Project Risk Management Step	Description
Project Risk Management Planning	The identification of the optimal level of risk management to apply to a particular project. The planning step includes establishing objectives for risk analysis aligned with project goals and the identification of resources desired rather than resources available for project activities. This step includes a comprehensive review of project scope, cost, and schedule to validate reasonableness of the project plan and incorporates risk management activities to create the project risk management plan.
Project Risk Identification	The process of identifying and documenting the risks and opportunities that could significantly affect project performance. The identification process could range from an informal brainstorming exercise to a more structured and facilitated work session in which project team members and independent subject matter experts are solicited for information and issues of concern. Risk identification begins as early as possible in successful programs and continues throughout the program with regular review and analysis.
Project Risk Analysis	The process of evaluating the attributes of each identified risk in terms of the probability of occurrence and the impact (consequences) on cost, schedule, and other project performance goals. By analyzing project uncertainties through either qualitative or quantitative analysis activities, project teams can proactively manage risk exposure and make risk-informed decisions about the cost/benefit of responses. Possible outputs from the risk analysis include probabilistic estimates of project cost and schedule, considering all uncertainties, and prioritized lists of risks and opportunities, including an assessment of their likelihood of occurrence and impacts if they were to occur.
Project Risk Response Planning	The process that identifies, evaluates, selects, and implements options in order to set risks at acceptable levels given program constraints and objectives. This includes the specifics on what should be done, when it should be accomplished, who is responsible, and the cost and schedule impact. Opportunities identified may require additional investment.
Project Risk Monitoring and Control	The process of tracking and reporting project performance against the project risk management plan. Effective risk tracking helps to identify what planning and budget requirements and contractual changes may be needed, and provides a coordination vehicle with management and other stakeholders to reevaluate risk response strategies as appropriate. Risk monitoring and control documents the change history and can be used as lessons learned for application on future projects.

- Capitalizing on opportunities. Reveal opportunities for improving projects early enough to realize them.
- Providing project priority and management support. Support and commitment are more easily won when projects are based on thorough, understandable information.
- Providing project portfolio management. Achieving and maintaining an appropriate mix of ongoing projects depends on risk data. The ideal portfolio would include both lower- and higher-risk projects that are consistent with business objectives.
- Refining plans to reduce risk. Risk analysis uncovers weakness in a project plan and triggers changes, new activities, and resource shifts that improve the project. Needed shifts in overall project structure or basic assumptions may also be revealed.

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- Establishing reserves or contingencies. Project risk analysis demonstrates the uncertainty of project outcomes and is useful for justifying contingencies for schedule and/or resources. Project risk analysis data provide both the rationale and the magnitude for the required contingency.
- Assisting in project communication. Communication is most effective when there is a solid credible plan. Risk data can also be useful in negotiations with project sponsors. Using information about the likelihood and consequences of potential events gives the project team more influence in defining objectives, determining budgets, obtaining staff, setting deadlines, and negotiating project changes.
- Increasing institutional knowledge. Using lessons learned from documented project risk management practices creates a database of institutional knowledge to demonstrate continuous improvement in project management.

1.2 Purpose of the Guidebook

This guidebook is based on the principle that risk management must be forward-looking, structured, informative, and continuous. It is also grounded in the philosophy that all projects delivered by an organization, regardless of size, type, or funding source, can benefit from some level of project risk management activity, and the results will be demonstrated in a more efficient use of the limited resources of time, people, and money in an organization.

This guidebook:

- Provides practical, consistent, and repeatable methods for ease in integration into existing programs and processes within an organization;
- Provides flexible tools that are simple to use and apply to any type of project (construction, maintenance, capital, operating, technology, systems, etc.);
- Provides a reusable framework that can be scalable to the complexity of a specific project;
- Provides an adaptable flow for project risk management steps to increase or reduce risk management activities as project complexity changes; and
- Is written for a wide audience and broken into parts so that readers can use those aspects that apply to their current circumstances and environment.

This guidebook has been structured to provide a basic understanding of risk management concepts and processes. It offers clear descriptions and concise explanations of core steps to assist in managing project risk.

1.3 Overview and Organization of the Guidebook

As an outgrowth of the ACRP Project 01-22 research effort, this guidebook was prepared to assist project teams with the implementation of project risk management. The guidebook presents a flexible framework that allows for tailoring based on project size, complexity, development phase, and duration, as well as the availability and skill level of personnel performing the risk analysis.

An example of the flexibility of the framework in the guidebook is the ability to navigate the amount of risk management to apply to a specific project by using the project risk management flowchart (Figure 2.1). While working through the identification step, activities could range from an informal brainstorming exercise to a more structured and facilitated work session in which project team members and independent subject matter experts are solicited for

information based on their expertise if the amount of risk management was determined to be moderate or high rather than minimal.

Likewise, the analysis of these risks and opportunities could range from a qualitative prioritization of risks based on the combined effect of their probabilities and impacts to more rigorous analytical methods involving uncertainty reduction through quantitative decision-tree analysis and probabilistic modeling. The selected method(s) will ultimately involve a trade-off between sophistication (and hence, defensibility) and the method's ease of use.

The tools and techniques included in this guidebook are intended to be a starting point for project risk management and have been developed using recognized project risk management methods. These methods can be integrated into existing programs like project management, program management, enterprise risk management, strategic planning, capital improvement, operating and maintenance, and other organization-wide business practices.

1.3.1 Organization of the Guidebook

The guidebook is divided into four parts. Each part has a specific purpose, and objectives are outlined on individual part title pages. The purpose and content of each part is as follows:

Part 1—Project Risk Management Overview

This is an introduction to project risk management and describes an overview of the project risk management process. This section includes key terms, definitions, and the purpose of the guidebook. It answers questions about project risk management such as:

What is project risk management?
When is project risk management performed?
Who performs project risk management?

The audience for this part of the guidebook may be sponsors of projects as well as project managers managing all aspects of projects.

Part 2—Project Risk Management: Step-by-Step Process

This part provides a step-by-step description of each of the steps included in the project risk management process. Each step is described in its own chapter, which includes the key activities of the step, the inputs used in completing the step, the tools and techniques that can be used throughout the step, and the outputs expected to be developed as a result of the efforts. The tools described include reference to the set of tools included in Part 3 of the guidebook as well as additional resources to research as the organization finds the need to expand the project risk management activities. The intended audience for this section is the project managers and project team members performing project risk management. Each chapter with its corresponding step is depicted in Table 1.3.

Part 3—Project Risk Management Toolbox

This part provides a usable, practical application of the contents of the guidebook. Organizations with project management practices looking to incorporate a level of risk management may choose to leverage the toolbox and embed it into existing project management practices. Organizations that need additional learning for the application of the tools will need to use Parts 2 and 3 together in implementing a program. The toolbox contains four risk management tools: the project risk management plan, the project risk checklist, the probability and impact matrix, and the risk register. Each tool is provided with a blank template, an instruction guide, and a filled-in example showing its intended use. The intended audience for this section is the project managers and project team members performing project risk management.

Table 1.3. Project risk management steps.

	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7
Step	Project Risk Management Planning	Project Risk Identification	Project Risk Analysis	Project Risk Response Planning	Project Risk Monitoring and Control

Part 4—Project Risk Management Implementation

The final section of the guidebook includes suggestions for successful implementation of a project risk management process into existing practices and cultures. This section discusses characteristics of successful project risk management, barriers to implementation, and fostering a risk-based culture. The intended audience for this section is the project sponsors and senior managers establishing project risk management within the organization.

1.4 Summary

Using this guidebook to implement a project risk management program will provide benefits from standardized, predictable project practices, increased communication, and identification of both risks and opportunities as they relate to specific projects. Capturing lessons learned through debriefing sessions can institutionalize knowledge for continuous improvements, which will elevate the operations of the organization.

CHAPTER 2

The Risk Management Process

2.1 What Is Project Risk Management?

Risk management can occur at multiple levels in an organization, as summarized in Table 2.1. The highest level, the enterprise level [as described in *ACRP Report 74: Application of Enterprise Risk Management at Airports* (Marsh Risk Consulting, 2012)], focuses on managing those uncertainties that can affect an organization's strategic goals. The second level, the program level, entails managing risks (e.g., material price escalation, regulatory changes, standard design changes) across multiple business units or projects. The third level, which is the focus of this guidebook, pertains to managing the risks unique to a particular project. At the project level, risks specific to individual projects are evaluated, and response strategies are established within the scope and guidance of program and enterprise risk strategies.

2.2 Overview of Project Risk Management

The methods selected for this guidebook support easily integrating project risk management into other existing processes in an organization. Using common practices such as risk identification, risk analysis, risk response planning, and risk monitoring and control creates links to existing risk management programs such as safety risk management and security risk management (see Table 2.2). These existing programs use similar practices that will allow users to capitalize on common language, processes, and tools to make integration more seamless.

The project risk management process contains five steps. Each step includes key activities that can be performed. These key activities can be determined based on the attributes of the organization, such as organizational risk tolerance, operational maturity, and time and resources available. The activities can also be determined based on project attributes such as size, type, exposure, and complexity.

Table 2.3 describes each step and the key activities included.

2.3 When to Perform Project Risk Management

Risk management planning should be applied early in the project planning process, ideally at the conceptual design phase, to help identify risks and opportunities in time to incorporate any necessary response actions into final designs and to help refine schedule and budget estimates.

Table 2.1. Relationship between enterprise, program, and project risk management.

Level	Responsibility	Type of Uncertainty	Management Strategy
Enterprise	Executive/senior managers	Risks with implications across multiple organizational functions	Manage risks in a way that optimizes the success of the organization rather than the success of a single business unit or project
Program	Program managers	Risks that are common to clusters of projects or entire business units	Manage risk in a way that optimizes the aggregate result of multiple projects or the end-state of a program
Project	Project managers	Risks that are specific to individual projects	Manage risks through advanced analysis techniques, contingency planning, and consistent risk response strategies with the perspective that risks are managed in projects

Source: D'Ignazio et al., 2011

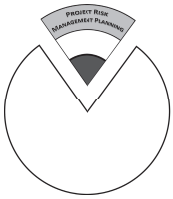
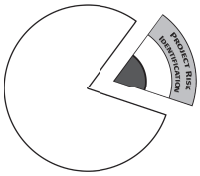
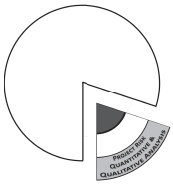
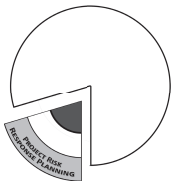
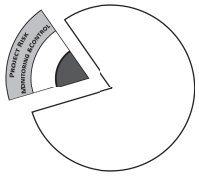
Figure 2.1 contains the complete flowchart of project risk management activities with decision points throughout the process. The flowchart depicts the flexibility of project risk management as well as the adaptability to add risk management activities along the course of a project as new information becomes available.

Capital and maintenance projects typically follow common phases for design and construction, although some may be more formal than others, depending on the size, type, and complexity of the project. Risk management practices can be integrated into project phases, and typical

Table 2.2. Types of risk management.

Type of Risk Management	Description	Sample Objectives
Generic	Any uncertainty that, if it occurred, would affect one or more objectives	N/A
Project Risk Management	**Any uncertainty that, if it occurred, would affect one or more project objectives**	**Time, cost, performance, quality, scope, client satisfaction**
Business Risk Management	Any uncertainty that, if it occurred, would affect one or more business objectives	Profitability, market share, competitiveness, internal rate of return, reputation, repeat work, share price
Safety Risk Management	Any uncertainty that, if it occurred, would affect one or more safety objectives	Low accident rate, minimal lost days, reduced insurance premiums, regulatory compliance
Technical Risk Management	Any uncertainty that, if it occurred, would affect one or more technical objectives	Performance, functionality, reliability, maintainability
Security Risk Management	Any uncertainty that, if it occurred, would affect one or more security objectives	Information security, physical security, access security, personnel security

Table 2.3. Project risk management process and key activities.

Step	Key Activities
Project Risk Management Planning 	• Establish objectives for risk analysis aligned with project goals • Identify resources desired versus resources available • Scale effort according to expected benefit • Perform comprehensive review of project scope, cost, and schedule to validate reasonableness
Project Risk Identification 	• Evaluate all project elements for risks and opportunities • Establish a non-overlapping list of all possible risks and opportunities related to project success
Project Risk Analysis 	• Qualitative and quantitative analysis • Evaluate risk and opportunity events in terms of the probability of their occurrence and their impacts • Prioritize major risks for further analysis or risk planning
Project Risk Response Planning 	• Identify feasible mitigation strategies for high-priority risks • Allocate risks to the parties best able to manage them
Project Risk Monitoring and Control 	• Monitor effectiveness of mitigation measures • Reevaluate risk response strategies as appropriate to improve outcomes • Document lessons learned for application on future projects

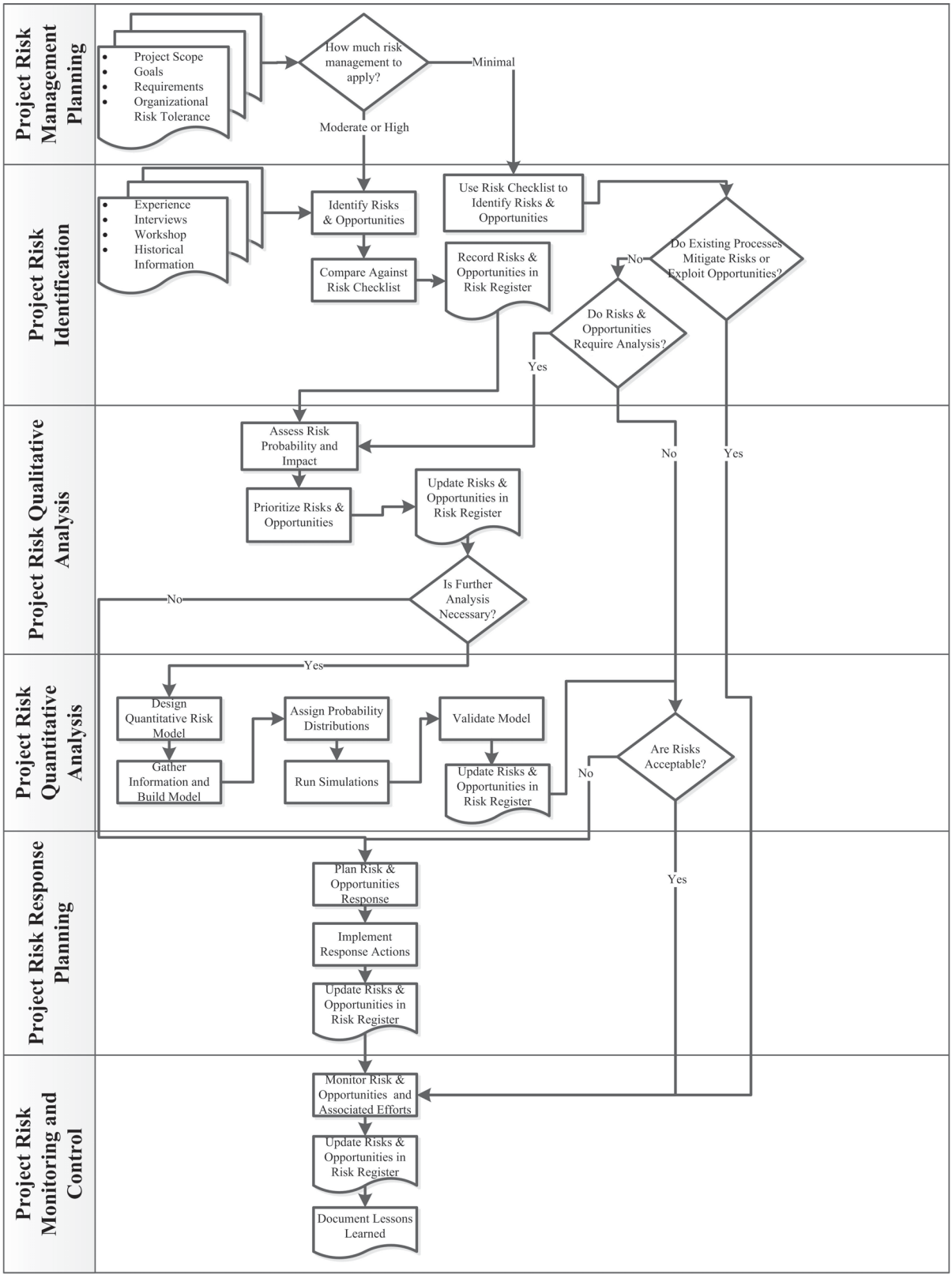


Figure 2.1. Project risk management flowchart.

Table 2.4. Project phase risk characteristics.

Project Phase	General Project State	Typical Risk Issues	Objectives of Risk Analysis
Conceptual Design	• Project details not fully defined • Funding possibly not committed • Order-of-magnitude cost estimate	• Uncertain support from key stakeholders • Competing interests and projects • Funding uncertainty • Cost relative to benefits	• Identify implementation challenges – political, tenants, public • Identify major design and construction risks and opportunities • Reach go/no-go decision on project
Preliminary Design	• Initial approvals received but long-term funding commitment may still be under review • Design approximately 30% complete • High cost and schedule uncertainties remain	• Changes to project scope and budget • Changes in design requirements • Market conditions	• Prepare list of major project risks and opportunities • Create preliminary risk management plan, focused on design and constructability risks • Determine type of project delivery method
Final Design	• Project scope, cost, and schedule well-defined	• Changes to project scope and budget • Errors or omissions • Changes in design requirements • Market conditions • Delays in final approvals	• List prioritized critical risks and opportunities based on impacts (combined likelihood and consequence) to total project cost, schedule, or other key project goal • Determine costs/benefits of risk mitigation strategies • Create risk management plan, focused on mitigation of unacceptable risks • Perform validation of reasonableness of contingencies and allowances in project budget and schedule
Construction	• Design complete • Funding in place • Contract executed	• Contractor performance • Construction quality • Unforeseen site conditions • Field design changes • Construction safety • Contractor coordination • Cash flow	• Perform monitoring and analysis of specific event, causes, and potential cost/schedule impact • Determine cost/benefit of possible corrective actions or response strategies

risk issues and objectives can apply. Table 2.4 outlines project risk management characteristics relative to project phases.

2.4 Determining Project Risk Management Effort

Determining how much project risk management to perform is an important aspect of the process, requiring balance between investing in some amount of effort versus not knowing the potential outcome. Too little effort can translate into costly impacts to the scope, schedule, and budget of a project. It can also translate into negative exposure, reputational issues, or even security or safety risks. Too much of a risk assessment effort can have diminishing returns on the investment of resources and creates a negative perception of the process. Determining just the right amount of project risk management can take practice and discipline in documenting efforts, debriefing results, and translating them into lessons learned to apply continuous improvement to the process. Gaining buy-in to the implementation of some project risk management is the correct first step in the process.

Figure 2.1 depicts the process of project risk management, including the decision points that indicate when to perform project risk management. The project risk management process is adaptable to the complexity of any project and can be performed iteratively throughout the life of a project. In Chapter 3, Table 3.2 describes typical characteristics of low-, medium-, and high-risk projects. A project manager can use this table to determine an appropriate level of risk associated with a project based on the typical characteristics and then reference Table 3.3 to select a path for how much risk management to apply. Table 3.3 provides guidance for low or high project risk activities with the associated tools in order to navigate a specific path. This path would translate to

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the project risk management plan. If a more moderate approach is determined to be needed, the project manager can select a blend of the tools for low and high risk in order to create a medium-risk approach. These two tables along with the project risk management flowchart can assist a project manager in determining a path and the associated activities for a project risk management plan.

Key decision points follow paths designated as being either of minimal risk or moderate to high risk. A project may begin down one path and revert to the other as new information reveals itself in the project cycle. Note that an organization's interpretation or definition of minimal, moderate, and high risk may vary depending on that organization's risk tolerance. Typical characteristics of low-, medium-, and high-risk projects are shown in Table 3.2.

Key decision points for low-risk projects include:

- How much risk management to apply?
- Do existing processes adequately mitigate risk?

Key decisions points for medium- to high-risk projects include:

- How much risk management to apply?
- Do risks require analysis?
- What level of analysis is required?
- Are identified risks acceptable without a further response strategy?

The project risk management flowchart can help a project manager navigate the challenges of managing project risk throughout the life of the project regardless of its complexity. Navigating the flowchart aligns directly to the project risk management steps, which define the corresponding key activities and then identify the tools to use to support the process. Determining the answers to these key decisions will lead the project manager to the selection of the tools to be used to implement the overall process of project risk management. Table 2.5 represents the key activities and associated tools to execute the project risk management activities associated with each step of the process. This table can be used in conjunction with the flowchart to navigate the application of project risk management practices to specific projects, and can be flexible to scale to the project size, type, and complexity as well as to the organization's tolerance for risk.

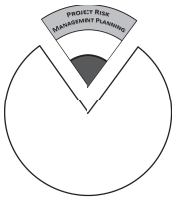
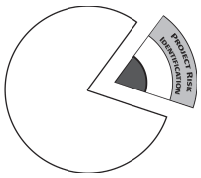
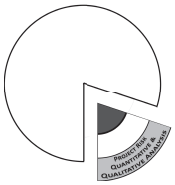
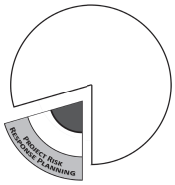
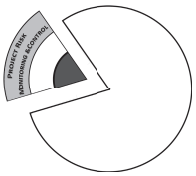
2.5 Who Performs Project Risk Management

Table 2.6 shows typical roles and responsibilities of project members for the project risk management process. This table can be customized with roles and responsibilities specific to the unique environment of each organization as well as for each project. Table 3.4 describes detailed responsibilities and activities associated with each role described in Table 2.6. Additionally, each chapter in Part 2 contains a table that shows the specific responsibilities associated to each step for each role identified.

2.6 Summary

Project risk management is a beneficial process that can be applied to any type, size, or complexity of project within an organization. The amount of project risk management can vary based on attributes such as risk tolerance, resources, and organization maturity along with specific project attributes. Any amount of project risk management can be a benefit to a project, although balance needs to be used to avoid wasting time and energy on excessive or costly activities that provide only diminishing returns. Use of the right amount of project risk management by the correct roles with a clear level of responsibility will return benefits in better management of project scope, schedule, and budget.

Table 2.5. Project risk management process and associated tools.

Step	Key Activities	Tools [1]
Project Risk Management Planning 	• Establish objectives for risk analysis aligned with project goals • Identify resources desired versus resources available • Scale effort according to expected benefit • Perform comprehensive review of project scope, cost, and schedule to validate reasonableness	• Risk management plan
Project Risk Identification 	• Evaluate all project elements for risks and opportunities • Establish a non-overlapping list of all possible risks to project success	• Risk checklist • Risk register
Project Risk Analysis 	• Qualitative and quantitative analysis • Evaluate risk events in terms of the probability of their occurrence and their impacts (consequences) on cost, schedule, and other project performance goals • Prioritize major risks for further analysis or risk planning	• Risk register • Probability and impact matrix
Project Risk Response Planning 	• Identify feasible mitigation strategies for high-priority risks • Allocate risks to the parties best able to manage them	• Risk register
Project Risk Monitoring and Control 	• Monitor effectiveness of mitigation measures • Reevaluate risk response strategies as appropriate to improve outcomes • Document lessons learned for application to future projects	• Risk register • Risk management plan

[1] Tools listed are not exhaustive. Other tools may be appropriate and are discussed in the text.

Table 2.6. Project risk management roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Establishes the threshold for risk tolerance for the organization. • Establishes the level of rigor and discipline at which project risk management will be performed through the organization. • Establishes level of importance to the process.
Project Sponsor	• Establishes the threshold for risk tolerance on a given project and approves the risk management plan. • Validates scope, schedule, and budget reasonableness.
Project Manager	• Oversees the risk management process for the project and organizes all risk management planning sessions. • Creates a team culture to the appropriate thresholds set and communicates progress to all project members.
Project Team Members	• Provide information, including approvals, endorsements, communication, and progress of tasks. • Participate in risk process, proactively identifying and managing risks in their areas of responsibility.
Risk Owner	• Identifies and implements any response strategies and tracking of their outcomes. • Regularly reports on current risk status.
Risk Analyst	• Conducts quantitative and/or qualitative risk analysis for identified risks. This role may be filled by the project team members.

PART 2

Project Risk Management: Step-by-Step Process

Chapter 3. Project Risk Management Planning 21
Chapter 4. Project Risk Identification 32
Chapter 5. Project Risk Analysis 42
Chapter 6. Project Risk Response Planning 55
Chapter 7. Project Risk Monitoring and Control 62

Part 2 Objectives

The chapters in this part address the following questions:

- What are the steps of the project risk management process?
- What are the key activities of each step?
- What tools and techniques can be used throughout each step?
- What outputs are expected to be developed as a result of these efforts?

CHAPTER 3

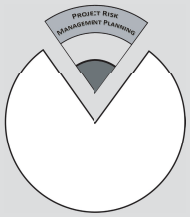
Project Risk Management Planning

Airport projects can range from routine, straightforward maintenance projects to highly complex, multifaceted capital projects valued in the millions of dollars. However, regardless of their type or size, all projects would benefit from some level of risk management.

The objective of the risk management planning step, as described in this chapter, is to identify the optimal level of risk management to apply to a particular project. Explicitly planning the risk management effort helps to ensure that:

- The level, type, and visibility of risk management activities are appropriate given both the perceived level of project risk and criticality of the project to the airport.
- Sufficient resources and time for risk management activities are incorporated into the project schedule and budget.
- Individuals assigned to participate in the risk management effort have an established and structured process for evaluating and responding to risks.

Project Risk Management Planning



Key Activities

- Understand the airport's risk tolerance
- Review the project scope, goals, and constraints
- Define the level of risk management to apply to the project
- Define the tools and techniques to use
- Define roles, responsibilities, and resources necessary to manage risk

Inputs

- Project scope or charter
- Airport's risk tolerance level

Tools and Techniques

- Risk management plan template

Outputs

- Risk management plan

3.1 Key Activities

3.1.1 Process Step Overview

Project risk management planning is a scalable activity with an approach and resource commitment commensurate with the project's size, complexity, and criticality. The objective of the risk management planning step is to define the approach and tools used to manage risks for a particular project through each step of the project risk management process.

A variety of tools and techniques are available to support each step. The selection of tools and techniques to use for each step depends in part on the project's development phase and complexity, resource availability, quality of input data, and the desired level of analytical rigor. There are seven key steps in project risk management planning, whether for capital or maintenance projects:

1. **Understand the Airport's Tolerance for Risk.** To establish how much risk management to apply to a particular project, it is important to first understand and view the risk posed by that project in the context of the airport's overall tolerance or appetite for risk, by considering such questions as:
   - What is the risk appetite of the oversight authority and/or management?
   - Have any recent events (e.g., negative press, overruns on other projects, heightened public or regulatory scrutiny) increased the airport's sensitivity to risk?
   - What is the financial investment in the project relative to the airport's overall budget for capital and maintenance projects?

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The answers to these questions will help define the level and nature of risk tolerance within the airport at a given point in time. This in turn will establish a foundation for subsequent discussions on what is and is not an appropriate level of risk for the project and how to manage this risk accordingly.

It is important to bear in mind that risk tolerance may change over time. Changing circumstances (e.g., heightened public, political, or regulatory scrutiny) may trigger a reevaluation of what constitutes an acceptable level of risk for the airport.

2. **Review Project Scope, Project Objectives, and Constraints.** Understanding project-specific objectives and constraints will help clarify what is important to project success, which may in turn drive the selected risk management approach. For example, for a high-profile project having a fixed completion date, it may be desirable to know, with a reasonable degree of certainty, how likely the project is to reach completion within the desired time frame. If the scope of the risk management effort extends to answering such questions, the risk management plan would have to allow for adequate time and resources to perform a quantitative risk analysis.
3. **Determine How Much Project Risk Management to Apply.** As noted previously, project risk management is a scalable activity that can be tailored to the airport's tolerance for risk and other project-specific factors such size, complexity, and criticality. For example, for a minor or routine project, risk management could simply entail verbally identifying risks with the goal of raising awareness of potential threats to project success among the project participants.

   As project size or complexity increases, the nature and objective of project risk management activities would change accordingly, as summarized in Table 3.1.
4. **Determine Which Project Risk Management Tools and Techniques to Use.** Table 3.2 and Table 3.3 further refine the amount of effort and, more specifically, which tools and techniques to apply to each step of the risk management process. Table 3.2 defines generic attributes associated with low-, medium-, and high-risk projects, the format of which individual airports can tailor to suit their own experience and needs.

   Participants in the planning effort can review the factors identified in Table 3.2 to generate an informal assessment of the perceived level of risk and uncertainty associated with a project.

   Where the project generally falls within the risk spectrum defined in Table 3.2 can then be used as an input into Table 3.3 to help establish how much risk management to apply to the

Table 3.1. Possible levels of project risk management.

Project Characteristics	Goal of Project Risk Management	Key Project Risk Management Steps
Small, Routine	Raise awareness of risks and opportunities	Project risk identification
Moderate Size or Complexity	Prioritize and mitigate risks	Use of a risk register to formally identify and document risks, their probability of occurrence and impact on project objectives, and the chosen risk response strategy
Large or Highly Complex	Develop risk-based cost and/or schedule contingency	Quantitative analysis of cost and schedule risks, with the results used to establish risk-based contingencies

Table 3.2. Typical characteristics of low-, medium-, and high-risk projects.

Characteristic	Low Risk	Medium (Blended) Risk	High Risk
Project Scope	• Well-defined • Unlikely to change	• Somewhat defined • Small change is possible	• Poorly defined • Likely to change
Project Budget	• Developed by experienced personnel using proven estimation processes	• Established by personnel with some experience	• Not established by experienced personnel using proven estimation processes
Market and Community Conditions	• Minimum variability or uncertainty	• Moderate variability or uncertainty	• High variability or uncertainty
Funding	• Committed and realistic	• Marginally adequate and expected to remain relatively stable	• Funding is less than estimated need and/or its stability is uncertain
Schedule Milestones	• Realistic and/or flexible dates	• Firm, pre-established milestones that may affect operations if missed	• Overly aggressive or unrealistic dates fixed by a specific operational commitment or regulatory requirements
Project Manager Experience	• Successfully completed multiple projects of similar size, scope, and complexity	• Finished one project of about the same size or complexity	• Prior experience limited to smaller or simpler projects
Project Staffing	• Available and committed to the specific project	• Key people identified	• Significant staffing unknowns remain or staff is overcommitted
Management Support	• Project sponsor identified and committed, and has reasonable/realistic expectations	• Project sponsor identified and generally agrees with project direction	• Project sponsor not identified, indecisive regarding project scope, or has unreasonable or unrealistic expectations
Technical Requirements	• Similar to past projects undertaken by the airport • Expertise available in-house	• Project team somewhat familiar with the subject matter • Expertise readily available from internal and/or external subject matter experts	• New and complex subject matter that is not well known to the project team • Subject matter expertise must be sought

(continued on next page)

Table 3.2. (Continued).

Characteristic	Low Risk	Medium (Blended) Risk	High Risk
Regulatory Requirements	• Regulations unlikely to change or changes would not affect project scope, schedule, or budget	• Regulations subject to change; however, minimal impact to project scope, schedule, or budget	• Regulations likely to change and affect the project scope, schedule, or budget
Coordination with Other Projects	• Project independent of other projects	• Project tied into another project	• Multiple tie-ins to other projects, requiring significant coordination
Contractor	• Has experience with type of project • Has experience with airport operations	• Has limited experience with project type • Has limited experience with airport operations	• Has no experience with type of project • Has no experience with airport operations

project (and by extension, which methods and tools included in this guidebook would be most beneficial in helping the team implement the chosen approach).

Table 3.3 recommends a course of action for managing both low- and high-risk projects. Some projects may actually be a blend between low and high risk, and the project manager should scale the appropriate course of action.

5. **Define Roles and Responsibilities.** Effective project risk management requires early and continual involvement of team members as well as outside help from subject matter experts, as appropriate. Establishing and documenting roles and responsibilities during the planning step will help ensure that the appropriate resources are committed to the project.

   Overall roles and responsibilities associated with the project risk management effort are summarized in Table 3.4 and are scalable to not only specific projects, but these roles and responsibilities can be adjusted for the risk tolerance established at the organization level. Additionally, each chapter in Part 2 contains a similar table showing the specific roles and responsibilities relevant to each step.

6. **Ensure Adequate Capability for Risk Management Activities**
   a. **Provide some level of risk management training/guidance to risk management participants.** Organizing and training the risk management participants to follow a disciplined, repeatable process for managing risk is important, especially given the differing attitudes and tolerances most individuals will initially have toward risk. Experienced teams do not necessarily have to receive training for each implementation of project risk management, but a quick review of lessons learned from earlier assessments combined with achieving consensus on the risk tolerance and risk definitions to apply to the particular project can help avoid false starts (e.g., "high probability" and "high impact" should mean the same thing to all participants in the risk management process).
   b. **Identify any need for subject matter experts and plan accordingly.** The time of subject matter experts tends to be limited (and possibly costly if using external consultants). To efficiently make use of their time, the project team should already begin thinking during the planning stage about any need to bring internal or external subject matter experts into the risk management process and when it would be most beneficial to do so (e.g., during

Table 3.3. How much risk management to apply.

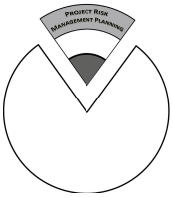
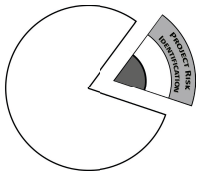
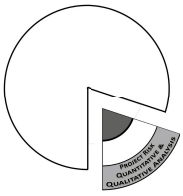
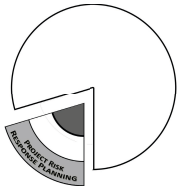
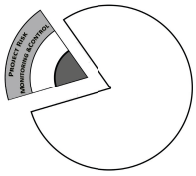
Step	Low Risk (Simple or Small-Scale Projects)	High Risk (Large, Critical, or Complex Projects)
Project Risk Management Planning 	Project manager establishes the general approach to risk management that the team will follow. May or may not result in a risk management plan	A formal, written risk management plan is developed and submitted to senior management for review and approval. At predetermined points and as necessary, plan is reviewed to determine if adjustments are necessary. **Tool**: Risk management plan
Project Risk Identification 	Conducted by the project manager with input from project team as necessary **Tool**: Risk checklist	Conducted during a facilitated risk workshop with internal and/or external subject matter experts **Tool**: Risk register
Project Risk Analysis 	Qualitatively assess risks to identify the most critical **Tool**: Probability and impact matrix worksheet	The team, working collaboratively with independent subject matter experts, reviews and/or validates cost and schedule estimates and identifies, characterizes, and analyzes risks. This process may involve both qualitative and quantitative tools to evaluate and prioritize risks and establish risk-based contingencies. **Tool**: Updated risk register (based on quantitative and/or qualitative analysis)
Project Risk Response Planning 	Brainstorming session **Tool**: Updated project plan Existing standard operating procedures	Perform cost–benefit analysis to determine the optimal response strategies **Tool**: Updated risk register
Project Risk Monitoring and Control 	Periodic status meetings as required, including discussion of progress and issues	Regularly monitor and record effectiveness of response strategies using the risk register Conduct formal after-action review workshop to identify lessons learned and best practices to apply to future project **Tool**: Risk register

Table 3.4. Typical project risk management roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Establishes the threshold for risk tolerance for the organization. • Establishes the level of rigor and discipline at which project risk management will be performed through the organization. • Establishes level of importance to the process.
Project Sponsor	• Establishes the threshold for risk tolerance on a given project and approves the risk management plan. • Validates scope, schedule, and budget reasonableness.
Project Manager	• Oversees the risk management process for the project and organizes all risk management planning sessions. • Clarifies the acceptable level of risks for the project in consultation with key stakeholders. • Finalizes and presents risk management plan to the project sponsor and/or other approving authorities. • Incorporates the resources and time required to implement the risk management plan into the project budget and schedule. • Regularly reports risk status to key stakeholders, offering recommendations for appropriate response actions to maintain acceptable risk exposure within established risk tolerance(s) of organization. • Monitors the efficiency and effectiveness of the risk management process. • Appoints risk owners for each identified risk. • Coordinates with risk owners to monitor risks and implementation of response strategies.
Project Team Members	• Participate in risk process, proactively identifying and managing risks in their areas of responsibility. • Participate in risk workshops and risk review meetings as required. • Provide input to project manager for risk reports. • Assist the project manager in developing and implementing the risk management plan.
Risk Owner	• Assumes responsibility for managing a specific identified risk. • Develops and implements responses to the risk. • Monitors risk status, including current likelihoods and impacts. • Reports progress to the project manager by updating the risk register as necessary.
Risk Analyst	• Defines appropriate tools and techniques for quantitative and/or qualitative risk analysis. • Conducts quantitative and/or qualitative risk analysis for identified risks. • Manages risk, opportunity, and response probability distributions based on outputs of risk identification, monitoring, and control. • Supports risk owner and project manager in development of risk response strategies.

risk identification or analysis). Consideration should also be given to how topics could be grouped or focused to ensure the appropriate experts are specifically reviewing those risks that would most benefit from their expertise and experience.

7. **Document Decisions in a Risk Management Plan.** For simple projects, the risk management planning step could simply entail the project manager establishing and communicating the general approach to risk management that the team will follow for a particular project.

   As projects increase in size and complexity, the project manager would likely develop a more formal plan in consultation with the project team, the project sponsor, and other key stakeholders. The results of the planning process should then be documented in a risk management plan. Formally documenting the results of the risk planning step will help:
   - Ensure the completeness of the plan with respect to the needs of a given project for risk management;
   - Provide a means to communicate the project's risk management approach and needs, thereby helping to ensure that risk management activities are incorporated into the project schedule, budget, and resource requirements;
   - Minimize the need for ad hoc decision making when implementing the other risk management steps;
   - Provide the rationale for why certain decisions were made;
   - Provide a structured road map that the project team can then use to implement the project risk management process for a particular project; and
   - Provide a baseline for assessments and updates as the project progresses.

3.1.2 Timing

Good planning provides the foundation for implementing an organized, comprehensive, and iterative approach to managing project risk.

To support project management efforts, the project risk management planning function should be performed as early as possible in the project life cycle to help identify risks and opportunities in time to incorporate any necessary response actions into final designs and to help refine schedule and budgets estimates.

Establishing a risk management approach during an initial planning step does not mean that this plan should remain fixed for the duration of the project. As the project progresses and new information becomes available (e.g., more or less risks materialize than originally thought), it may be beneficial to reevaluate the original plan for effectiveness and make adjustments as necessary.

3.1.3 Participants

For a given project, the project manager, with assistance from the project team as necessary, should develop the risk management plan and identify the resources required to perform the risk management activities.

The project manager may also wish to engage the project sponsor and other key stakeholders to obtain their buy-in and support for the plan. Although this guidebook recommends a standardized approach for performing risk management, the specific processes, tools, and resources used to manage risk on a particular project will vary. It is therefore important for management and stakeholders to understand and concur with the chosen approach.

Table 3.5 outlines the roles and responsibilities for the project risk management planning step.

Table 3.5. Project risk management planning roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Establishes the threshold for risk tolerance for the organization. • Establishes the level of rigor and discipline at which project risk management will be performed through the organization. • Establishes level of importance to the process.
Project Sponsor	• Establishes the threshold for risk tolerance on a given project and approves the risk management plan. • Validates scope, schedule, and budget reasonableness.
Project Manager	• Oversees the risk management process for the project and organizes all risk management planning sessions. • Clarifies the acceptable level of risks for the project in consultation with key stakeholders. • Finalizes and presents risk management plan to the project sponsor and/or other approving authorities. • Incorporates the resources and time required to implement the risk management plan into the project budget and schedule.
Project Team Members	• Assist the project manager in developing and implementing the risk management plan.
Risk Owner	None
Risk Analyst	None

3.2 Inputs

Risk planning should build on and be consistent with the overall project planning and development process. As such, key inputs that would inform the project risk management plan are project charters, scopes of work, and similar documents outlining project assumptions, goals, and constraints.

It may also be helpful for the project team to conduct an informal organizational and environmental scan to determine the airport's current sensitivity toward risk. Recent events (e.g., negative press, budget/schedule overruns, heightened political or public scrutiny) may play a role in shaping the risk tolerance for a particular project.

In addition to such project-specific information, historical data and lessons learned from past projects may also help establish the appropriate level of risk management to apply to a particular project.

3.3 Tools and Techniques

Risk management planning entails developing a structured and comprehensive approach for each step in the risk management process—from identifying and analyzing risks to developing risk response plans and monitoring risks as the project progresses.

Part 3 of this guidebook includes a sample risk management plan that can be used as a template to facilitate and guide the risk planning step and to capture the resulting decisions.

3.4 Outputs

Risk management planning should confirm or establish:

- The purpose and objective for performing project risk management,
- The risk threshold for the project,
- The role and responsibilities of the project team with regard to project risk management activities,
- The need for any outside technical assistance,
- The timeline for performing risk management activities,
- The depth of analysis required (e.g., qualitative versus quantitative risk analysis),
- The approach and tools to be used to assess and manage project risks, and
- Risk reporting and documentation requirements.

Such results are typically documented in a risk management plan that describes how the project risk management process will be structured and performed. The content of the plan will vary based on the complexity and size of the project, but typical content includes:

- A summary of the selected risk management approach that identifies the methodologies and tools that will be used,
- The roles and responsibilities of the people involved,
- Guidance for risk rating (e.g., high, medium, and low probability and impact) for use with the risk management tools,
- The schedule and agenda for risk management milestones and periodic risk reviews,
- Required formats for inputs and reporting, and
- Monitoring and tracking requirements.

The detail and time invested in developing a risk management plan should be balanced with the size and complexity of the project. For a small or relatively routine project, development of a formal plan may be unnecessary. For projects requiring more formal documentation, the risk management plan may serve as a repository of all decisions made if updated with the results from each step in the risk management process.

3.5 Best Practices

Best practices related to the success of risk management planning include the following:

- **Reach Consensus on Project Goals.** To design and scale a risk management process for a given project, participants in the risk management effort must share a mutual understanding of the project under evaluation. Achieving such a consensus requires, at a minimum, a defined project scope with established needs and goals. Therefore, early in the project development process, the project team, with input from other key stakeholders as necessary, should develop and refine a list of project goals, if not already articulated in a project charter or scoping document. As it is rarely possible to optimize quality, time, and cost goals on a single project, trade-offs may be necessary to ensure that the primary goal is achievable. Reaching a consensus on the relative importance of individual project goals early on will later help the project team make informed decisions regarding risk prioritization and the optimal mitigation strategies to increase the likelihood of achieving the primary project goal (e.g., enhanced quality), even if at the expense of secondary goals (e.g., cost).
- **Understand the Airport's Risk Tolerance.** Project risk exists within the overall context of the airport's organizational tolerance for risk. The project team must therefore have a clear

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understanding of this tolerance or appetite for risk to ensure that the appropriate management strategies are incorporated into the risk management plan to maintain risks at acceptable levels.

- **Achieve a Balance Between Cost (i.e., Level of Effort) and Benefit of Project Risk Management.** Project risk management is a scalable activity, and the approach and resource commitment should be tailored to the particular project's size, complexity, and criticality. Although it can be tempting to overdo risk management, applying unnecessary time and resources to risk management activities can be both wasteful and counterproductive to ensuring the project's budget and schedule objectives are met.
- **Pay Adequate Attention to Project Opportunities.** Risk management plans should not neglect project opportunities. Project uncertainty means that some things may go better than expected. In contrast to risk management, which seeks to understand what might threaten a project, opportunity management focuses on what might go better. Recognizing late in the project that a better alternative would have been available is generally of little use since it is typically too late at that point to take full advantage of the opportunity.
- **Engage the Project Team and Key Stakeholders.** For project risk management to be effective, it must have the support of the project team. Engaging these team members during the initial planning step will help ensure their buy-in and commitment to performing the subsequent risk management activities.

  In addition to the project team, key stakeholders also need to be engaged throughout the project's life cycle to ensure that the broadest view of potential risks and opportunities is obtained. By reaching out to stakeholders, industry, and subject matter experts, the project team can extract additional best practices, techniques, and information that may improve its implementation of project risk management.
- Define clear roles and responsibilities. Establishing and documenting roles and responsibilities during the planning step will help ensure that the appropriate resources are committed to the project.
- Ensure that project risk management resources are defined and that sufficient capacity exists.

See Exhibit 3.1 for a discussion of how organizations can scale project risk management.

3.6 Summary

Project risk management planning entails defining the approach, tools, and resources that will be used to perform project risk management over the course of the project. Careful and explicit planning sets the stage for and increases the likelihood of success of the subsequent project risk management steps described in Chapters 4 through 7.

Planning the activities to manage risk over the entire project life cycle helps to ensure that the degree of risk management is scalable to the project's size, complexity, and type, and is consistent with the airport's risk tolerance. It also enhances the probability that sufficient resources (staff, budget, time) for project risk management are incorporated into the project budget and schedule.

Exhibit 3.1. A Closer Look: How Organizations Can Scale Project Risk Management

To streamline the risk planning step and provide a consistent framework for all project teams to follow, some organizations have chosen to standardize their project risk management practices according to project size, complexity, or some other metric. For example, both the Port Authority of New York and New Jersey (PANYNJ) and the Washington State Department of Transportation (WSDOT) specify use of a specific risk management approach based on project size, as shown here.

Project Size ($ million)	**Required Process** (Project managers may use a higher-level process if desired.)
<$10	Risk assessment conducted by the project team using project management office–sponsored tools and templates.
$10 to $20	Informal workshop using interdepartmental resources and specialized software to conduct the risk analysis.
$20 to $100	Project risk assessment workshop using interdepartmental staff or external expert facilitation.
>$100	Project parameter validation workshop using external subject matter experts to validate base costs and schedule parameters and risk analysis process and results.

Source: PANYNJ, 2011

	Project Size ($ million)	**Risk Assessment Level**	**Notes**
Less Formal Risk Assessment	0 to 10	Project team risk assessment Project management online guide (PMOG) risk management plan Qualitative tool	The project team assesses each identified risk for its probability of occurrence and its impact on project objectives. Project teams may request assistance from subject matter experts or functional units to assess the risks in their respective fields. The self-modeling spreadsheet can be used for any project.
	10 to 25	Project team risk assessment self-modeling spreadsheet	
More Formal Risk Assessment	25 to 100	Cost estimate validation process (CEVP) workshop Quantitative tool	The team, working collaboratively with independent subject matter experts, reviews and/or validates cost and schedule estimating and identifies, characterizes, and analyzes risks. This is accomplished in a structured workshop setting. Modeling can be accomplished with off-the-shelf software or using the self-modeling spreadsheet.
	Over 100	CEVP workshop Quantitative tool	

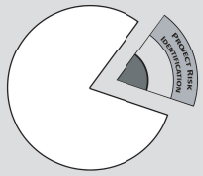
Source: WSDOT, 2010

Establishing such norms helps organizations institute a degree of consistency when implementing project risk management principles on a program-wide basis. However, care should be used when basing the risk management approach solely on project cost since smaller projects are often just as likely to experience scope creep, if not more so.

CHAPTER 4

Project Risk Identification

Project Risk Identification



Key Activities

- Gather available project information
- Identify and document all risks and opportunities that could affect project performance

Inputs

- Project scope and objectives
- Budget and cost estimates
- Schedule
- Designs and specifications
- Subject matter interviews
- Stakeholder input
- Lessons learned from past projects

Tools and Techniques

- Checklists
- Brainstorming
- Expert judgment

Outputs

- Risk checklist
- Risk register

What can affect our plans for this project?

This question captures the essence of risk identification.

As introduced in Chapter 1, three elements are needed to fully define risk:

- A future root cause, which, if eliminated or corrected, would prevent a potential consequence from occurring;
- The likelihood or probability of that event occurring; and
- The consequence or impact of that future occurrence.

Project risk identification—the process of identifying and documenting the uncertainties that could affect project performance—addresses the first component of risk and is the focus of this chapter. The subsequent step of project risk analysis—the evaluation of the identified risks in terms of their likelihood of occurrence and associated impacts—is discussed in Chapter 5.

4.1 Key Activities

4.1.1 Process Step Overview

Risk identification entails examining each project element to identify possible risk or opportunity events and their associated root causes, beginning their documentation, and setting the stage for subsequent analysis and response, if deemed necessary.

Risk identification generally consists of the following activities:

1. Determine who may have insight into project risks.
2. Gather available information on project assumptions and constraints (see inputs listed in Section 4.2) and circulate to those participating in the risk identification effort.
3. Review risk identification results from previous similar projects.
4. Determine which risk identification tools and techniques to use (see Section 4.3), if not already specified in the risk management plan.
5. Identify and document risks. (The general risk categories shown in Table 4.2 may provide a useful starting point to brainstorm project risks.)
   a. Review list to ensure that all known risks have been identified.
6. Proceed to risk analysis (see Chapter 5).

The exact tools and techniques used to support these steps could range from an informal brainstorming exercise to a more structured and facilitated work session in which project team members and independent subject matter experts are solicited for information and insight into potential project concerns. For a given project, the approach taken to identify

risks should represent a balance between project needs and the available resources and skills of the project team.

4.1.2 Timing

Project risk identification should begin as soon as project management planning has defined a sufficient structure for identifying risks. However, as with each step in the risk management process, it is important to perform risk identification continuously throughout the project life cycle. As the project proceeds through project planning and preliminary engineering to construction and possibly beyond to maintenance and operation, new risks may become known, or more refined information may become available that warrants revisiting the project's original risk profile. Remember, risk characteristics associated with each project phase differ (see Table 2.4), reflecting the refinement that generally occurs as project unknowns become known and designs reach completion.

As a project unfolds, new risks may emerge or uncertainties may be resolved. To address such changes over time, risk identification should be an iterative process that is conducted throughout the project life cycle.

4.1.3 Participants

The resources committed to the risk identification effort should be scaled to the project's size, complexity, and criticality to airport operations.

Risk identification is an iterative process that serves to capture any new risks that may emerge as the project progresses through its life cycle while dismissing previously identified risks that are resolved. The timing and frequency of these iterations and who participates in the identification process at each phase of a project's life cycle will vary from case to case.

On a routine project expected to present minimal risk, the project team may have sufficient expertise and knowledge to identify and manage risk.

For more complex projects or those touching on unfamiliar ground, participants in the risk identification effort may extend beyond the project team to include internal subject matter experts from design, construction, maintenance, operations, security, environmental groups, airlines, the FAA, the Transportation Security Administration (TSA), and other affected functional areas, key stakeholders, business partners, and outside experts.

Table 4.1 outlines the roles and responsibilities for the project risk identification step.

Table 4.1. Project risk identification roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• May participate in risk identification activities.
Project Sponsor	• May participate in risk identification activities.
Project Manager	• Validates the acceptable level of risks for the project in consultation with key stakeholders. • Appoints risk owners for each identified risk.
Project Team Members	• Participate in risk workshops. • Provide input to project manager for risk reports.
Risk Owner	• Assumes responsibility for managing a specific identified risk.
Risk Analyst	None

It can take substantial effort and organizational support to collect accurate data about project risk. Risks are therefore often identified based on the judgment and expertise of informed individuals.

4.2 Inputs

A key to successful risk identification is taking the time and resources to collect realistic and high-quality data about the project and the potential risks it may face. To inform the risk identification process, key inputs regarding project assumptions and constraints could include (to the extent available at the time of the risk identification):

- Project scope and objectives,
- Project budget/funding and cost estimates,
- Preliminary schedules (and updates as the project progresses),
- Designs and specifications,
- Subject matter interviews,
- Stakeholder input, and
- Regulatory requirements pertaining to the project.

In addition to such project-specific information, historical data from past projects can also serve as a rich source of information regarding potential risk events. Solid, factual data collected with discipline during earlier work generally yield the most useful historical information; however, such information is often difficult to access, especially if the organization does not maintain an extensive document and records management system.

Although written historical information, such as that found in lessons-learned reports and status reports from recent projects, tends to be more reliable and defensible (especially if the data are recent and relevant to the project at hand), informal information is often easier to capture. By discussing the project with colleagues or outside experts, the project team may gain insight into the possible risks facing its current project.

4.3 Tools and Techniques

Various techniques and tools can be used to elicit risks, the most common of which are described in the following. These techniques may be used alone or in combination, depending on the approach that is best for the team, the project's size and complexity, time and resource constraints, and the information available.

4.3.1 Information Gathering Techniques

Brainstorming Workshops. One of the most frequently used risk identification techniques is to hold brainstorming workshops to compile a comprehensive list of risks for subsequent evaluation during the analysis step described in Chapter 5.

Brainstorming can assume many forms, but it generally works as follows:

1. The project manager organizes a meeting with the project team, inviting other multidisciplinary experts and project stakeholders as deemed necessary.
2. Under the guidance of a qualified facilitator, participants work together to uncover potential events. Group members verbally identify risks, which provide the opportunity to build on each other's ideas. (A more structured brainstorming session, where each group member presents an idea in turn, may be used to ensure that feedback is obtained from all group members.)

   Early in the project development process, when relatively little information is available, the general risk factors and categories shown in Table 4.2 may provide a useful starting point to brainstorm project risks.

Table 4.2. Potential project risk categories.

	Technical	External	Organizational	Commercial
Risk Factors	Scope definition Requirements Design Quality Safety Security Complexity Interfaces Site conditions	Customer Political Public relations Market conditions Weather Environmental Property acquisition Permitting Regulatory changes Funds availability	Resources Dependencies Financial capacity Revenue impacts	Contractual terms and conditions Suppliers and vendors Procurement process Contractors Air service

3. The flow of ideas should proceed without comment, questions, or criticism, and without regard to the participants' status in the organization. Ideally, every participant should be heard from. Consideration should be given to risks that could arise out of internal changes as well as to outside factors such as natural disasters, market conditions, and government or regulatory change.
4. After all known risks are identified and posted for participants to examine during the meeting, the facilitator should attempt to categorize the identified risks into naturally related groupings to refine their definitions and eliminate duplication (see risk categories identified in Table 4.2).

For brainstorming workshops to be most effective:

- Relevant documents should be provided to the participants in advance to allow for some preparation.
- The facilitator should be familiar with the risk process and should identify some risks in advance.
- A note taker should be appointed to capture the ideas that are discussed.
- The meeting should be structured by project segment or risk category to ensure that no potential risks are overlooked. For more complex projects or situations, it may be desirable to hold multiple workshops, each focused on a specific risk category (e.g., geotechnical problems) with key subject matter experts participating.

Other common tools used to identify risks in brainstorming workshops are SWOT (strengths, weaknesses, opportunities, threats) analysis, affinity diagrams, and cause-and-effect maps.

Retrospective Analysis. Risks tend to recur on project after project unless something is done differently to avoid or mitigate the root cause(s). Data from earlier work, lessons learned, and close-out documents can therefore provide a rich source of risk information for the current project. A retrospective analysis of earlier projects performed either on its own or in conjunction with a brainstorming workshop can serve as a useful tool to identify risks and effective practices worth repeating and areas where improvement is possible.

Scenario Analysis. Additional risks may be discovered by considering the following questions while deliberately thinking through each step in the project timeline:

- What might go wrong here?
- What will keep me up at night during this portion of the work?
- Given the possible scenarios, are the current project assumptions correct?

When identifying risks, take care to avoid the following common biases that could influence results:

- Status quo—making choices that perpetuate the current situation.
- Confirming evidence bias—emphasizing information that reaffirms existing points of view while neglecting contradictory data.
- Anchoring—placing disproportionate weight to the first information given.
- Sunk cost—making decisions in a way to justify past choices.

Expert Consensus. This method, also known as the Delphi technique, is used to obtain the judgment of a panel of experts on a complex issue or topic such as project risk. It is a systematic method of data collection and structured discussion that aims to minimize bias and the influence any one person can have on an outcome. In brief, a Delphi analysis entails the following steps:

1. A facilitator develops and distributes a questionnaire to solicit ideas regarding perceived project risks.
2. The facilitator receives and processes the survey responses.
3. The risks identified in this first survey round are then circulated back to the experts for further comment and refinement.
4. The process is repeated until consensus is achieved on the main project risks (typically requiring two or three more survey rounds).

The iterative nature of this process has been found to yield more reliable results than a single survey round.

Interviews. Risks can also be identified by interviewing experienced project managers and subject matter experts. After being briefed on the project, the interviewees can be asked to identify risks based on their experience and knowledge. Interview results can be used to validate the results of earlier brainstorming or other information gathering techniques or as an input to these other methods.

Part 3 of this guidebook provides a sample checklist of common project risks.

Checklists. Risk checklists can provide useful guidance to help ensure that all major project risk areas are considered. Part 3 of this guidebook contains a sample risk checklist, but risk teams are encouraged to draw from their own historical project experience to develop lists that reflect the issues commonly encountered on their airport projects.

Checklists are most effective when used as a follow-up to a brainstorming session or other risk identification technique to ensure that all areas of concern have been covered. However, for a routine project expected to present minimal risk, reviewing and completing such a checklist might suffice.

Checklists are not exhaustive. Users should look beyond the risks identified in the checklist to ensure that all possible uncertainties are addressed.

When using checklists, bear in mind that not every risk included will necessarily be relevant and applicable to the current project or situation. Likewise, a standardized list may not capture all of the unique risks facing a specific project. Tapping into the experience of the project team and other stakeholders will generally always be necessary to identify the full spectrum of risks.

4.3.2 Root-Cause and Cause-and-Effect Analysis

When identifying risks, it is important to seek their root causes rather than stop at what could be merely symptoms of largely underlying problems. Project teams may therefore find root-cause analysis or cause-and-effect analysis to be useful for risk discovery and subsequent risk analysis and response planning. Some common root-cause and cause-and-effect analysis techniques include the following:

Failure Mode and Effects Analysis (FMEA). This technique provides a quantitative analysis that involves identifying a single risk event (failure mode) and the probabilities of the various impacts that may stem from that event.

Fishbone Diagram. This is a cause-and-effect analysis technique that generally entails stating an outcome the project intends to avoid (e.g., a delay or a significant increase in cost of some portion of the work), and then challenging the project team to work backward to uncover plausible sources that could cause the problem.

Five Whys. The Five Whys is a simple problem-solving technique designed to quickly uncover the root of a problem. Popularized in the 1970s by the Toyota Production System, the Five Whys strategy entails evaluating a problem by repeatedly asking: "Why?" and "What caused

this problem?" (The "five" in the name comes from the empirical observation that five iterations will generally resolve the problem.)

Mind Mapping. Mind mapping tools can be used to organize and document the output of a root-cause analysis exercise. A mind map is often created around a single word or text, placed in the center, to which associated ideas, words, and concepts are added. In project risk management, the single word would be the risk, and the possible inputs and influences would be the associated ideas.

4.4 Outputs

Once identified, risks should be documented to produce a non-overlapping, comprehensive list of all of the perceived risks to achieving the project's objectives.

4.4.1 Risk Checklist

For a simple project, checking off the relevant risks on a predefined list of common risks may be sufficient.

4.4.2 Risk Register

For more complex projects, use a risk register to begin capturing information regarding the perceived project risks and opportunities. A risk register provides a common, uniform structure for cataloging, tracking, and reporting the identified risks as the project progresses. The register, which may take the form of a spreadsheet or a table, incorporates key information regarding each risk to provide a cursory overview of what information is currently available regarding each identified risk.

Part 3 of this guidebook provides a template and completed example of a risk register.

The level of detail to include in the risk register can be driven both by project complexity and available resources. Table 4.3 identifies the typical content found in a risk register.

The risk register serves multiple purposes and will be returned to throughout the risk management process. At this stage (i.e., at the conclusion of the first iteration of the risk identification step), the register serves to warehouse all identified risks and to initiate the risk analysis step.

As shown in Table 4.3, the following information may be recorded in the register at the conclusion of project risk identification:

- Risk description,
- Risk owner, and
- Date identified.

The risk register should be reviewed and updated throughout the project and amended to include the results from subsequent risk management steps.

4.5 Best Practices

Regardless of the exact tools and techniques used, the risk identification process should generally conform to the following principles and best practices:

- **Understand Project Objectives, Constraints, and Assumptions.** To meaningfully and deliberately delve into the uncertainties facing a project, participants in the risk identification effort would benefit from having a shared understanding of the objectives and

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Table 4.3. Typical risk register content.

Heading	Description	Associated Risk Management Step
Risk or Opportunity Description	Description of the risk stated as full sentences, including both the cause and effect of the risk. For example, *"As a result of [cause], [risk] may occur, which would lead to [effect on project objective]."*	Risk identification
Risk Owner	The individual responsible for identifying and implementing any response strategies and tracking their outcomes, as well as regularly reporting on the current risk status.	Risk identification
Date Identified	The date the risk was identified.	Risk identification
Probability	The probability of the risk occurring, typically expressed in qualitative terms (e.g., high, medium, or low likelihood of occurring).	Risk analysis
Impact	The consequence of the risk to achieving project objectives, typically expressed in qualitative terms (e.g., high, medium, low impact).	Risk analysis
Risk Rating	The combination of probability and impact, used to support the prioritization of individual risks relative to others.	Risk analysis
Risk Response Strategy	Risk: mitigate, avoid, accept, transfer. Opportunity: accept, capitalize, enhance/grow, share, lose.	Risk response planning
Risk Response Description	Description of the risk response plan to document the response strategy that was selected.	Risk response planning
Cost to Respond	Estimated value of the cost to implement the chosen response strategy.	Risk response planning
Current Status	Updated information on actions taken.	Risk response planning
Monitoring and Control	Updated information on the risk (e.g., Were the risks addressed? Based on new information, should the ratings be revised? What are the residual risks, cost, and so forth?)	Monitoring and control

Ensure that the list of project risks is not only comprehensive but also non-overlapping and mutually exclusive. Overlapping risks could lead to double counting of risks.

constraints driving the project. Knowledge of the project context can help the project team focus on specific or unique sources of risks that may affect the project. For example, will political circumstances subject the project to heightened scrutiny or influence from external stakeholders?

- **Develop a Comprehensive List of Project Risks and Opportunities.** When initially identifying potential risks and opportunities, consideration should be given to all factors that could affect the project's needs and goals, regardless of how remote the possibility of their occurrence and how minimal their expected impact. Such inclusiveness with regard to risk identification will help ensure that all factors affecting project performance are identified. This list of risks can later be screened and refined during the analysis step to focus on the critical project

risks. Likewise, risks should not be excluded from the list on the basis that subsequent field investigations or design efforts will eliminate the potential event.

- **Consider Both Risks and Opportunities.** The risk identification effort should not focus exclusively on potential problems. Opportunities (i.e., uncertainties that could lead to positive consequences) identified early can enhance project performance.
- **Define Each Risk Completely and Unambiguously.** Risks should be clearly stated and fully defined so as to ensure a common understanding by all parties. A single word (e.g., *coordination*, *weather*) rarely provides sufficient information to fully communicate the exact nature of the risk. Instead, to the extent possible, a structured risk statement, similar to the following, should be used to define each risk:

  As a result of [cause, condition that is true], [risk] may occur, which would affect [effect on project objective].

  In this structure, the *cause* is a fact or condition, without which the risk might not exist. The *risk* is the resulting uncertainty. The *effect* is the impact on a project objective such as cost, time, scope, or quality. For example:

  As a result of limited site investigation, subsurface contaminants may be discovered during construction, which would affect both cost and schedule.

  It may also be useful to identify risk triggers—warning signs that suggest a risk is becoming a near-certain event requiring implementation of a response plan or contingency measure.

To convey the exact nature of a risk, the risk description should be defined in terms of both its cause and its effect:

As a result of [cause], [risk] may occur, which would affect [effect on project objective].

- **Do Not Confuse Risks with Issues.** If the problem event has already occurred, it is an *issue* that requires resolution, not a *risk* that may happen and that would benefit from proactive planning or action. Although issue management is a key project management activity, its focus is on applying resources to address and resolve current problems, whereas risk management applies resources to mitigate or avoid future potential problems or capitalize on opportunities before they can become or escalate into issues or crises.
- **Ensure That You Have the Right People Participating.** Participants should include project team members, subject matter experts, and stakeholders or customers of the project. To capture a wide variety of perspectives on potential risks and opportunities, the project team should consult with key stakeholders early in the identification process.
- **Assign Risk Owners.** Each risk should be assigned a single risk owner with clear responsibility and accountability for its management.
- **Limit Bias When Identifying Risks and Opportunities.** If participants in the risk identification effort have a vested interest in advancing (or terminating) the project or have some other conflict of interest, it could compromise the results of the risk identification exercise. To help mitigate such bias (whether conscious or not), consider using a qualified facilitator or project-independent subject matter experts to elicit risks.

4.6 Summary

Risk identification is a vital component of the overall risk management process that involves identifying, categorizing, and documenting the risks and opportunities that could significantly affect project performance. Risk identification begins as early as possible and continues throughout the project with regular review and analysis.

Risk identification is a scalable activity, and the approach and resource commitment applied should align with the complexity of the project and the information available. The identification process could range from a quick checklist activity to a more structured and facilitated work

Table 4.4. Scaling the risk identification step.

Simple or Small-Scale Projects	Large, Critical, or Complex Projects
Use a risk checklist to identify and document possible risks	Conduct a structured risk management workshop with internal and/or external subject matter experts and independent expert facilitation
Conduct an informal team meeting if necessary	Compare the risks identified in the workshop to a risk checklist to ensure that all possible areas of concern have been covered
Document the identified risks in the risk checklist	Document the identified risks in a risk register
Use or expand existing standard operating procedures	

session in which project team members and independent subject matter experts are solicited for information and concerns. Table 4.4 suggests how the tools and techniques discussed in this chapter can be tailored based on the perceived risk level of the project.

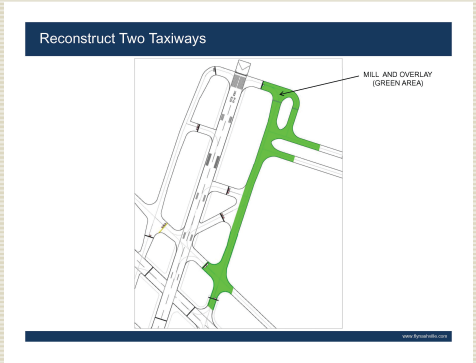
See the following excerpt from the case study on taxiway reconstruction for an illustration of the risk management process. The full case study is presented in Appendix A.

Case Study: Taxiway Reconstruction

This case study will be used later in this guidebook to illustrate the various steps of the risk management process. The complete case study is presented in Appendix A.

Project Overview

A medium-hub airport was preparing to conduct the taxiway reconstruction as defined in the airport's master plan.



The project was scheduled to begin design in June, with construction expected to begin 6 months later. The reconstruction project was scheduled in alignment with FAA funding schedules in anticipation of receiving funds in time to begin and conduct construction.

The taxiway project was originally scoped for 4,000 ft of asphalt pavement, with an estimated $6 million budget funded by the FAA and airport passenger facility charges in a 75/25 percent ratio.

The funding for this project was fixed, so scope and schedule were the areas that were affected by the risks and mitigations of this project.

The project was being managed by an internal airport project manager, consultants for design, construction by contractors, and inspections by consultant staff.

For the scope of this project, the design–bid–build construction process was selected.

The project risk management process was included in the project management of the project. Many risks were realized through the project duration and will be highlighted at each phase throughout this example.

Case Study: Taxiway Reconstruction – Project Risk Identification

Background of Airport

The airport was managing multiple construction projects at the same time using a combination of internal and contract staff. The airport operates two runways and receives funding based on medium-hub status. Operations are primarily origination and destination traffic.

The airfield does not operate at full capacity; however, all maintenance downtime must be carefully scheduled to avoid any air traffic delays.

The airport typically outsources construction design to experts outside of the airport staff. The internal procurement process works in accordance to federal regulations.

Risk Identification Step

The project team performed the identification of risks in a risk workshop using an outside facilitator to conduct the session. The entire internal project team was present, along with the contracted resources that would be performing project work.

Risks and opportunities identified through this workshop were captured in a risk register. Each risk was assigned an owner who would take responsibility for the risk analysis and response plan and would provide monitoring and control reviews.

The risk workshop took approximately 4 hours to complete and also included the risk analysis process. The identification of risks took less than 1 hour to generate the list.

Risk Register

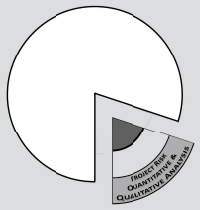
Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways Will require descoping because budget is fixed Circular #?
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	Mitigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects results in schedule delays	Sue Johnson	10/27/2012	4	4	16	Mitigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	Mitigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delays schedule and impacts budget	John Norman	10/27/2012	1	4	4	Mitigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	Avoid	Training Barriers Markings	$100,000	Training completed on 11/30	

CHAPTER 5

Project Risk Analysis

Project Risk Analysis



Key Activities

- Evaluate risks (and opportunities) in terms of their likelihood of occurrence and potential impact
- Prioritize major risks for response planning
- Establish risk-based cost and schedule contingencies (quantitative techniques)

Inputs

- List of possible risk events
- Historical data

Tools and Techniques

Qualitative:

- Probability and impact matrix

Quantitative:

- Modeling and simulation

Outputs

- Prioritized ranking of critical risks
- Results of quantitative analysis

The goal of the project risk analysis step, as discussed in this chapter, is to characterize and prioritize the previously identified risks by determining:

- How likely is the risk or opportunity?
- How big is the risk or opportunity (e.g., impact)?
- What is the risk to (e.g., schedule, capital cost, maintenance cost, or other project goals)?
- Who assumes the risk (e.g., the airport, contractor, or other stakeholder)?

By providing answers to such questions, it is possible to classify risks based on their criticality to project success and importance to key stakeholders. Prioritizing risks in this manner can support subsequent decision making and aid in the risk response planning efforts described in Chapter 6.

5.1 Key Activities

5.1.1 Process Step Overview

The objective of risk analysis is to evaluate risk events in terms of the probability of their occurrence and their impacts (consequences) on cost, schedule, or other project performance objectives.

This process could range from rigorous statistical methods to more subjective and qualitative methods for prioritizing risks based on the combined effect of their probability and impact. The selected method will ultimately involve a trade-off between sophistication (and hence, defensibility) and the method's ease of use.

Regardless of the method used, the project risk analysis process step generally consists of the following activities:

1. Gather any additional information needed to evaluate or analyze risks.
2. Determine which risk analysis tools and techniques (see Section 5.3) to use, if not already specified in the risk management plan.
3. Evaluate and prioritize risks using the selected methodology.
4. Determine if further evaluation would be beneficial (e.g., if a quantitative analysis should be performed).
5. Document results and proceed to risk response planning (see Chapter 6).

5.1.2 Timing

Risk analysis is performed sequentially after the risk identification step. In practice, however, the distinction between risk identification and risk analysis is often blurred, with some risk analysis preceding or concurrent with the identification step. For example, in the process of

Table 5.1. Project risk analysis roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Reviews analysis results; provides guidance if necessary.
Project Sponsor	• Reviews analysis results; provides guidance if necessary.
Project Manager	• Oversees the completion and reviews the results of appropriate risk analysis activities as determined by the project risk management plan.
Project Team Members	• Participate in risk analysis activities. • Provide input to project manager for risk reports.
Risk Owner	• Assumes responsibility for managing a specific identified risk.
Risk Analyst	• Defines appropriate tools and techniques for quantitative risk analysis. • Conducts quantitative risk analysis for identified risks.

gaining input from experts, it may make sense to continue beyond the mere identification of risks to the probability of them occurring, their consequences, and, possibly, ways to respond to them. These latter actions are more formally part of the risk analysis and risk response planning steps but often begin during risk identification.

Risk analysis results represent a snapshot in the project's life cycle and may change significantly as the project progresses and more information becomes available. As with the iterative nature of all steps in the project risk management process, risk analyses should be revisited periodically to ensure that the assessment remains current and valid.

5.1.3 Participants

The project team may have sufficient expertise and knowledge to provide the risk data needed to support the analysis. However, it may be desirable to seek input from internal and external subject matter experts, particularly if relevant historical data are limited, requiring increased reliance on expert judgment.

If a quantitative analysis is to be performed, it may also be beneficial to use qualified probabilistic modelers who are well versed in statistical analysis techniques to perform simulations.

Table 5.1 outlines the roles and responsibilities of the project risk analysis step.

5.2 Inputs

Risk analysis generally begins with a detailed study of the risks that have been identified previously and (ideally) documented in a risk register or checklist.

Additional information should then be gathered as necessary to determine the root cause(s) (if not already determined during the risk identification step), likelihood, and consequence or impact of each risk. Two primary sources of data to support this analysis are interviews with subject matter experts and comparisons with similar projects.

Particularly if a quantitative risk analysis is being performed, it is also important to have a defined base project against which the risks can be measured. The base project conditions should

exclude any built-in conservatism (e.g., cost or schedule contingencies) intended to cover uncertainty. Such contingencies will instead be established through the analysis process described in Section 5.3.2.

5.3 Tools and Techniques

As discussed previously, risk analysis involves evaluating risks (or opportunities) by considering the likelihood of their occurrence and their potential impact on cost, schedule, or other key project goals.

Approaches used to analyze risks are commonly classified as being either qualitative or quantitative in nature. Each approach has its own perceived advantages and disadvantages (summarized in Table 5.2) that should be considered when selecting the optimal or practical approach to use for a particular project or project element.

5.3.1 Qualitative Risk Analysis

Qualitative risk analysis entails prioritizing risks for further analysis or response planning on the basis of a subjective assessment of their probability (likelihood or frequency) and impact (consequence or severity).

Qualitative analysis is often used:

- As an initial screening or review of project risks,
- When a quick assessment is desired, and
- As the preferred approach for simpler and smaller projects where more rigorous quantitative analysis is not necessary or practical.

Table 5.2. Comparison of qualitative and quantitative techniques.

Technique	Objectives	Advantages	Disadvantages
Qualitative	• Subjectively evaluate the probability and impact of each risk • Prioritize risks for risk response planning or for additional analysis using quantitative techniques • Validate the risk management plan for risk analysis	• Relatively quick and simple to perform • User-friendly, particularly for those less skilled in probability and statistics • Indicator of need for further quantitative analysis	• Ratings can be ambiguous and difficult to defend. • Ratings can be misperceived due to lack of consistency of those providing input.
Quantitative	• Numerically analyze the effect of identified risks on overall project objectives • Determine which activities or elements contribute the most to project objectives • Reduce the uncertainty in the project input variables	• Less ambiguity in values • Probability and impacts can be analytically combined in a rigorous manner • Risk-based contingencies can be defined • Reduced uncertainty in the output variables	• Development of models and running of simulations can be time consuming and may require external expert assistance.

Probability			
Likely	Low	Medium	High
Moderate	Low	Medium	Medium
Unlikely	Low	Low	Low
	Low	*Medium*	*High*
	Impact on Selected Objective		

Figure 5.1. Example P-I matrix (3 × 3).

Part 3 provides a sample worksheet to use for performing qualitative risk analysis with a P-I matrix.

To estimate probabilities and impacts, project teams may find it beneficial to review historical data from past projects. More often than not, availability of historical data is limited. Values are therefore often based on the experience and judgment of team members and other subject matter experts, as obtained by conducting risk analysis workshops, interviews, or surveys.

Once probability and impact values are estimated, they are typically combined in some manner so as to assign a rating to each risk.

Although in and of itself the numerical value holds little meaning, the ranking has a meaningful purpose—providing a simple, albeit subjective, way to rank risks relative to one another based on the perceived threat they pose to the project success criteria.

Probability–Impact (P-I) Matrix. One of the most commonly used tools to qualitatively rate risks is a P-I matrix, an example of which is shown in Figure 5.1.

As shown in the figure, a typical P-I matrix has probability ratings on the *y*-axis and impact ratings on the *x*-axis. The plotted position of these two measures in the matrix reflects the combined effect of the risk's likelihood of occurrence and the estimated severity of its unmitigated effect on the project if it were to occur.

It is important to note that those estimating the probability and impact ratings may have biases to assess with overconfidence or under confidence. Calibration techniques exist for improving skill in assessing uncertainty.

To develop and use such a tool requires performing the following steps:

1. **Establish Probability Scale.** For each risk event identified, the likelihood or probability that the risk will happen must be determined. Typically, the project team will arrive at this assessment, in consultation with any subject matter experts deemed necessary, in a workshop setting. For such a process to be effective, all participants must share a common understanding of the probability of occurrence (e.g., "high probability" should mean the same thing to all participants).

   If not already specified within the risk management plan, the project team should first define the probability scale to use in the P-I matrix. Establishing this range up front lends structure to the analysis exercise and ensures that all participants are viewing likelihood in a consistent manner.

   Clearly, the likelihood or probability of any specific risk event occurring will fall somewhere between 0% (i.e., no chance of occurrence) to 100% (foregone conclusion). For a very simple project, this could mean dividing the probability scale into just two ranges:

   - More likely than not to occur (50% to 100%), and
   - Less likely than not (0% to 49%).

It should be noted that the risk score itself is an arbitrary value. It should be used as a simple way to prioritize efforts based on perceived impact to the project success criteria.

Although the rating system shown in Table 5.3 reflects the impact of risk in terms of threats (or negative consequences), a similar system could be established for opportunities by describing the impact in terms of schedule or quality *improvements* and cost *reductions.*

Table 5.3. Example levels of probability criteria.

Level	Likelihood	Probability of Occurrence
5	Near certain	~90%
4	Highly probable	~70%
3	Probable	~50%
2	Low probability	~30%
1	Not probable	~10%

Although most project teams can quickly reach consensus on one of these choices, finer granularity is often needed to prioritize risk. For this reason, three ranges, as shown in Figure 5.1, or five ranges, as shown in Table 5.3, are more commonly used.

2. **Establish Impact Scales.** For each risk identified, in addition to estimating its probability of occurrence, the project team must rate the magnitude of its impact should it occur.

   As with estimating probabilities, all participants must share a common understanding of what impact is for the process to be effective. Therefore, if not already specified within the risk management plan, the project team should first define the impact ranges to use in the P-I matrix, bearing in mind that a risk event can have an impact on a project in multiple ways. (In other words, what is the impact to cost, schedule, and quality?) For example, the risk of encountering differing site conditions could result in schedule delays and cost overruns. Impacts should be considered separately for each major project objective (e.g., cost, time, scope, quality).

   Figure 5.2 provides an example of the scales used to assign probability and impact values on a scale of one to five. Five levels of values are shown, ranging from very low to very high, but three levels (low, medium, high) are often used. Project teams should select the range that allows them to best differentiate the probability and impact values on identified risks.

For each risk, the probability of occurrence will remain the same for each project objective analysed. However, the risk could have an impact on multiple project objectives. For each risk, the output of this step is therefore a single probability and the impacts to the project that could result from that risk.

3. **Estimate Probability and Impact.** Once the rating scales have been established, the next step is to assess each risk on the basis of:

   - Its probability of occurring, using the probability ranking scale established for the project (which using Figure 5.2, would range from 1 to 5), and

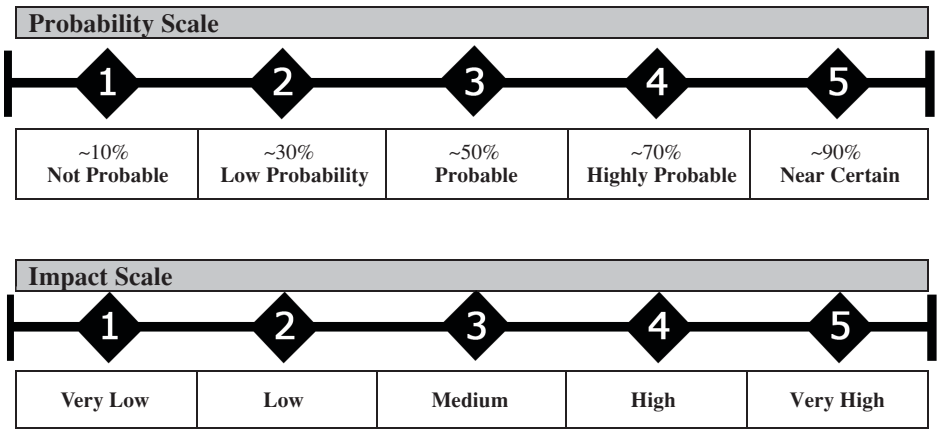


Figure 5.2. Example impact and probability scales.

- Its impact of occurring, using the impact ranking scale established for the project (which using Figure 5.2, would range from 1 to 5).

Impact is rated separately for each objective (e.g., cost, schedule, quality). Therefore, for each risk, the output of this step is a probability and the impacts to the project that could result from that risk.

4. **Plot Risk on P-I Matrix.** The probabilities and impacts obtained from Step 3 can now be plotted on the P-I matrix established for the project. The matrix helps determine whether a risk with a certain combination of probability and impact is of high, moderate, or low priority, in order to rank them.

   Figure 5.3 provides an example P-I matrix, which incorporates the probability and impact rating scales.

   In the example matrix shown in Figure 5.3, the risk is plotted into an intersecting box that represents the value assigned for the probability of that risk (*y*-axis) and the value assigned for the impact of the risk (*x*-axis). The box where the two values intersect is the point where the risk is plotted.

   This matrix is then used to prioritize risks for further management using a pre-established scale that translates the risk score (probability × impact) into a risk rank (low, moderate, high risk) similar to that shown in Figure 5.4. This ranking can be completed using the organization's risk tolerance and risk threshold information. The ranges may change slightly by project.
5. **Rank Risks and Update Risk Register.** Once the risk score and ranking have been determined for each risk, this information can be used to update the risk register to support the prioritization by which the risks should be managed or further analyzed using more rigorous techniques.
6. **Review Rankings for Reasonableness.** The key advantage to the P-I matrix is its user-friendliness. However, its application is limited to subjective prioritization of risks. The method also does not account for other possible risk prioritization criteria such as the imminence and ability to detect risks. For this reason, the project team should carefully review the resulting risk rankings for reasonableness prior to proceeding to the response planning step. The project team must determine if the results of the qualitative analysis indicate the need for further quantitative analysis or a recalibration of the rating scales.

See the office build-out case study in this chapter (and in Appendix B) for an example of the use of risk analysis.

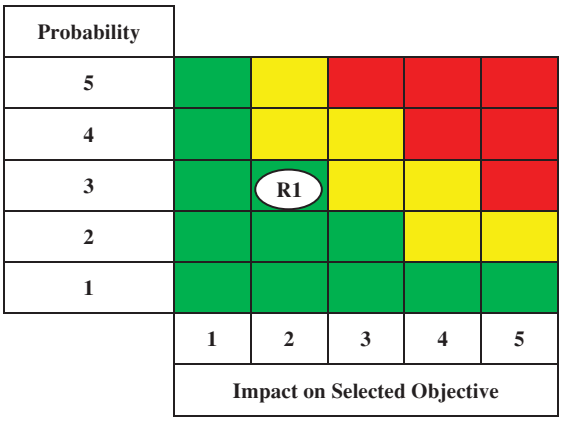


Figure 5.3. Example P-I matrix (5 × 5).

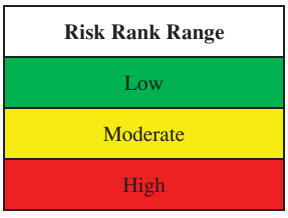


Figure 5.4. Risk range categories.

Note that the mathematical combination of the probability and impact ratings does not in and of itself convey meaning. It is merely used to prioritize risks on the basis of their relative threat levels. The project team should carefully review the resulting risk rankings for reasonableness prior to proceeding to the response planning step.

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Case Study: Office Build-Out

The TSA recently mandated a change to the passenger screening process. In order to accommodate this mandate, a small-hub airport needed to perform an internal build-out to reconstruct the physical space where staff are located in order to create the required space. This small-hub airport services commercial air traffic and has 52 employees and a $30 million operating budget.

The internal build-out is determined to be an operating project using internal maintenance staff. The changes require minor demolition to existing walls and build-out of two offices with access to the passenger concourse. Scope includes replacement of ceiling tiles; flooring; walls; power; and data; and heating, ventilation, and air conditioning (HVAC) adjustments. The area affected is approximately 400 square feet.

The maintenance operating budget is $8 million, and this project is one of many in the course of the year that will be performed to maintain functional operations for the staff at the airport. A project of this scope should not exceed $12,000 in material costs and should not involve more than 3 weeks of construction time. The work effort is approximately two full-time resources for the 3 weeks, although the resources will be different talent and expertise over the duration of the project.

Internal resources used include maintenance manager, superintendent, electrician, and HVAC, carpentry, and general maintenance staff. The maintenance manager assumed the role of project manager for this project.

The project constraints for this office build-out are determined as schedule and budget.

The maintenance manager determined that the project was relatively low risk based on the experience of the resources assigned to the project and the scope identified for the build-out. He decided to use a probability-impact matrix with the project team to identify and rank the risks. The maintenance manager conducted a project kickoff session in which the team brainstormed a list of risks and then ranked and prioritized the risks using the probability-impact matrix in order to determine if more project risk management might be needed.

The project kickoff session included the team of internal resources used to perform the project activities. During the discussion, the maintenance manager described the scope of the project, and the whole group reflected on past experiences with the customer as well as the type of work to identify preventative risks and reactive impacts.

The following risks were identified:

- Customer slow in making decisions about design, which affects schedule.
- Competing priorities for project work team will affect schedule and budget.
- Unforeseen conditions found in demolition affect scope and may cause redesign.
- Need for permits to perform construction activities may affect schedule.
- Long lead time for selected materials causes delay in start of project.

The following probability and impact scores were applied:

#	Risk Description Summary	Probability Value	Impact Value
1	Customer slow in making decisions about design, which affects schedule.	4	4
2	Competing priorities for project work team will affect schedule and budget.	4	2
3	Unforeseen conditions found in demolition affect scope and may cause redesign.	2	4
4	Need for permits to perform construction activities may affect schedule.	2	1
5	Long lead time for selected materials causes delay in start of project.	1	2

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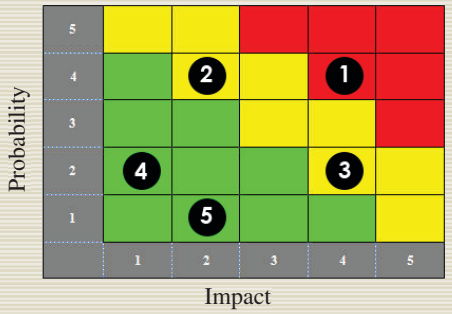
Case Study: Office Build-Out (Continued)

The following probability and impact scores were applied, and discussion was held to analyze the overall results. The risks were plotted with their corresponding number from the list.



The results of the discussion determined that all of the risks identified could be controlled by managing the schedule of the project very closely. The team decided to plan a schedule with realistic timelines and contingency days included. The maintenance manager also determined that clear communication was needed with the stakeholders of the project to discuss the schedule, the realistic timelines, and the risks associated with the project in order to increase awareness up front. The maintenance manager committed to a meeting with stakeholders and to holding regular progress meetings with the team as a result of this risk review. With these activities and commitments determined, no additional project risk management was determined to be necessary at this point.

5.3.2 Quantitative Risk Analysis

Project teams often have difficulty accurately predicting the ultimate cost and schedule of a project. This is particularly true early in the project development phase, when information on project conditions is limited, yet decision makers are seeking answers to key questions, such as:

- Which project alternative is best?
- How likely is the project to come in on budget?
- Can the project be completed within the time frame allowed?

The traditional practice of computing cost or schedule estimates on the basis of single data points, representing the cost or duration of each project activity, is often inadequate for providing defensible answers to such questions. At best, such deterministic estimating techniques can provide an indication of the best-case, expected-case, and worst-case project scenarios. However, the resulting point estimates often suggest a level of precision that is unwarranted given the uncertainty associated with the input data. To address unknowns, a contingency value is frequently added on top of the estimate to provide some degree of conservatism. The contingency value is typically calculated as a percentage of the total estimate on the basis of expert judgment, organizational policy, and/or historical experience.

Although this practice can be used to produce conservative estimates, it can also yield misleading results if several risks can *simultaneously* affect the project. To produce better estimates, some organizations have begun to use quantitative risk analysis techniques to more transparently and accurately account for uncertainty and allow for better, more informed decision making.

Unlike the qualitative techniques discussed in Section 5.3.1, which just allow you to prioritize risks, quantitative methods allow you to answer such questions as:

- What are the odds that this project will meet its cost or schedule targets?
- How much of a contingency reserve should be set aside?

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Table 5.4. Traditional versus risk-based estimating techniques.

Traditional	Risk Based
Inputs and outputs are single values.	Inputs and outputs are probability distributions.
Risk and uncertainty are addressed by adding generic padding to estimates.	Risk and uncertainty are explicitly and quantitatively evaluated.
Risk management is ad hoc.	Risk management is formalized and transparent.
Cost and schedule risk are unknown.	Cost and schedule risk are explicitly evaluated, documented, and monitored.

Note: adapted from Sangrey et al., 2003.

Quantitative analysis techniques, as discussed further in the following, generally involve the use of advanced statistical methods to determine, with a certain degree of confidence, whether the project will meet its cost or schedule targets given the combined effect of the identified project risks. As summarized in Table 5.4, instead of point estimates, a quantitative analysis takes a range of input values and generates a probability density function that describes all possible outcomes of an uncertain situation in terms of their likelihood of occurrence.

The information resulting from a risk-based analysis would allow a project manager to communicate, for example, that there is only a 60% chance that a project would reach completion within the desired time frame, the range of the expected completion time frame, and that providing greater certainty regarding the project's completion date would require allocating resources to mitigate key risk drivers. Such detail would provide decision makers and other project stakeholders with a much more nuanced understanding of the true nature of the project risk on which to base subsequent decisions.

Probabilistic Modeling. One of the most widely accepted quantitative analysis techniques is probabilistic modeling, a computer-driven methodology of simultaneously evaluating the impact of all identified risks to arrive at a defined probability distribution of the project's cost, completion date, or other key project input or objective. The overall process is depicted in Figure 5.5.

Probabilistic modeling generally requires use of specialized risk analysis software packages and possibly outside risk analysts if such expertise is unavailable in-house. However, the associated investment of time and resources can be warranted if:

- Enough information is known about the risks to perform the analysis (i.e., the analysis is only as good as the input values),

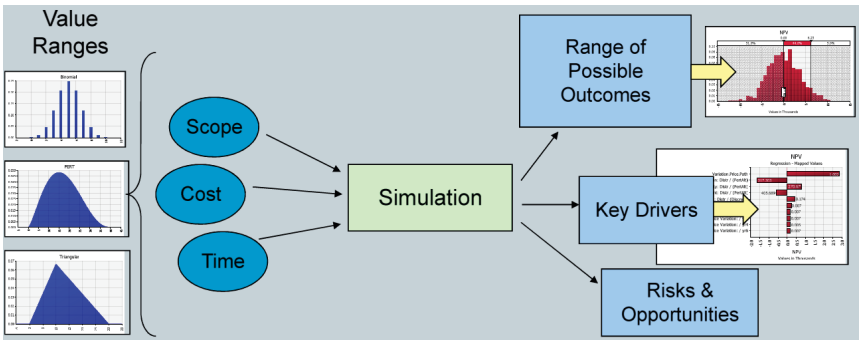

Figure 5.5. Simulation inputs and outputs.

- The project is highly complex or critical, or
- Given project conditions and constraints, there is little flexibility or tolerance for cost or schedule overruns.

The general steps involved with probabilistic modeling are described in the following to provide an indication of both the power of this technique and the level of effort involved. Figures to illustrate the specific how-to procedures related to performing probabilistic modeling risk analysis can be found in Appendix C.

1. **Define the Desired Output from the Analysis.** At the outset, the project team should identify the goals of the analysis, bearing in mind that the question to be answered must be well-suited to mathematical modeling for the simulation to be effective. Cost, schedule, and integrated cost/schedule models have been widely used by several organizations, including the Port Authority of New York and New Jersey, the Federal Transit Administration, and various state departments of transportation across the United States, to develop risk-based project contingencies, refine project plans, and prioritize and define optimum risk response plans.
2. **Validate the Project Scope, Cost, and Schedule.** Before the effects of risk can be evaluated, the project team must have a clear understanding of the project's base scope, cost, and schedule. If an objective of the quantitative analysis is to develop a transparent, risk-based contingency plan, the cost and schedule must be carefully reviewed to ensure that no excess reserves remain hidden in the cost or schedule.
3. **Prioritize the Identified Risks.** Referring to the risk register developed during the risk identification step, the main risks and uncertainties that could threaten or enhance project success are identified. Qualitative techniques may be used to support this activity.
4. **Build a Base Model.** Quantitative risk analysis starts with the model of the project, such as its schedule or cost estimate, depending on the problem to be addressed. As most of the commercially available risk analysis software packages act as plug-ins to programs such as Microsoft Excel, it is often best to prepare the model using a spreadsheet.
5. **Define Input Distributions.** Inputs into the schedule or cost models are represented by probability distributions, recognizing that the actual cost or duration of each item is more accurately represented by a range of values rather than a single point estimate. The selection of the most appropriate distribution for a given situation is best done with the assistance of a skilled risk analyst with knowledge of the project environment.

   For each project cost or schedule element, the probability distributions are usually specified in terms of three points: the minimum, most likely, and maximum values. These values are often identified in a workshop setting with input provided by subject matter experts.
6. **Run the Simulation.** A number of commercially available software packages are available to perform the actual simulation process that automates the process of iterating the project schedule and cost estimate computations, randomly drawing duration or cost values for each iteration from the probability distribution inputs. The details of how these tools work are outside the scope of this guidebook.

   The resulting output of the simulation is a probability distribution function of possible project outputs (e.g., completion dates, project costs) and their likelihood of occurrence.
7. **Explore Results Using Sensitivity Analysis.** The risk model can also be used to determine which tasks are most responsible for affecting project output (e.g., driving up costs, increasing the overall project schedule) or otherwise positively or negatively affecting project objectives.

   Identifying the main risk drivers in this manner allows the project team to effectively target its proactive risk response strategies toward the most critical variables.

For more information on developing probabilistic modeling for cost and schedule, refer to Appendix C, which includes diagrams and figures to support the steps outlined in this section.

Quantitative risk analysis techniques are generally perceived as providing greater precision and analytical rigor than qualitative methods. However, the accuracy of a quantitative analysis is still limited by the quality and nature of the input data and the applicability of the model.

Computer software greatly simplifies the analysis process for skilled risk practitioners. However, for users with less practice and experience, such tools can create false confidence, leading to misinterpretation or over-reliance on model output. Quantitative tools should therefore never be used as a replacement for personal judgment.

Other common tools used to analyze risks include failure mode and effects analysis, risk bow tie, and decision analysis. These tools are described in the following.

Failure Mode and Effects Analysis. This tool was introduced in the risk identification step as a way to conduct root-cause analysis to identify risks associated with a project. FMEA is also commonly used to qualitatively analyze risks. In addition to evaluating risk events based on probability and impact (as was the case with the P-I matrix technique discussed previously), FMEA adds the dimension of risk detectability (i.e., how likely you are to know if the potential risk event has occurred or is imminent) as a third analysis parameter. The product of these three parameters (impact, probability, and detection) is then used to prioritize risks.

Risk Bow Tie. A risk bow tie is a diagram that visualizes the risk being dealt with in one easy-to-understand picture. The diagram is shaped like a bow tie, creating a clear differentiation between proactive and reactive risk management. The power of a bow-tie diagram is that it gives an overview of multiple plausible scenarios in a single picture. It provides a simple, visual explanation of a risk that would be much more difficult to explain otherwise.

Decision Analysis. The decision analysis method identifies and formally assesses important aspects of a risk for prescribing a recommended course of action. The method uses prescribed steps to take a project team through the process of making a decision. The RACI (responsible, accountable, consulted, and informed) matrix helps identify and define the various roles in the decision-making process.

5.4 Outputs

Two general approaches have been discussed in this chapter for assessing project risks: qualitative and quantitative analysis. The objectives, and the hence the output, of each technique differ, as summarized in Table 5.5. Regardless of the analytical approach used, the results should be recorded in the risk register.

Table 5.5. Risk analysis output.

Technique	Objectives	Typical Output
Qualitative	• Subjectively evaluate the probability and impact of each risk. • Prioritize risks for risk response planning or for additional analysis using quantitative techniques.	• Prioritized listing of risk, as recorded in a risk register.
Quantitative	• Numerically analyze the effect of identified risks on overall project objectives. • Determine which activities or elements contribute the most project objectives.	• Numerical analysis of the project's likelihood of achieving its overall objectives. Possible deliverables include: – Cost and/or schedule curves showing the relative likelihood of meeting targets, – Tornado diagrams identifying the key risk drivers, and – Contingency recommendations.

5.5 Best Practices

The risk analysis effort should generally conform to the following principles and best practices:

- **Collect High-Quality Input Data and Recognize Bias.** To ensure useful output is generated from the risk analysis step, it is important to start with accurate and unbiased data. Just as with the identification step, data gathered from individuals during the analysis step are subject to bias. To help mitigate such bias (whether conscious or not), consider using a qualified facilitator or project-independent subject matter experts to manage the analysis process.

  The quality of the data can also drive the analysis approach. For example, with minimal or highly subjective information, performing a quantitative analysis may not be practical or may suggest a level of precision that is not warranted from the input data.
- **Establish a Standard Format for Evaluating and Reporting Risks.** Instructing participants to follow a disciplined, consistent process for analyzing risk is important, especially given the differing attitudes and tolerances individuals may bring to the analysis step. Defining up front the risk definitions to apply to the particular project can help avoid false starts (e.g., "high probability" and "high impact" should mean the same thing to all participants in the risk management process).
- **Calibrate Participants Involved in Analyzing Risks.** Calibrating the participants will reduce overconfidence and under confidence biases in estimating risk probability and impact. Calibration is the process of setting everyone to a common starting point. Determine what the values in the probability and impact matrix mean to the group so that the process begins with equal values.
- **Engage Stakeholders.** Increased collaboration and communication between project team members and key stakeholders can enhance the assessment of key risks and opportunities.
- **Modeling Is Beneficial to Understanding the Risks Resulting from Phasing Scenarios of a Large, Complex Project.** Use modeling analysis techniques in order to determine critical paths for projects and additional clarity in understanding the uncertainty of project risks. Resulting tornado charts will visually provide scaled results from highest to lowest degrees of risk influence.
- **Review Results for Reasonableness.** All risk analysis techniques are subject to some limitations. For this reason, the project team should carefully review the results for reasonableness prior to proceeding to the response planning step. In addition, when quantitative methods are used, the team should recognize that while computer software can greatly simplify the analysis process for skilled risk practitioners, for those users with less practice and experience, such tools can create false confidence, leading to misinterpretation of model output. Quantitative tools should therefore never be used as a replacement for expert judgment.

5.6 Summary

Risk analysis provides a systematic and structured methodology by which project teams can evaluate and prioritize risks for subsequent proactive response planning. This process is an inherently scalable activity, and the approach and resource commitment applied should be commensurate with the complexity of the project and the information available.

Both qualitative and quantitative risk analysis techniques have been presented in this chapter. As noted in Table 5.2, both techniques hold unique advantages and disadvantages that should be carefully weighed when considering how best to analyze project risk:

- Qualitative techniques tend to be easier to apply and are generally sufficient as a screening or prioritizing tool to determine which risks are significant enough to warrant further analysis or response planning.
- Quantitative analysis is an attempt to determine how much combined risk the project contains and to identify the key risk drivers to allow the project team to more efficiently and effectively allocate project resources. Given the greater level of effort involved in conducting quantitative analysis, it is generally reserved for larger or more complex projects.

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Table 5.6. Scaling the risk analysis step.

Low Risk (Simple or Small-Scale Projects)	High Risk (Large, Critical, or Complex Projects)
Conduct an informal team meeting to determine the level of risk analysis that is necessary or if it is possible to proceed directly to risk response planning.	Identify risk analysis resources based on the level of analysis defined in the risk management plan.
If analysis is necessary, conduct a qualitative risk analysis of the key project risks, convening a risk workshop if necessary to obtain input data or to validate results.	Conduct a structured risk analysis workshop with internal and/or external subject matter experts and outside expert facilitation.
Document the identified risks in a risk register.	Document results in the risk register.

Table 5.6 discusses how the techniques in this chapter can be tailored based on the perceived level of risk facing the project.

See the following excerpt from the case study on taxiway reconstruction for a discussion of project risk analysis.

Case Study: Taxiway Reconstruction – Project Risk Analysis

Returning to the case study first introduced in Chapter 4, the following discussion focuses on how the project team applied the techniques discussed in this chapter to analyze the previously identified risks. The complete case study is presented in Appendix A.

Risk Analysis

Once the risks were identified, analysis was performed using the risk register. A rating of 1 through 5 was assigned to qualitatively analyze the probability of the risk occurring as well as the impact of the risk occurrence on the project. The risk rating applied was the product of the probability multiplied by the impact. This equation was used to produce a ranked list of risks for the response planning discussion. The results of this analysis allowed the team to focus on the highest combined impact and probability risks in order to determine actions for responses.

Risk Register

Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identifie	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	ccept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways Will require descoping because budget is fixed Circular #?
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	itigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects results in schedule delays	Sue Johnson	10/27/2012	4	4	16	itigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	itigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delays schedule and impacts budget	John Norman	10/27/2012	1	4	4	itigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	void	Training Barriers Markings	$100,000	Training completed on 11/30	

CHAPTER 6

Project Risk Response Planning

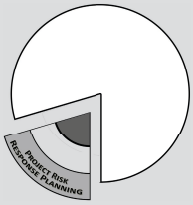
Once risks are identified and evaluated as described in Chapters 4 and 5, respectively, the following question remains:

What is the best approach for managing this risk (or exploiting this opportunity)?

The step of risk response planning attempts to answer this question by determining if the identified risks can be:

- **Accepted** on the basis that the risk and its consequences are minimal or the preventative response would not be feasible;
- **Transferred** to the contractor or other third party in a manner that is equitable and consistent with the project goals (Note: Risks that are transferred to the contractor or other third party must be managed within their project plan.);
- **Mitigated** by taking certain actions that are expected to reduce the probability of the risk event from occurring or its expected impact; or
- **Avoided** by eliminating the root cause.

Project Risk Response Planning



Key Activities

- Identify feasible response strategies for high-priority risks
- Allocate risks to the parties best able to manage them

Input

- Prioritized list of risks

Tools and Techniques

- Risk register

Outputs

- Risk response plan

6.1 Key Activities

6.1.1 Process Step Overview

Risk response planning entails the identification, evaluation, and selection of options to set risk at acceptable levels given project constraints and objectives. Tasks to be performed under risk response planning include determination and documentation of:

- What should be done,
- When it should be accomplished,
- Who is responsible, and
- How the response should be funded (if there is an associated cost).

Key steps are identified in the following and discussed in further detail in Section 6.3.

- Brainstorm strategies to bring the identified risks to an acceptable level, given the organization's risk threshold.
- Estimate the cost associated with the implementation strategies.
- Compare benefits of response actions to their estimated cost and benefit.
- Assign individuals to take responsibility for the response action (risk owner).
- Document results and proceed to risk monitoring and control (see Chapter 7).

Risk response strategies should be continually reviewed for their affordability, achievability, and effectiveness.

6.1.2 Timing

Risk response planning follows risk analysis, but like the other steps in the risk management process, it is iterative in nature since many of the project characteristics that could affect response strategies (e.g., scope, resources, internal and external environments) change over time.

6.1.3 Participants

The project team may have sufficient expertise and knowledge to determine the appropriate response strategies. However, it may be necessary to seek input from internal and external subject matter experts as well as contractors and suppliers to determine the most cost-effective response approach.

Table 6.1 outlines the roles and responsibilities for the project risk response planning step.

6.2 Inputs

To develop a feasible risk response strategy, the project team should start with the prioritized listing of risks developed as part of the risk analysis step. In addition, as with the risk identification step, to reach consensus on the optimal response strategy, the project team must share a mutual understanding of project's needs and goals.

Information from past projects and other historical data, if available, may also provide useful insight into effective mitigation techniques.

6.3 Tools and Techniques

6.3.1 Identifying Possible Response Strategies

Based on the list of prioritized risks and opportunities developed during the risk analysis step, the project team should develop the optimal response strategy that balances the consequence posed by each risk against the resources needed to manage that risk to an acceptable level. This determination is often performed in a workshop setting.

Table 6.1. Project risk response planning roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Reviews results; provides guidance if necessary.
Project Sponsor	• Reviews results; provides guidance if necessary.
Project Manager	• Approves project risk response plan. • Appoints risk owners for each identified risk. • Coordinates with risk owners to monitor risks and implementation of response strategies.
Project Team Members	• Assist the project manager in developing and implementing the risk response plan.
Risk Owner	• Assumes responsibility for managing a specific identified risk. • Develops and implements responses to the risk.
Risk Analyst	• Manages risk, opportunity, and response probability distributions based on outputs of risk identification, monitoring, and control. • Supports risk owner and project manager in development of risk response strategies.

The primary options available for responding to risks include the following:

- **Accept.** Risk acceptance involves adopting the risk, either without further action or in conjunction with establishing a contingency plan to be implemented if the risk occurs.
- **Transfer.** Risk transference involves shifting the risk to the party that is best able to manage it. For example, an owner could transfer the risk of construction unknowns to the contractor. Such action would only reduce the risk if the contractor were capable of managing the risk. Contractor transference tools can include the use of risk premiums, insurance, performance bonds, warranties, guarantees, incentive/disincentive clauses, and A + B contracts.
- **Mitigate.** Risk mitigation entails proactively reducing the potential impact and/or probability of the risk, recognizing that early action focused on potential causes for risks to occur is often more effective than trying to repair the damage after the risk has occurred. However, mitigation may require expenditure of valuable resources or time, so any upfront investment must be balanced against the benefit of risk reduction. Examples of mitigation actions are increasing the number of parallel activities in the schedule, early involvement of regulatory agencies in the project, and early and continuous outreach to communities/advocacy groups. In the case of positive risk events, the approach would be to *enhance* opportunities to increase the likelihood that they would occur.
- **Avoid.** Avoiding or eliminating the risk requires identification and elimination of the root cause, and typically involves design changes, process changes, or policy actions (e.g., relaxing constraints by adding time or resources). Some risks that are identified early in the project development process can also be eliminated by obtaining more information. For example, conducting additional site investigations (at a cost to the project) may reduce uncertainties regarding unforeseen conditions. Avoidance is generally considered the most desirable response strategy; however, selecting this option requires the availability of a suitable, cost-effective alternative to the originally planned approach. To *exploit* opportunities, this option would entail removing the uncertainty to ensure that the opportunity will definitely occur.

The primary options available for responding to opportunities include the following:

- **Accept.** Acknowledgment of an opportunity and the possibility of being able to take advantage of it during the project.
- **Capitalize.** There may be a variety of different ways an opportunity could be exploited, but every reasonable outcome is addressed such that the result is positive gain within the project scope, schedule, or budget.
- **Enhance/Grow.** Foster the impact an opportunity has on a project so that it will occur within the duration of the project to be a benefit.
- **Share.** Partner with some other organization or person to increase the probability of achieving the desired outcome.

6.3.2 Selecting the Optimal Risk or Opportunity Response Strategies

Similar to the risk identification and analysis steps, the evaluation of response alternatives is best done in a workshop setting, with knowledgeable participants working to collaboratively identify and quantify the optimum risk response strategies.

When evaluating the alternatives, the participants should consider the following:

- The project's objectives and whether the option aligns with the stated project goals;
- The feasibility of the option given funding, resource, and schedule constraints;
- The expected effectiveness of the risk response strategy;
- The results of a cost–benefit analysis; and
- The impact of the risk response strategy on other portions of the project or other ongoing/future projects.

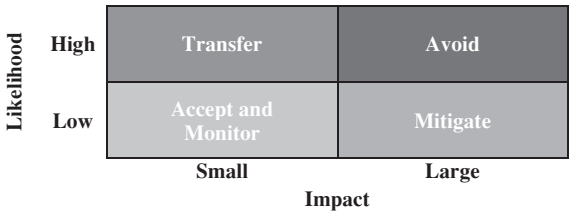


Figure 6.1. Simple risk response matrix.

To make the most efficient use of resources, it is important to tailor the risk response strategies to the nature and magnitude of the risks defined in the risk analysis. A simple way for project teams to begin to think about risk response is displayed in the matrix shown in Figure 6.1. For example, for a risk falling in the upper right quadrant, representing those that have both a high likelihood of occurring and a potential for causing a large impact on project objectives, it may be best to first consider avoidance strategies.

As a starting point for identifying responses, Figure 6.1 suggests some possible response strategies to correspond to the general airport risk categories first presented in Table 4.2.

Similarly, response strategies can be categorized for opportunities. Figure 6.2 represents a guideline for opportunities.

6.3.3 Establishing Contingency

For cases where risks cannot be avoided and mitigation efforts will not fully bring the risk to an acceptable level, project teams can establish and set aside contingency funds and schedule allowances to handle expected risk events.

Developing risk-based contingency plans allows the project team to formally plan for risk events instead of adding generic reserves to cost and schedule estimates. When contingencies are arbitrarily established, a project's actual cost and schedule tend to gravitate toward the estimates regardless of whether the contingencies are truly used to mitigate the identified risk. The formality and transparency imposed by the quantitative analysis techniques discussed in Section 5.3.2 can help reinforce the need to control and monitor contingency usage.

If used appropriately, contingency funds should only be tapped if mitigation strategies fail. Ideally, only a portion of the set aside contingency should be consumed, making it unnecessary to establish cost and schedule reserves for each and every contingency plan. If the risk management plan includes quantitative analysis, probabilistic modeling that accounts for the combined effect of all identified project risks can be used to develop the appropriate cost and/or to schedule reserves.

Table 6.2 provides a list of possible risk factors for each risk group, categorized by typical project locations found on airport property. Each of these groups and factors includes a list of possible risk response strategies. This complete table can be used when planning for risk management or brainstorming possible risks to consider for a project.

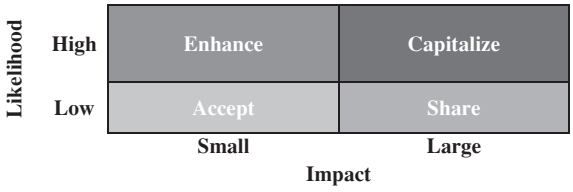


Figure 6.2. Simple opportunity response matrix.

Table 6.2. Possible risk responses for general airport risk categories.

Risk Groups	Project Location			Possible Risk Response Strategies
	Airside/Airfield	Landside (Civil and Buildings)	Terminal (Secure and Non-Secure)	
	Potential Risk Factors			
Airline/ Aircraft Operational Impact	• Security • Dependencies • Interfaces	• Regulatory • Interfaces	• Security • Interfaces	• Coordination plans • Work hour restrictions • Alternate routes
Continuity of Operations	• Site conditions • Dependencies • Resources • Security	• Site conditions • Dependencies • Resources	• Dependencies • Resources	• Coordination plans • Work hour restrictions • Temporary power • Temporary HVAC
Customer Impact	• Air service	• Customer and political	• Customer and political	• Work hour restrictions • Signage • Alternate routes
Environmental	• Regulatory • Customer and political	• Regulatory customer and political • Public relations	• Regulatory customer and political	• Pollution prevention plans
Regulatory	• Regulatory changes • Suppliers and contractors	• Regulatory changes • Suppliers and contractors	• Regulatory changes • Suppliers and contractors	• Coordination design review • Contract language
Reputational/ Image	Not a significant source of potential risk factors	• Customer and political • Public relations	• Customer and political • Public relations	• Public relations • Community outreach
Revenue/ Financial	• Funds availability • Market conditions	• Financial capacity • Market conditions	• Financial capacity • Market conditions	• Phasing • Project timing
Safety	• Safety • Suppliers and contractors • Requirements	• Safety • Suppliers and contractors • Permitting	• Safety • Suppliers and contractors • Permitting	• Lock-out/tag-out • Personal protective equipment (PPE) • Safety briefings
Security	• Design • Security • Requirements	• Design	• Design • Security • Requirements	• Training • Badging • Inspection
Unforeseen Conditions	• Site conditions	• Site conditions	• Site conditions	• Additional site investigation
Wildlife Management	• Design requirements	Not a significant source of potential risk factors	Not a significant source of potential risk factors	• Fence height • Habitat removal
Market Conditions	• Air service	• Suppliers and vendors • Contractors	• Suppliers and vendors • Contractors	• Outreach to business community • Active recruitment • Escalation clauses in contracts

The risk register included in Part 3 of this guidebook can be used to document response planning.

6.4 Outputs

Once the alternatives have been analyzed, the selected response actions should be documented either by expanding the existing risk register or preparing a stand-alone risk response plan. The following information should be recorded (if not already included in the risk register):

- A description of the identified risk (including a summary of the scope, schedule, and cost impacts; likelihood of occurrence; impact; and whether the risk is within the control of the airport or a third party); and
- Identification of the chosen risk response strategy (i.e., mitigate, avoid, accept, transfer), accompanied by a description of the risk response plan; and
- Cost to respond (i.e., estimated value of the cost to implement the chosen response).

6.5 Best Practices

Risk response planning should generally conform to the following principles and best practices:

- **Consider Project Objectives.** To determine the optimal response strategies, it is important to consider project objectives. It is rarely possible to optimize quality, time, and cost goals on a single project, and therefore, trade-offs may be necessary to ensure that the primary goals are achievable. Understanding the relative importance of individual project goals will help the project team make informed decisions regarding the optimal response strategies to increase the likelihood of achieving the primary project goal (e.g., enhanced quality), even if at the expense of secondary goals (e.g., cost).
- **Consider Risk Prioritization.** The prioritization of risks resulting from the risk analysis step should, for the most part, drive the allocation of resources allocated to reducing the risks to acceptable levels. However, it may be useful to address small or insignificant risks immediately if it would be quick and low in cost to do so.
- **Engage Stakeholders.** Increased collaboration and communication between project team members and key stakeholders can enhance the identification and development of possible risk response strategies.
- **Incorporate the Planned Responses into the Overall Project Management Plan.** The planned responses should be incorporated into the overall project management plan to the extent that they affect the project budget, schedule, and resource assignments.
- **Assign a Risk Response Owner.** Each risk response should be assigned a single owner who has clear responsibility and accountability for its execution. This individual may or may not be the same as the overall risk owner.

6.6 Summary

Risk response planning entails identifying and implementing actions to address the identified risks and bring them to acceptable levels. Like all of the steps in the risk management process, risk response planning is a scalable activity, as summarized in Table 6.3.

See the continuation of the excerpt from the case study on taxiway reconstruction for more discussion of project risk planning.

Table 6.3. Scaling risk response planning.

Simple or Small-Scale Projects	Large, Critical, or Complex Projects
Conduct an informal team meeting to brainstorm possible response strategies	Conduct a structured risk management workshop with internal and/or external subject matter experts, as necessary
Complete the response plan's appropriate project document, such as the risk register or project plan	Perform cost–benefit analysis to determine the optimal response strategies
	Consider establishing risk-based cost or schedule contingencies
	Document the response plan in the risk register

Case Study: Taxiway Reconstruction – Project Risk Response Planning

Returning to the case study first introduced in Chapter 4, the following discussion focuses on how the project team applied the techniques discussed in this chapter to plan its response strategies. The complete case study is presented in Appendix A.

Risk Response Plan

During the risk workshop, after analysis was complete, actions were identified and captured in the risk register to respond to risks according to the perceived severity and probability of each risk occurring. The response was determined using a standard choice of activity, including to avoid, transfer, mitigate, or accept. A clear action to be taken was then documented along with an estimated cost for the response itself. Status was updated as the response activity occurred throughout the project progress.

Risk Register

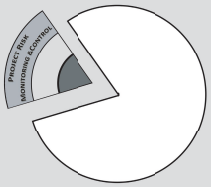
Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to planning requirements on taxiways Will require descoping because budget is fixed Circular #?
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	Mitigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects results in schedule delays	Sue Johnson	10/27/2012	4	4	16	Mitigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	Mitigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delays schedule and impacts budget	John Norman	10/27/2012	1	4	4	Mitigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	Avoid	Training Barriers Markings	$100,000	Training completed on 11/30	

CHAPTER 7

Project Risk Monitoring and Control

Project Risk Monitoring and Control



Key Activities

- Monitor effectiveness of response strategies
- Reevaluate risk response strategies as appropriate to improve outcomes
- Document lessons learned for application on future projects

Inputs

- Risk register
- Project status reviews
- Project measures

Tools and Techniques

- Risk register

Outputs

- Updated risk response strategies
- Updated risk management plan
- Documentation of lessons learned

Project risk monitoring entails those actions needed to respond to these questions:

"*How are things going?*"

"*Do any of the steps in the project management process need to be revisited?*"

The step of risk monitoring and control attempts to answer these questions by:

- Monitoring:
  - Reviewing regular project status updates; and
  - Reviewing implementation and effectiveness of risk response plans.
- Control:
  - Implementing, adjusting, or choosing alternate response strategies;
  - Taking corrective action;
  - Escalating risk management activities;
  - Identifying and revisiting steps in the project risk management process; and
  - Identifying potential preventive actions.

7.1 Key Activities

7.1.1 Process Step Overview

A typical element of project management is periodic project status reviews/meetings. During these reviews, progress toward implementation of risk response strategies and results should be included. This review allows the project team to:

- Assess the effectiveness of the risk response strategies,
- Identify if any additional risks have arisen or new risks should be added, and
- Determine if risk prioritization should be adjusted.

7.1.2 Timing

Risk monitoring and control continues for the life of the project, is iterative in nature, and should actively occur at routine intervals. As the project progresses, the list of project risks may change as new risks develop or previously anticipated risks fail to materialize. Risk monitoring and control activities may also be conducted when performance targets or risk thresholds are exceeded. The conclusion of this step is typically an after-action review or an assessment of lessons learned.

7.1.3 Participants

The resources committed to the risk monitoring and control effort should be scaled to the complexity of the risk response plan.

Table 7.1. Project risk monitoring and control roles and responsibilities.

Role	Typical Responsibilities
Senior Management	• Receives regular updates on status of project risk management plan.
Project Sponsor	• Receives regular updates on status of project risk management plan. • Supports resource requirements as required.
Project Manager	• Regularly reports risk status to key stakeholders, offering recommendations for appropriate response actions to maintain acceptable risk exposure within established risk tolerance of organization.
Project Team Members	• Participate in monitoring of risk response plans and identification of potential new risks and opportunities and provide input to project manager for risk reports.
Risk Owner	• Monitors effectiveness of risk response plans, takes appropriate corrective actions, identifies necessary modifications to risk response strategies, and reports progress to the project manager by updating the risk register as necessary.
Risk Analyst	• Manages risk, opportunity, and response probability distributions, based on outputs of risk identification, monitoring, and control.

The responsibility for project monitoring is typically defined in the risk management plan. Control activities include input from the risk owner, project team members, and subject matter experts from design, construction, maintenance, operations, security, the FAA, the TSA, airlines, environmental groups, and other affected functional areas and business partners.

Table 7.1 outlines the roles and responsibilities for the project risk monitoring and control step.

7.2 Inputs

The effectiveness of the response strategies, identified on the risk register, is the key input to risk monitoring and control. Effectiveness is typically based on performance related to identified measures or standards, risk review, and project issues reporting, and is reviewed through routine project status or review meetings.

7.3 Tools and Techniques

Various techniques and tools can be used to monitor and control risks, the most common of which are described in the following. These techniques may be used alone or in combination, depending on the approach that is best suited to the risk response strategies and the information and resources available.

Project Management/Status Meetings. Monitoring and control activities within project management include routine review, recording, and communication of project performance, including performance of defined risk response strategies. These reviews, using the updated risk register, indicate the occurrence of new or potential risks as well as the effectiveness of risk response strategies. At the completion of a project, after-action reviews identify lessons learned and best practices to apply to future projects.

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Performance, Variance, and Trend Analysis. This analysis is used to monitor project performance against the schedule, budget, or technical standards defined in the project objectives or risk response plan. Significant variations or unfavorable trends may indicate the need for further risk identification, analysis, or response planning. Methods may include control charting, trend analysis, and performance-to-standard monitoring.

Reserve/Contingency Analysis. Risk events may occur with a positive or negative impact on planned contingencies. Contingency analysis evaluates the sufficiency of the contingency amount by comparing planned to remaining contingency reserve to the remaining risk. Contingency analysis may also serve as an input to the lessons learned.

Risk Audits. The effectiveness of risk responses is evaluated through predefined and scheduled risk audits. These are typically reserved for large, complex projects, and requirements are defined in the risk management plan.

7.4 Output

Risk monitoring and control documents like project status reports may include information such as risk response effectiveness measures, project progress to outcomes, and performance to schedule and budget.

The risk management plan may be used to record the information necessary to close out the project's risk management activities. For example, such information may include:

- For each risk identified, information regarding whether it occurred, its impact, effectiveness of response and/or control actions, and any unplanned actions that had to be implemented;
- Effectiveness of avoidance, transfer, and/or mitigation actions;
- Closure of mitigation actions:
  - Performance bonds,
  - Retainage,
  - Compliance audits, and
  - Return of contingency equipment;
- Unexpected or undocumented risks encountered;
- Verification of warranties;
- Transfer of project ownership; and
- Closure of implications related to scope, schedule, and budget.

7.5 Best Practices

Risk response planning should generally conform to the following principles and best management practices.

- **Report on Risks Regularly.** A fundamental aspect of project risk management is the review and timely communication of the results of risk monitoring and control activities to the project team and other key stakeholders. This provides the opportunity to give positive feedback for well-managed efforts, to escalate the response to risks that may not have been previously identified, and to make necessary revisions to risk response strategies before issues arise.
- **Close-Out of Contingency Activities.** These activities may become part of the lessons learned.
- **Capture the Risk Environment.** As previously described, risks are future events or potential problems creating uncertainty regarding a project's success. In contrast, issues are problems

that have already occurred and require resolution. Risk control should include maintenance of risk documentation and capturing the environment and history when risks become issues.
- **After-Action Reviews.** Documentation of lessons learned increases institutional knowledge and supports continuous improvement. Lessons-learned documents should include successes and opportunities for improvement.

7.6 Summary

Risk monitoring and control evaluates the effectiveness of the risk management plan, provides a coordination vehicle with management and other stakeholders to reevaluate risk response strategies as appropriate, and may be used as input to lessons learned for future projects. Like all of the steps in the risk management process, risk response monitoring and control is iterative and is a scalable activity, as summarized in Table 7.2.

See the following excerpt from the case study on taxiway reconstruction for more discussion of risk monitoring and control.

Table 7.2. Scaling risk monitoring and control.

Simple or Small-Scale Projects	Large, Critical, or Complex Projects
Monitor performance to standards	Conduct formal project update meetings and after-action reviews to update stakeholders on the results of project risk management activities
Conduct informal project status updates to update members on the results of project risk management activities	Monitor performance to standards, variance analysis, and trend analysis
Document monitoring results in the appropriate project document, such as the risk register or project plan	Perform reserve/contingency analysis
	Consider inclusion of risk audits in the risk management plan
	Document results of monitoring and control activities in the risk register and project review reports

Case Study: Taxiway Reconstruction – Risk Monitoring and Control

Returning to the case study first introduced in Chapter 4, the following discussion focuses on how the project team applied the techniques discussed in this chapter to monitor the identified risks. The complete case study is presented in Appendix A.

Risk Monitoring and Control

The monitor and control step was managed in daily project progress meetings with all stakeholders attending. These meetings included risk review and project issues reporting. The results captured in the risk register were solely the risk review items. Project issues were documented and shared with the whole team through project management status reporting. Project progress issues were identified and conflict resolved as much as possible in the meeting.

Project monitoring and control followed the project life-cycle phases, and project issues that occurred that were not identified as risks early in the planning process caused a need to revisit the project risk management plan and conduct a brief version of identification, analysis, and response to update the risk register.

Risk Register

Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways Will require descoping because budget is fixed Circular 37
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	Mitigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects results in schedule delays	Sue Johnson	10/27/2012	4	4	16	Mitigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	Mitigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delays schedule and impacts budget	John Norman	10/27/2012	1	4	4	Mitigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	Avoid	Training Barriers Markings	$100,000	Training completed on 11/30	

PART 3

Project Risk Management Toolbox

Chapter 8. Project Risk Management Toolbox 69

Part 3 Objectives

Part 3 provides the toolbox that contains the tools used to support performing the steps associated with the project risk management process. The tools included in this part are:

- Project risk management plan,
- Project risk checklist,
- Probability and impact matrix, and
- Risk register.

CHAPTER 8

Project Risk Management Toolbox

8.1 Overview

The tools in this chapter are provided to support the project risk management process described in Part 2 of this guidebook. The tools have been developed to meet the needs of airports with little or no formal project risk management practices in place and can be used to develop a rigorous program to follow regardless of the complexity or type of project being performed.

The tools are intended to be customized to the unique requirements of each project as well as according to the project risk management formality necessary.

8.2 How to Use This Toolbox

The inventory of tools included in this part of the guidebook includes three versions of each:

- A blank template, which may be customized with the language and information appropriate to the unique needs of each airport;
- A template with instructions, which is an annotated template with instructions for filling in the template; and
- An example template filled in with sample, representative project information.

Table 8.1 describes the inventory of tools and the intended purpose by step in the project risk management process.

8.3 Project Risk Management Plan

8.3.1 Overview

The project risk management plan is a document created at the start of a project to determine the level of project risk management to perform. The document captures how much project risk management will be performed for a specific project and provides structured, clear accountability and a record of the process. The project risk management plan includes documentation tracking, roles and responsibilities, strategy, and milestone tracking. This plan should be updated as project risk management activities occur, and attachments should be added as appropriate throughout the life of the project.

The project risk management plan (see Exhibit 8.1) is typically used in the project risk planning step of project risk management.

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Table 8.1. Project risk management toolbox.

Step: Project Risk Planning	
Tool	**Description**
Project Risk Management Plan	Document created at the start of a project to determine the level of project risk management to perform. Describes how project risk management will be structured and performed. The project risk management plan includes documentation tracking, roles and responsibilities, strategy, and milestone tracking. This plan should be updated as activities occur, and attachments should be added as appropriate throughout the life of the project.
Step: Project Risk Identification	
Tool	**Description**
Risk Checklist	Guides identification of risks associated with a project. Can be used as a checklist to identify risks associated with a project or after a brainstorming session to ensure all risks were identified.
Risk Register	Formal document to capture risks for tracking and assignment to resources. Typically is a deliverable resulting from a facilitated session/risk workshop that is shared with the project team and project stakeholders.
Step: Project Risk Analysis	
Tool	**Description**
P-I Matrix	Provides a clear, simple interpretation of which risks are significant and which risks do not merit immediate time and attention.
Step: Project Risk Response Planning	
Tool	**Description**
Risk Registers with Response Plan	Initiated in the risk identification step, the risk register captures risk response plans, including the response to the risk, the actions to be taken, and the cost to respond. Status is updated as the project progresses. The risk register is updated with additional information and maintained for the life of the project.
Step: Project Risk Monitoring and Control	
Tool	**Description**
Updated Risk Registers	Initiated in risk identification step and updated at various points in the project life cycle. Updated risk registers, including risk response planning, become a structured approach to tracking project progress updates and reporting risk through documenting the monitoring and control activities.

8.4 Project Risk Management Checklist

8.4.1 Overview

The project risk management checklist guides identification of specific and generic risks associated with a project. This tool can be used as an informational job aid to increase the ability to identify risks in preparation for the planning and management of the scope, schedule, and budget of the project. It ensures consistency and completeness in reviewing risks and can be used before or after a brainstorming session to ensure all risks were identified.

The project risk management checklist (see Exhibit 8.2) is typically used in the project risk identification step of project risk management.

8.5 Probability and Impact Matrix

8.5.1 Overview

The P-I matrix provides a clear, simple interpretation of which risks are significant and which risks do not merit immediate time and attention. This tool can be used to qualitatively assess both sets of criteria—probability and impact—of risks identified for a specific project. The assessment creates the ability to visually display risks on a matrix to quickly and easily identify which risks rank higher than others and then discuss the need to explore additional strategies for response.

Exhibit 8.1. Sample project risk management plan.

PROJECT RISK MANAGEMENT PLAN – PAGE 1

Project Risk Management Plan Purpose

This project risk planning document describes how project risk management will be structured and performed. The project risk management plan includes documentation tracking, roles and responsibilities, strategy, and milestone tracking. This plan should be updated as activities occur, and attachments should be added as appropriate throughout the life of the project.

Project Name:

Project Scope:

Project Schedule (start and end dates):

Project Budget:

Current Engineering Estimate:

Project Risk Management Roles and Responsibilities

Role	Responsibilities
Project Manager:	
Project Sponsor:	
Project Approvals:	
Contractor:	
Project Team Members:	

Documents Available for Project Risk Management:

(To be updated throughout life of project; as you complete steps and add documents, attach or include in package with this plan.)

Project Risk Tolerance

The project team will rate the probability of each risk on a scale of _____ and the impact of those risks on a scale of _____. The acceptable level of risk for the scope, schedule, and budget of this project is _____.

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Exhibit 8.1. (Continued).

PROJECT RISK MANAGEMENT PLAN – PAGE 2

Project Risk Management Strategy

Define the risk management methodology to be used, the risk assumptions, the roles and responsibilities, the time frames, and risk rating/scoring techniques, establish risk thresholds, define risk communications, and develop a risk tracking process.

Project Risk Management Step		Document or Activity Used	Person Responsible	Planned Date	Completed Date	Comments
Risk Identification: Generate list of possible risks						
		Workshop				
		Checklist				
		Risk Register				
		Other				
Risk Analysis: Prioritize list of risks, recommend schedule and cost contingencies						
		Qualitative Matrix				
		Quantitative Modeling				
		Update Risk Register				
		Other				
Risk Response Planning: Determine responses to identified risks						
		Update Risk Register				
		Other				
Risk Monitor and Control: Monitor risk activity						
		Update Risk Register				
		Other				

Milestones:	Comments:	Date:
Project Risk Management Plan Approved		
Risks Identified		
Risk Analysis Performed		
Risk Responses Documented		
Risk Monitoring and Control Performed		

Date Plan Completed: Last Updated: By

Exhibit 8.1. (Continued).

PROJECT RISK MANAGEMENT PLAN *INSTRUCTIONS* – Page 1

This document is an annotated version of the project risk management plan template and outlines the type of information to be included in the template. Customize the template with appropriate language and content for the unique needs of the airport environment and each project specifically.

PROJECT RISK MANAGEMENT PLAN

Project Risk Management Plan Purpose:

This Project Risk Planning document describes how Project Risk Management will
performed on a project. The project risk management plan includes documentation
responsibilities, strategy, and milestone tracking. This plan should be updated as
attachments added as appropriate through the life of the project.

Project Name:

Project Scope:

Project Schedule (start and end dates):

Project Budget:

Current Engineering Estimate:

Fill in the appropriate information to describe the project, including name, scope, schedule, budget, and estimates.

Project Risk Management Roles and Responsibilities

Role	Responsibilities
Project Manager:	
Project Sponsor:	
Project Approvals:	
Contractor:	
Project Team Members:	

Fill in the appropriate information to describe the roles and responsibilities associated with the project described above. Roles may be added or removed and responsibilities outlined to ensure accountabilities.

Documents available for Project Risk Management:
(To be updated throughout life of project, as you complete steps and add documents

Fill in the names of the documents created and used in the life of the project. List of document names is filled in here; the actual documents may be attached to the plan as well.

Project Risk Tolerance

The project team will rate the probability of each risk on a scale of _____ and the impact of those risks on a scale of _____. The acceptable level of risk for the scope, schedule and budget of this project is _____.

Project manager determines the risk scale for probability and impact as well as an acceptable level of risk and fills in blanks.

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Exhibit 8.1. (Continued).

PROJECT RISK MANAGEMENT PLAN *INSTRUCTIONS* – Page 2

Identify the person responsible for completing the activity.

This section documents the level of project risk management applied to specific project described on page 1.

Management Strategy

gement methodology to be used, the risk assumptions, the roles and re
risk rating/scoring techniques, establish risk thresholds, define risk communications, and dev

Project Risk Management Step	Document or Activity Used	Person Responsible	Planned Date	Completed Date	Comments
Risk Identification: Generate list of possible risks					
	Workshop				
	Checklist				
	Risk Register				
	Other				
Risk Analysis: Prioritize list of risks, Recommend schedule and cost contingencies					
	Qualitative Matrix				
	Quantitative Modeling				
	Update Risk Register				
	Other				
e Planning: Determine responses to identified risks					
	Update Risk Register				
	Other				
Risk Monitor and Control: Monitor ris					
	Update Risk Register				
	Other				

Check the boxes in this column if document or activity will be used.

Identify the date the activity is scheduled to occur.

Identify the date the activity actually occurs.

Fill in additional or other techniques, activities, or documents used for the specific needs of each project.

Document any comments relative to the activity or other information included.

	Comments:	Date:
nagement Plan		
erformed		
s Documented		
and Control		

This section captures comments and dates completed for milestone activities outlined above. Milestones can be customized to appropriate activities for each project.

Fill in the dates and names corresponding to origination and updates to the document. Use the Save As function to manage multiple versions of the document throughout the life of the project.

Date Plan Completed: **Last Updated:** **By:**

Exhibit 8.1. (Continued).

PROJECT RISK MANAGEMENT PLAN *EXAMPLE*

The following is an example of the project risk management plan with an airport project example.

Project Risk Management Plan Purpose

This project risk planning document describes how project risk management will be structured and performed. The project risk management plan includes documentation tracking, roles and responsibilities, strategy, and milestone tracking. This plan should be updated as activities occur, and attachments should be added as appropriate throughout the life of the project.

Project Name: ***Terminal Utilization Study***

Project Scope: ***Evaluate current use of terminal versus future terminal needs***

Project Schedule (start and end dates): ***March – August***

Project Budget: ***$125,000***

Current Engineering Estimate: ***$105,000***

Project Risk Management Roles and Responsibilities

Role	Responsibilities
Project Manager:	*ROBERT JOHNSON*
Project Sponsor:	*SUE MOORE*
Project Approvals:	*RANDY ROSE*
Contractor:	*HILL INTERNATIONAL*
Project Team Members:	*TODD JAMES, BETH JONES, CAROL WILLIAMS*
	MIKE SMITH, WILL ROBINSON, CHARLIE PRICE

Documents Available for Project Risk Management:

(To be updated throughout life of project; as you complete steps and add documents, attach or include in package with this plan.)

RFP

PROCUREMENT CONTRACT

PROBABILITY AND IMPACT MATRIX

Project Risk Tolerance

The project team will rate the probability of each risk on a scale of 1–5 and the impact of those risks on a scale of 1–5. The acceptable level of risk for the scope, schedule, and budget of this project is *MODERATE*.

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Exhibit 8.1. (Continued).

PROJECT RISK MANAGEMENT PLAN *EXAMPLE* – Page 2

Project Risk Management Strategy

Define the risk management methodology to be used, the risk assumptions, the roles and responsibilities, the time frames, and risk rating/scoring techniques, establish risk thresholds, define risk communications, and develop a risk tracking process.

Project Risk Management Step	Document or Activity Used		Person Responsible	Planned Date	Completed Date	Comments
Risk Identification: Generate list of possible risks						
	✔	Workshop	RJ			
	✔	Checklist				
	✔	Risk Register				
		Other				
Risk Analysis: Prioritize list of risks, recommend schedule and cost contingencies						
	✔	Qualitative Matrix				
	N/A	Quantitative Modeling				
	✔	Update Risk Register				
		Other				
Risk Response Planning: Determine responses to identified risks						
	✔	Update Risk Register				
		Other				
Risk Monitor and Control: Monitor risk activity						
	✔	Update Risk Register				
		Other				

Milestones:	Comments:	Date:
Project risk management plan approved	*PLAN APPROVED BY SUE MOORE*	*2/1/2013*
Risks identified	*RISKS IDENTIFIED IN WORKSHOP*	*2/13/2013*
Risk analysis performed	*P-I MATRIX COMPLETED*	*4/12/2013*
Risk responses documented	*ADDITIONAL RISKS IDENTIFIED, PERFORMED SECOND RISK WORKSHOP TO UPDATE LIST*	*5/20/2013*
Risk monitoring and control performed	*REGULARLY SCHEDULED STATUS MEETINGS OCCUR ON TUESDAYS AT 10:00*	

Date Plan Completed: Last Updated: By

Exhibit 8.2. Sample project risk management checklist.

PROJECT RISK MANAGEMENT CHECKLIST – PAGE 1

Project Name:	
Checklist Completed by:	**Date Completed:**
Project Manager:	**Date Updated:**

	PROJECT MANAGEMENT RISKS			COMMENTS
	Area		**Risks**	
1	**Contract Management**	**Project SCOPE Risks**		
			Requirements are incomplete or not identified	
			Requirements are unrealistic	
			Requirements are unstable	
		Project SCHEDULE Risks		
			Project has fixed deadline for completion	
			Workdays are restricted for project activities	
			Potential for work stoppages	
			Lengthy decision/approval chains	
			Lengthy permitting process	
		Project BUDGET Risks		
			Funding sources are not determined	
			Availability of cash flow not certain	
			Funding delays, or reduced funding available	
			Expiration of capital, operations, and maintenance funding affects schedule and scope	
2	**Regulatory, Safety, and Security Risks**		Barrier for secure area project work impedes project work access	
			Vehicle/aircraft incursion causes a work stoppage	
			Noncompliance or violation of regulatory standards stops work progress	
			Regulatory changes require redesign or rescoping	
3	**Environmental Risks**		Environmental protection/approval causes delay in schedule	
			Environmental impact and nuisances (smells, noise, spills) cause delay in schedule	
			Streams and wetlands and wildlife require additional oversight	
			Erosion control/storm water impact cause additional scope to be defined	

Exhibit 8.2. (Continued).

PROJECT RISK MANAGEMENT CHECKLIST – PAGE 2

PROJECT MANAGEMENT RISKS				COMMENTS
4	**Staffing and Vendor Risks**		Staffing for the size, complexity, and/or challenges of the project is inadequate, causing budget increase or schedule delay	
			Competing priorities for the same project team members cause schedule delay or rephasing of project	
			Contractor has limited familiarity with airport, causing schedule and cost impacts for training and education	
			Limited availability of vendors increases cost	
5	**Market- and Community-Related Risks**		Limited vendor/contractor availability and/or interest due to external market conditions	
			Material availability/volatility of pricing affects budget	
			Community disrupted by construction causes rephasing of project	
			Passenger traffic disrupted, causing rephasing of project	
			Noise concerns from construction work area cause change in work schedule	
6	**Site Risks**		Unknown site conditions are encountered, affecting scope, schedule, and budget	
			Need to coordinate with other construction activities constrains schedule or affects scope and budget	
7	**Operational Risks**		Natural disaster/weather affect schedule and cost	
			Airfield traffic for construction vehicles limited by airline traffic, causing rephasing	
			Lack of coordination of external and internal stakeholders, contractors, and customers interrupts operations	

Exhibit 8.2. (Continued).

PROJECT RISK MANAGEMENT CHECKLIST *INSTRUCTIONS* – Page 1

This document is an annotated version of the project risk management checklist template and outlines the type of information to be included in the template. Customize the template with appropriate language and content for the unique needs of the airport environment and each project specifically.

Fill in this section with information about the specific project. Include dates for completion and update if appropriate. Customize additional information as needed.

PROJECT RISK MANAGEMENT CHECKLIST

Project Name:	
Checklist Completed by:	**Date Completed:**
Project Manager:	**Date Updated:**

	Area		Risks	COMMENTS
1	Contract Management		**Project SCOPE Risks**	
			Requirements are incomplete or not identified	
			Requirements are unrealistic	
			Requirements are unstable	
			Project SCHEDULE Risks	
			Project has fixed deadline for completion	
			Work days are restricted for project activities	
			Potential for work stoppages	
			Lengthy decision/approval chains	
			Lengthy permitting process	
			Project BUDGET Risks	
			Funding sources are not determined	
			Availability of cash flow not sure	
			Funding delays or reduced funding available	
			Expiration of Capital, Operations, and Maintenance Funding impacts schedule and scope	
2	Regulatory, Safety and Security Risks		Barrier for secure area project work impedes project work access	
			Vehicle / Aircraft Incursion causes a work stoppage	
			Non-compliance or violation of regulatory standards stops work progress	
			Regulatory changes require redesign or rescoping	
3	Environmental Risks		Environmental protection / approval causes delay in schedule	
			Environmental Impact and Nuisances (Smells, Noise, Spills) causes delay in schedule	
			Streams and wetlands and wildlife require additional oversight	
			Erosion control / storm water impact causes additional scope to be defined	

Check all boxes that apply as possible risks.

Include specific comments that pertain to each risk individually.

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Exhibit 8.2. (Continued).

PROJECT RISK MANAGEMENT CHECKLIST *INSTRUCTIONS* – Page 2

PROJECT RISK MANAGEMENT CHECKLIST

4	**Staffing and Vendor Risks**		Staffing for the size, complexity, and/or challenges of the project are inadequate causing budget increase or schedule delay	
			Competing priorities for the same project team members cause schedule delay or rephrasing of project	
			Contractor has limited familiarity with airport causing schedule and cost impacts for training and education	
			Limited availability of vendors increases cost	
5	**Market and Community Related Risks**		Limited vendor/contractor availability and/or interest due to external market conditions	
			Material availability/ volatility of pricing impacts budget	
			Community disrupted by construction causes rephrasing of project	
			Passenger traffic disrupted causing rephrasing of project	
			Noise concerns from construction work area causes change in work schedule	
6	**Site Risks**		Unknown site conditions are encountered, impacting scope, schedule and budget	
			Need to coordinate with other construction activities constrains schedule or impacts scope and budget	
7	**Operational Risks**		Natural Disaster/ Weather impact schedule and cost	
			Airfield traffic for construction vehicles limited by airline traffic causing rephasing	
			Lack of coordination of External and Internal Stakeholders, Contractors and Customers interrupt operations	

Add additional risks to a category for the specific needs of a project or the unique needs of the airport.

Add additional categories and risks specific to a project or the unique needs of the airport.

This checklist is to be used as a guideline to ensure that potential risks are identified. It is not intended as a complete checklist and may be used in conjunction with other checklists as the user may see fit.

Exhibit 8.2. (Continued).

PROJECT RISK MANAGEMENT CHECKLIST *EXAMPLE* – Page 1

The following is an example of the project risk management checklist with an airport project example.

Project Name: Triturater Replacement	
Checklist Completed by: George Glover	**Date Completed: 2/1/2013**
Project Manager: Troy Valentine	**Date Updated: 5/9/2013**

PROJECT MANAGEMENT RISKS				COMMENTS
	Area		**Risks**	
1	**Contract Management**	**Project SCOPE Risks**		
		✔	Requirements are incomplete or not identified	
			Requirements are unrealistic	
		✔	Requirements are unstable	
		Project SCHEDULE Risks		
			Project has fixed deadline for completion	
			Workdays are restricted for project activities	
			Potential for work stoppages	
			Lengthy decision/approval chains	
		✔	Lengthy permitting process	Need to get Robert to make phone calls in advance
		Project BUDGET Risks		
			Funding sources are not determined	
			Availability of cash flow not certain	
			Funding delays, or reduced funding available	
		✔	Expiration of capital, operations, and maintenance funding affects schedule and scope	
2	**Regulatory, Safety, and Security Risks**		Barrier for secure area project work impedes project work access	
			Vehicle/aircraft incursion causes a work stoppage	
			Noncompliance or violation of regulatory standards stops work progress	
			Regulatory changes require redesign or rescoping	
3	**Environmental Risks**	✔	Environmental protection/approval causes delay in schedule	
		✔	Environmental impact and nuisances (smells, noise, spills) cause delay in schedule	
		✔	Streams and wetlands and wildlife require additional oversight	
			Erosion control/storm water impact causes additional scope to be defined	

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Exhibit 8.2. (Continued).

PROJECT RISK MANAGEMENT CHECKLIST *EXAMPLE* – Page 2

4	**Staffing and Vendor Risks**	✔	Staffing for the size, complexity, and/or challenges of the project is inadequate, causing budget increase or schedule delay	Escalate issues
		✔	Competing priorities for the same project team members cause schedule delay or rephasing of project	
		✔	Contractor has limited familiarity with airport, causing schedule and cost impacts for training and education	Use George for training
			Limited availability of vendors increases cost	
5	**Market- and Community-Related Risks**	✔	Limited vendor/contractor availability and/or interest due to external market conditions	
			Material availability/volatility of pricing affects budget	
		✔	Community disrupted by construction causes rephasing of project	
			Passenger traffic disrupted, causing rephasing of project	
			Noise concerns from construction work area cause change in work schedule	
6	**Site Risks**	✔	Unknown site conditions are encountered, affecting scope, schedule, and budget	
			Need to coordinate with other construction activities constrains schedule or affects scope and budget	
7	**Operational Risks**		Natural disaster/weather affect schedule and cost	
			Airfield traffic for construction vehicles limited by airline traffic, causing rephasing	
		✔	Lack of coordination of external and internal stakeholders, contractors, and customers interrupts operations	

The probability and impact matrix (see Exhibit 8.3) is typically used in the project risk analysis step of project risk management.

8.6 Risk Register

8.6.1 Overview

The risk register is a formal document used to capture risks for tracking and assignment to resources. It is typically a deliverable resulting from a facilitated session/risk workshop and is used to communicate status back to the project team and project stakeholders.

While initiated in the risk identification step, the risk register may capture risk response plans, including the response to the risk, the actions to be taken, and the cost to respond. Status is updated as the project progresses. The risk register is updated with additional information and maintained for the life of the project.

The risk register (see Exhibit 8.4) is typically initiated in the project risk identification step of project risk management and is updated and used throughout the remaining steps in the process for the life of the project.

Exhibit 8.3. Probability and impact matrix.

PROBABILITY AND IMPACT MATRIX – Page 1

Project Name:	
Matrix Completed by:	**Date Completed:**
Project Manager:	

Probability Scale

~10% **Not Probable**	~30% **Low Probability**	~50% **Probable**	~70% **Highly Probable**	~90% **Near Certain**

Impact Scale

Very Low	**Low**	**Medium**	**High**	**Very High**

Step 1 – Determine Risk Score for Documented Project Risks

Risk Number	Risk Description Summary	Probability Value	Impact Value

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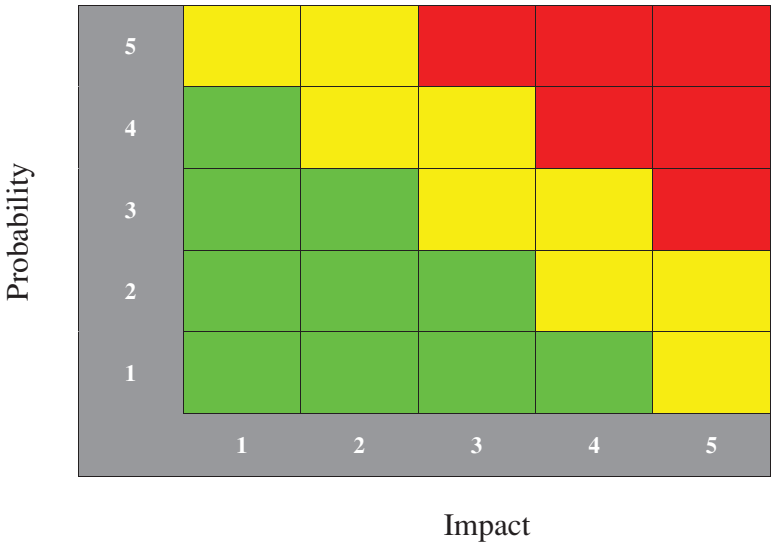
Exhibit 8.3. (Continued).

PROBABILITY AND IMPACT MATRIX – Page 2

Step 2 – Plot Probability/Impact Values for All Documented Risks

- Plot each documented risk by the value of its probability and impact in the matrix.



Step 3 – Assign Risk Levels to Plotted Matrix Based on Organization's Risk Tolerance

- Color code the risk ranking matrix boxes by assigning risk level values according to the organization's risk tolerance. The color coding here can be used as a starting point and can be customized. Create a key for the custom ranges.

Sample Key:

Risk Level
Low
Moderate
High

- Draw a line to differentiate high risks from low risks in the matrix. Determine whether additional steps should be taken to respond to the results.

Exhibit 8.3. (Continued).

PROBABILITY AND IMPACT MATRIX *INSTRUCTIONS* – Page 1

This document is an annotated version of the project risk management checklist template and outlines the type of information to be included in the template. Customize the template with appropriate language and content for the unique needs of the airport environment and each project specifically.

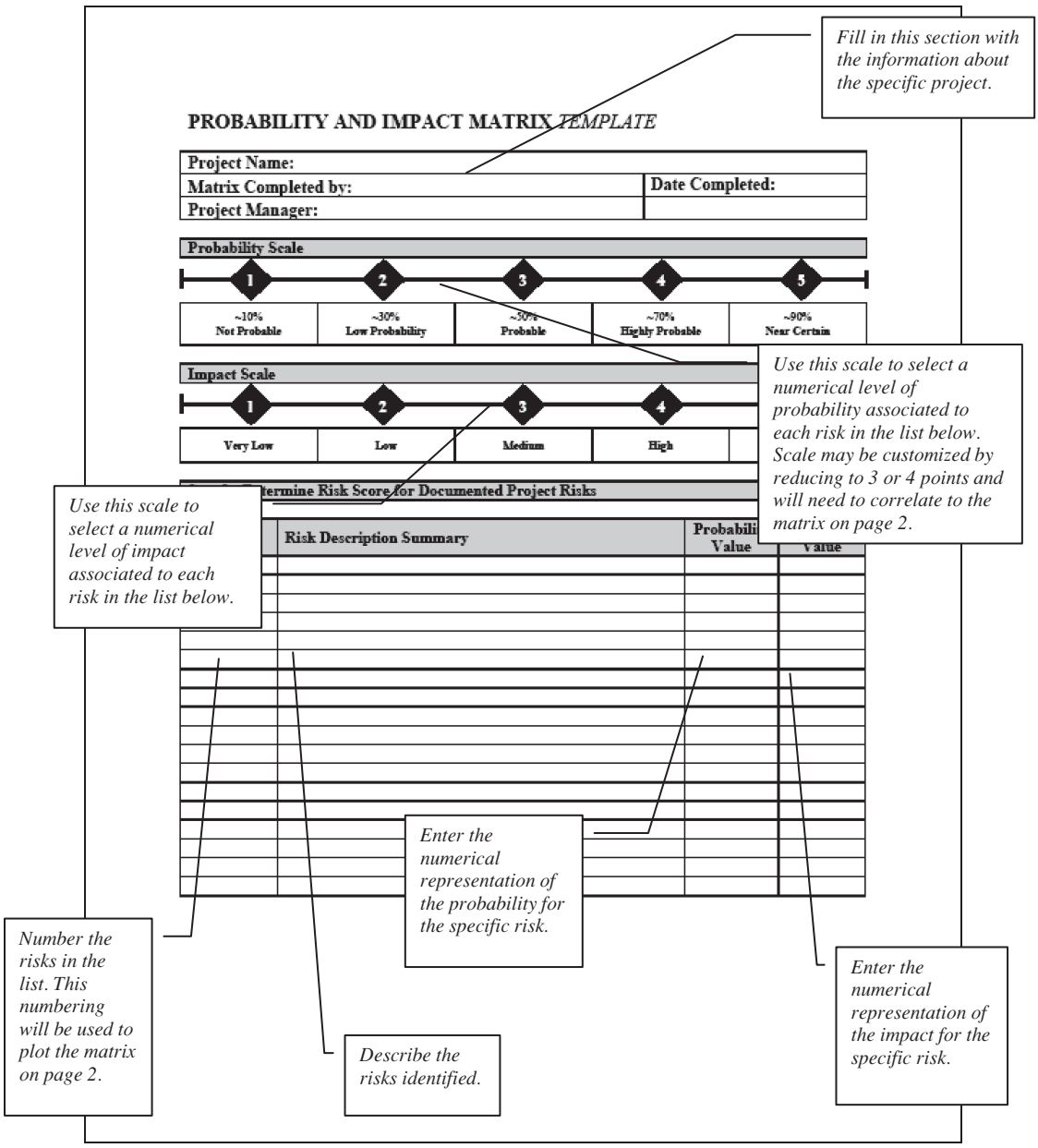


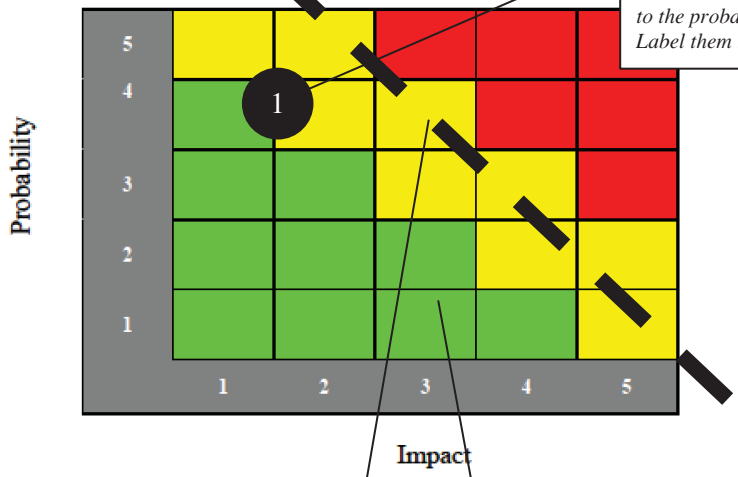
Exhibit 8.3. (Continued).

PROBABILITY AND IMPACT MATRIX *INSTRUCTIONS* – Page 2

Step 2 - Plot Probability / Impact Values For All Documented Risks:

- Plot each documented Risk by the value of its Probability and Impact on the m

Plot each risk from the list according to the probability and impact score. Label them using the risk number.



Step 3 – Assign Risk Levels to Plotted Matrix

- Calibrate the Risk Ranking Matrix boxes by assigning Risk Level values according to the following table.

Risk Score Range (Probability score multiplied by Impact score)	Risk Level
1-6	Low
7-14	Moderate
≥ 15	High

- CAVEAT: Default Risk Score Ranges are presented in worksheet template as a starting point. Organizations should determine the Risk Score Ranges that reflect their own risk tolerances.

Draw the line to designate risk thresholds visually.

Color code the matrix based on a threshold specific to the project and customized to the unique needs of the airport.

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Exhibit 8.3. (Continued).

PROBABILITY AND IMPACT MATRIX *EXAMPLE* – Page 1

The following is an example of the probability and impact matrix for an airport project.

Project Name: Internal Workspace Build-Out	
Matrix Completed by: Floyd Crook	**Date Completed: 11/29/2013**
Project Manager: Floyd Crook	

Probability Scale

1	2	3	4	5
~10%	~30%	~50%	~70%	~90%
Not Probable	**Low Probability**	**Probable**	**Highly Probable**	**Near Certain**

Impact Scale

1	2	3	4	5
Very Low	**Low**	**Medium**	**High**	**Very High**.

Step 1 – Determine Risk Score for Documented Project Risks

Risk Number	Risk Description Summary	Probability Value	Impact Value
1	Customer slow in making decisions about design, which affects schedule	4	4
2	Competing priorities for project work team will affect schedule and budget	4	2
3	Unforeseen conditions found in demolition impact scope may cause redesign	2	4
4	Need for permits to perform construction activities may affect schedule	2	1
5	Long lead time for selected materials causes delay in start of project	1	2

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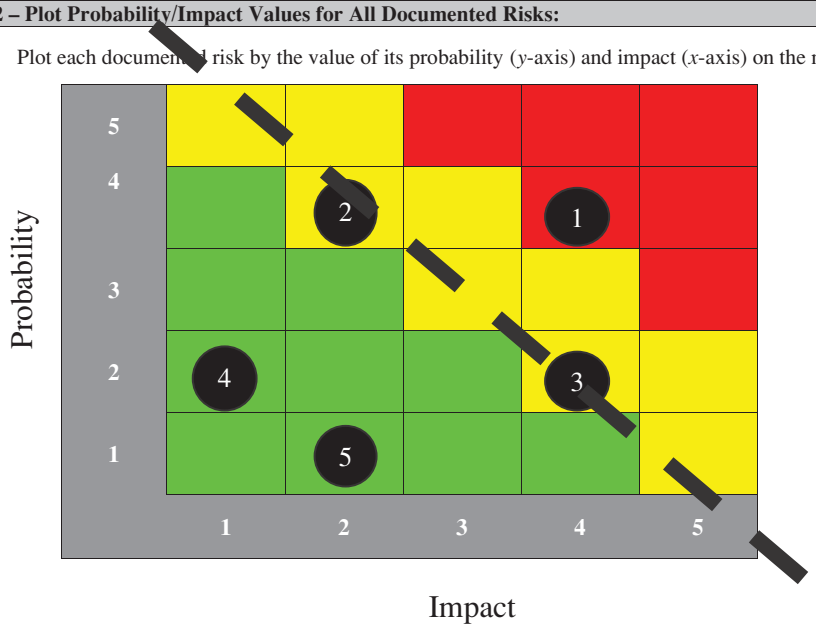
Exhibit 8.3. (Continued).

PROBABILITY AND IMPACT MATRIX *EXAMPLE* – Page 2

Step 2 – Plot Probability/Impact Values for All Documented Risks:

- Plot each documented risk by the value of its probability (*y*-axis) and impact (*x*-axis) on the matrix.



Step 3 – Assign Risk Levels to Plotted Matrix Based on Organization's Risk Tolerance

- Color code the risk ranking matrix boxes by assigning risk level values according to the organization's risk tolerance. The color coding included here can be used as a starting point and can be customized. Create a key for the custom ranges.

Sample Key:

Risk Level
Low
Moderate
High

- Draw a line to differentiate high risks from low risks in the matrix. Determine whether additional steps should be taken to respond to the results.

Exhibit 8.4. The risk register.

Project Name:	
Checklist Completed by:	**Date Completed:**
Project Manager:	**Date Updated:**

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to Be Taken	Cost to Respond	Status	Date, Status, and Review Comments

Exhibit 8.4. (Continued).

RISK REGISTER *INSTRUCTIONS*

This document is an annotated version of the risk register template and outlines the type of information to be included the template. Customize the template with appropriate language and content for the unique needs of the airport environment and each project specifically.

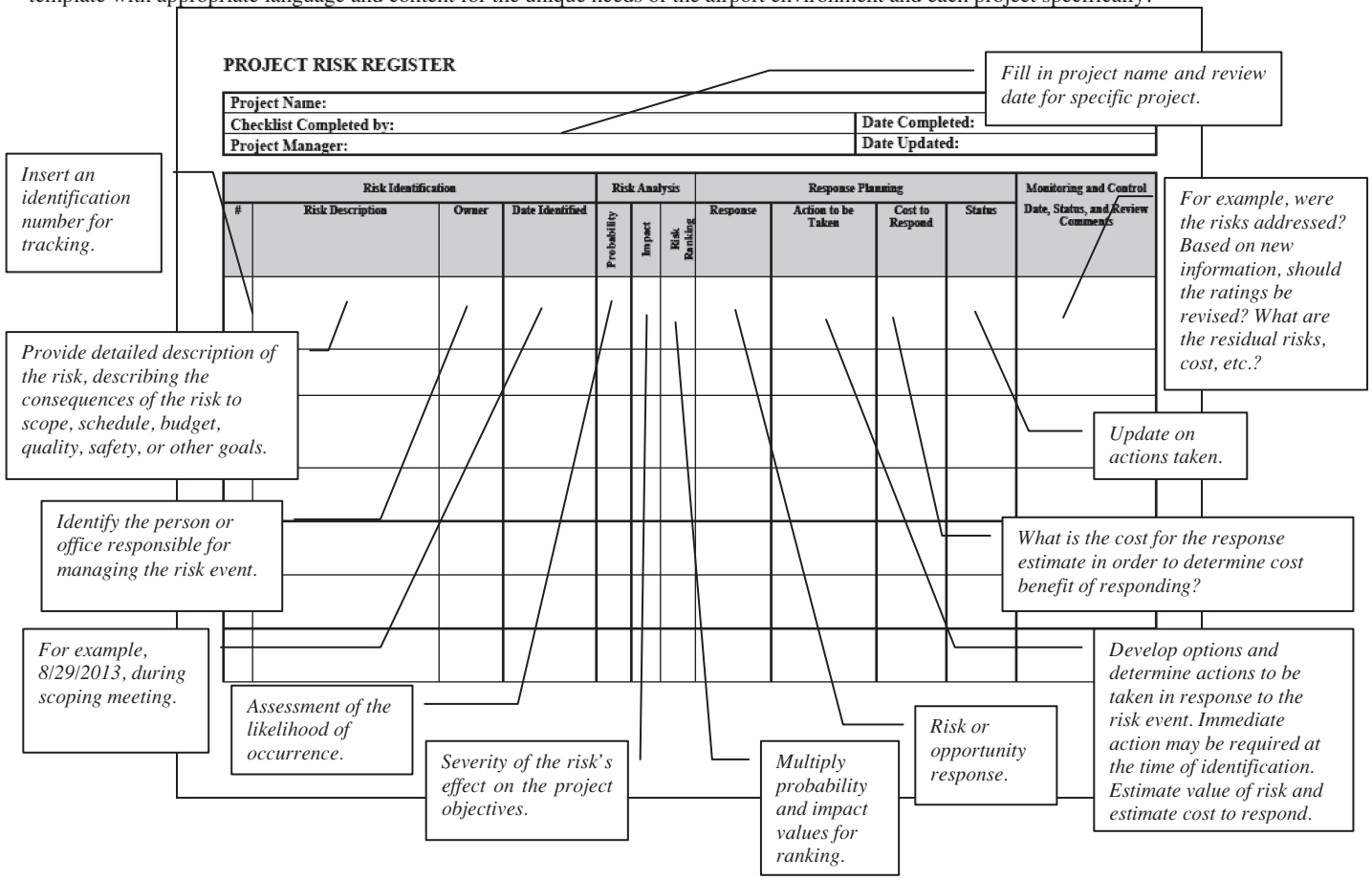


Exhibit 8.4. (Continued).

PROJECT RISK REGISTER *EXAMPLE*

The following is an example of the risk register for an airport project.

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to Be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change affects design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways. Will require descoping because budget is fixed. Circular #?
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	Mitigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects result in schedule delays	Sue Johnson	10/27/2012	4	4	16	Mitigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	Mitigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delay schedule and affect budget	John Norman	10/27/2012	1	4	4	Mitigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line, prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	Avoid	Training, barriers, markings	$100,000	Training completed on 11/30	

PART 4

Project Risk Management Implementation

Chapter 9. Implementing Project Risk Management 95

Part 4 Objectives

Part 4 addresses the following questions:

- What are the characteristics of successful project risk management processes?
- How can a risk-based culture be fostered?
- How are the appropriate tools and level of rigor integrated into an organization's project risk management process?

CHAPTER 9

Implementing Project Risk Management

All projects delivered in an organization, regardless of size, type, or funding source, can benefit from some level of project risk management activity. The process must make the most efficient use of the limited resources of time, people, and money in the organization. When implementing project risk management, consideration should be given to attributes of the organization such as the organization's risk tolerance, operational maturity, and time and resources available. The project risk management process must also be scalable and flexible based on the project attributes such as size, type, exposure, and complexity.

An effective method to start a new project risk management program in an organization quickly is to simply begin using a risk checklist at the kickoff of every capital or maintenance project regardless of the size, resources, or complexity. The organization can then increase competency by incorporating a probability and impact matrix, add in the project risk management plan, and document actions from all steps in the process in the risk register.

9.1 Characteristics of Successful Project Risk Management Processes

Successful project risk management processes will have the following characteristics:

- A focus on managing risk through the iterative steps of risk management planning, identification, analysis, response planning, and monitoring and control—to cost-effectively keep risk exposure at an acceptable level.
- A focus on managing opportunities—to lower costs, shorten schedules, or enhance scope and/or quality.
- Practical, repeatable, and consistent methods for ease of integration into existing programs and processes.
- Flexible, scalable tools that are simple to use and apply to any type of project (construction, maintenance, capital, operating, technology, systems, etc.).
- A standard framework that can be scalable to the complexity of specific projects, as well as the organization's stakeholders, resources, and risk maturity.
- Project staff members who demonstrate project risk management processes as part of their daily work activities, however small their contribution might be.
- Flexible flow for project risk management steps to add more or reduce risk management if a project's complexity changes.
- Dynamic flow that can be performed iteratively through the life of a project and is adaptable to an organization's need to rapidly respond to the changing internal and external environment.

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- Inclusion of project standards to trigger response strategies, enable monitoring and control, and provide a basis for evaluation of effectiveness.
- Incorporation of process and project lessons learned to drive continuous improvement and build institutional knowledge.

9.2 Fostering a Risk-Based Culture

Prior to implementing project risk management and further embedding project risk management into an organization's standard processes, an organization must assess its current risk culture—the values and behaviors that shape risk decisions. The organization must address weaknesses within its risk culture to create an environment for successful and sustainable project risk management implementation.

The signs of a weak risk culture include:

- The organization's risk culture is unknown, unclear, or not demonstrated in decision making;
- Risk tolerances are unknown or not communicated at organizational or project levels;
- Project teams are frequently surprised by poor project performance, such as project cost or schedule overruns or under runs;
- Project risks and opportunities, or their potential impacts on project success, are not understood;
- Efforts are undertaken without a clear understanding of short- and long-term consequences;
- Project risk management is often skipped or shortchanged due to a perceived lack of time or resources; and
- "Fighting fires" is a common practice.

Implementing project risk management by embedding it into existing processes in capital and maintenance project management increases the likelihood for sustainability within the organization. Implementing the process by using some of the basic tools and then growing the utilization of additional tools over time will likely increase the ability to gain buy-in as well as the ability to embed the process in the organization's project processes.

9.3 Overcoming Implementation Barriers

Institutionalizing project risk management provides a means to overcome the challenges of a weak risk culture and promote a more positive approach toward managing project risk.

Successful implementation of project risk management may require project team members to assume additional responsibilities and accountability for project performance. This could initially be perceived as a burden to the project team, especially to those members that are not accustomed to documenting their decision processes.

A critical element of implementing anything new—project risk management included—is the ability to manage change within the organization to ensure that personnel understand both the need for the change and the benefits it will provide. Senior management can demonstrate commitment to the project risk management effort by tailoring traditional change management best practices to the roll-out of project risk management. Table 9.1 adapts the process presented in John Kotter's seminal work on change management, *Leading Change*, to the steps needed to integrate project risk management into an airport's standard procedures (Kotter, 1996). The table presents the actions needed to progress through each step as well as the potential pitfalls that could hinder the initiative. Each of these steps is further described in the following text.

Table 9.1. Overcoming barriers to implementing project risk management in an organization.

Step	Barrier	Actions
Establish the Need	• Lack of senior management support or involvement	• Compare historical project performance to determine if project goals are routinely met versus missed • Hold project teams accountable for project performance
Develop and Communicate a Vision for Actively Managing Project Risk	• Lack of a simple and concise vision as to how project risk management can make a difference and help fulfill an airport's needs • Inability to communicate the vision • Behaving in ways contrary to the vision (e.g., not providing adequate resources, lack of consideration of existing resource capacity and capability, using poor project performance not as a learning experience but as a weapon)	• Engage internal and external stakeholders with a compelling message as to why project risk management would help ensure project objectives are met and why it is important to meet project scope, schedule, budget, and quality objectives • Ensure that appropriate resource capacity and capability exists
Form the Right Implementation Team	• Failure to get past traditional silos of responsibility (e.g., between design and construction and between construction and maintenance) • Failure to tap the right people to develop and champion project risk management	• Assemble a cross-disciplinary team that understands the full project life cycle and project risk management • Clearly define roles and responsibilities of team members
Empower Others to Act on the Vision	• Failure of senior management to remain involved, hold project teams accountable, and/or allocate the necessary resources • Underestimating organizational inertia and the difficulty of pushing people out of their comfort zones	• Remove obstacles that would undermine efforts to implement project risk management • Provide adequate resources to those accountable and responsible for managing project risks • Review and approve risk management plans developed for individual projects
Develop an Action Plan and Include Milestones for Short-Term Achievements	• Failure to set realistic expectations • Failure to adequately account for the learning curve that people must navigate before understanding and mastering a new process or technology	• Identify and communicate the goals and objectives of the implementation effort
Institutionalize Project Risk Management	• Failure to formalize new procedures • Lack of patience related to realizing the benefits of implementing project risk management (some of which may be purely anecdotal)	• Identify and communicate benefits of actively managing project risks • Establish scalable and flexible guidance and templates for managing project risk • Conduct training sessions • Communicate and document project risk management thinking in decision making • Use lessons learned in the project risk management process • Start with simple tools and elevate to more complicated tools as the process matures

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9.4 Flowchart as Project Risk Management Tool Selection Guide

Figure 9.1 depicts the different decision points included in the project risk management process and can be used at the planning step to guide the selection of tools to be used based on the complexity of the project. The flowchart can also be referenced at various points

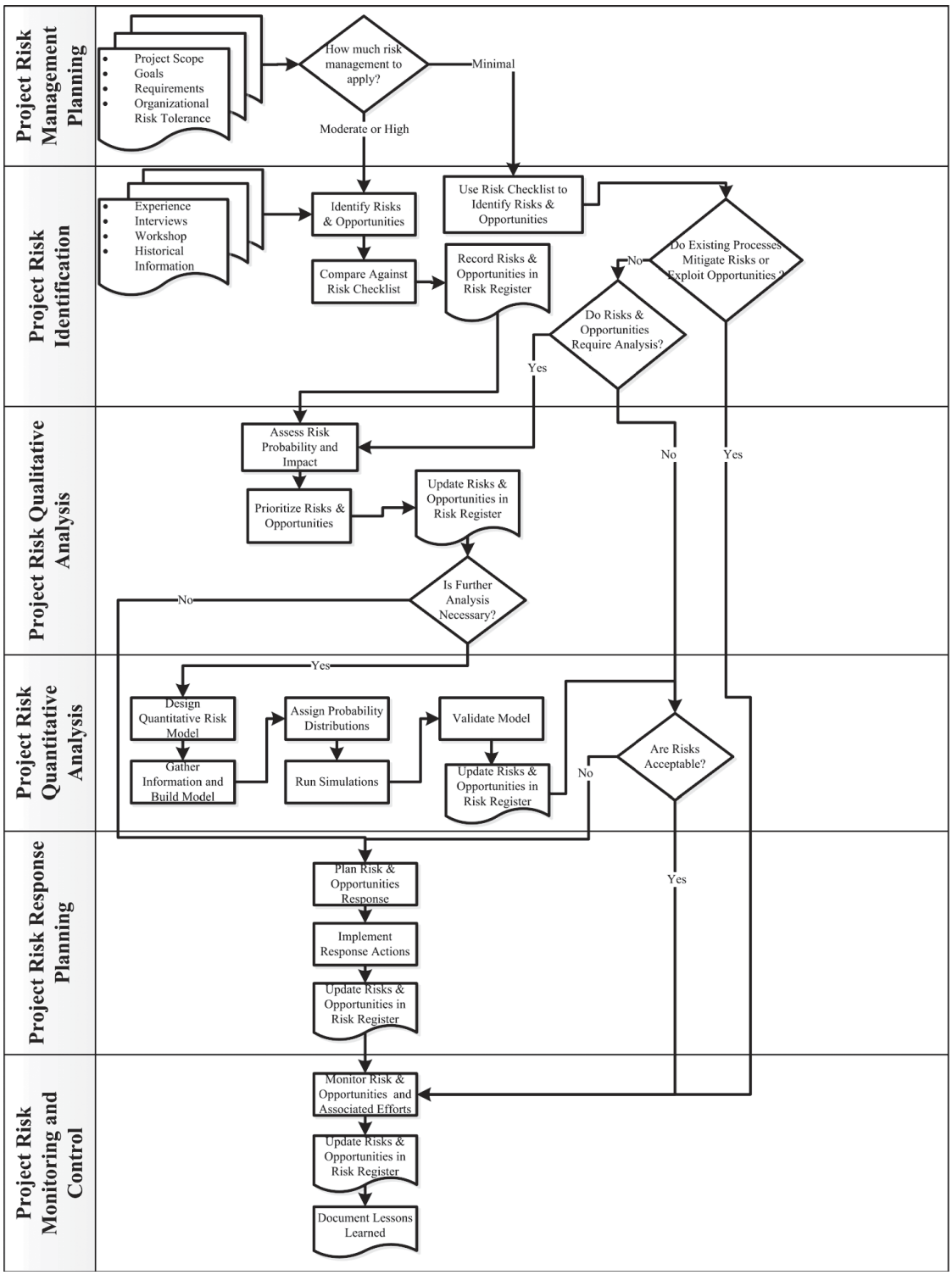

Figure 9.1. Project risk management flowchart.

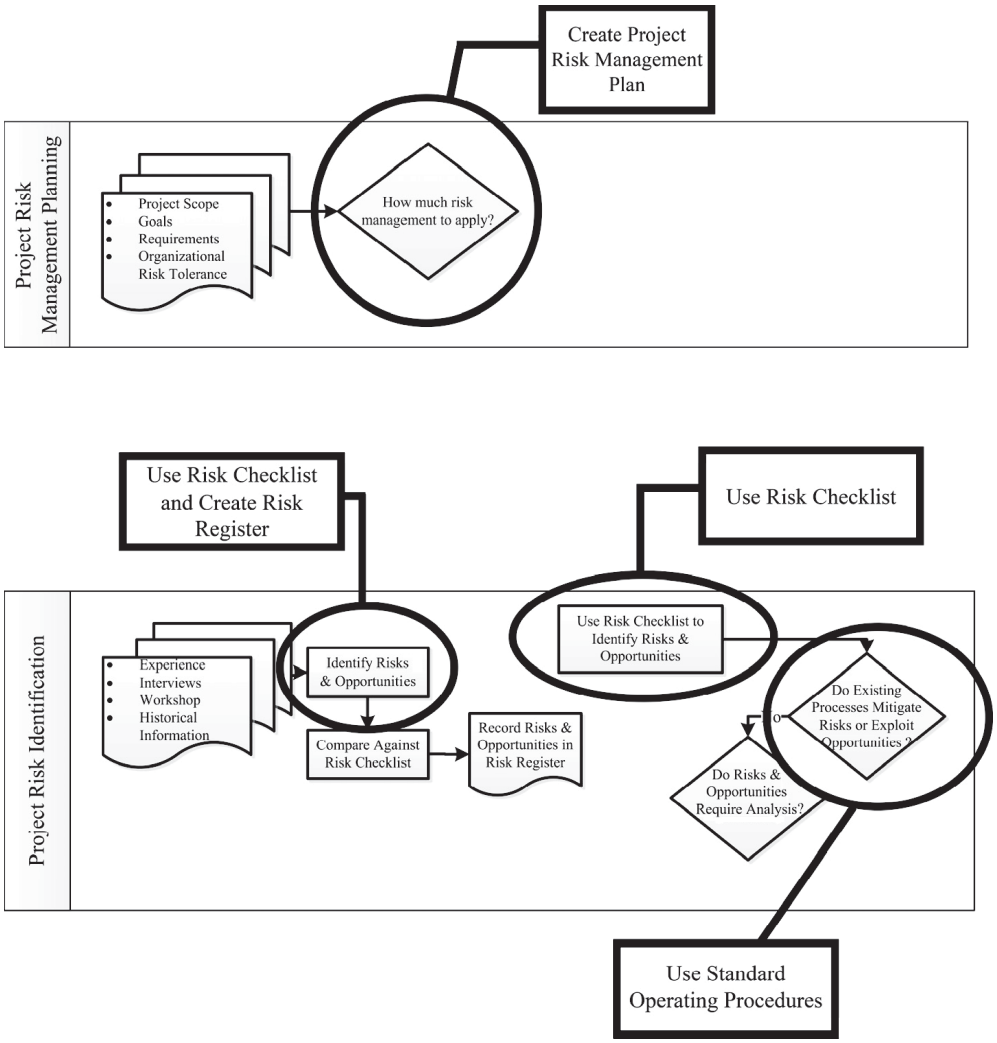

Figure 9.2. Deconstructed project risk management flowchart.
(continued on next page)

throughout the life of the project to ensure that the right amount of project risk management has been applied.

Figure 9.2 illustrates a deconstructed view of the project risk management flowchart with each step separated in order to highlight the decision point and the tool that would be selected as a result of the decision.

9.5 Integrating and Maturing Utilization of Tools

The tools outlined in this guidebook are flexible for use in most organizations regardless of project risk management process maturity and are also scalable for the size, type, and complexity of the project.

The flowchart in Figure 9.1 can guide the selection of various tools to be included in the project risk management plan.

The guidelines outlined in Table 9.2 include the scalability of the tools for low-risk versus high-risk projects. The last column in the table lists additional tools to add to the process as the organization begins to mature the project risk management process.

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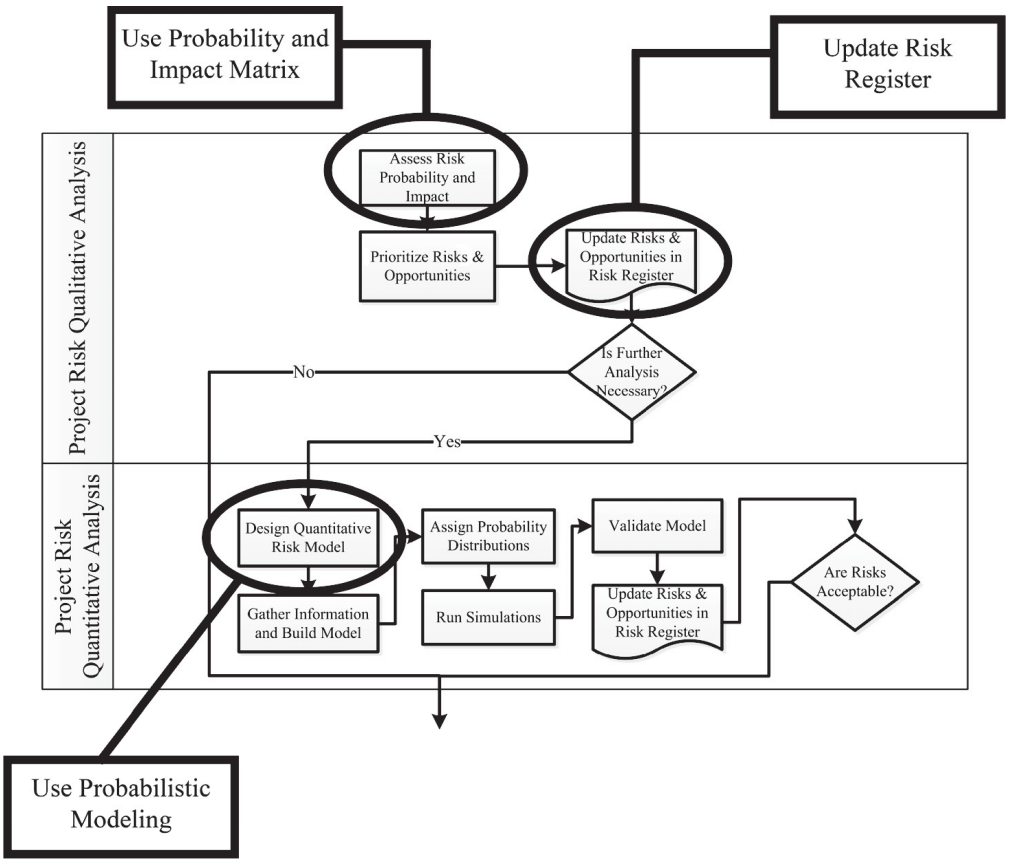
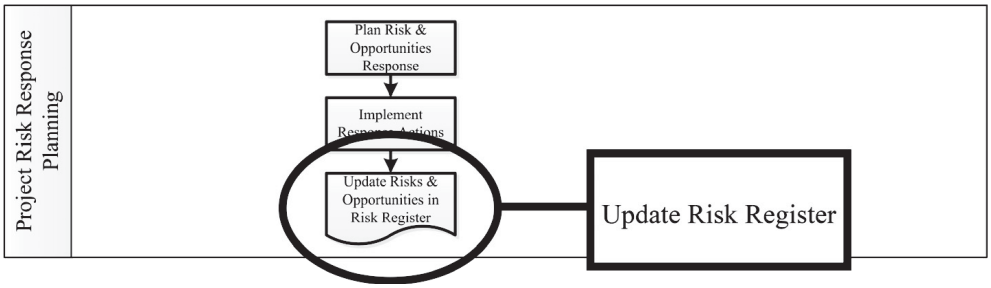




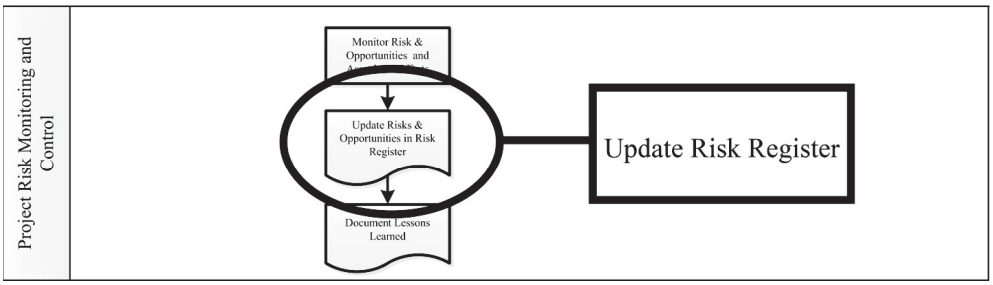
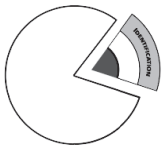


Figure 9.2. (Continued).

Table 9.2. Additional tools for project risk management.

Step	Low Risk (Simple or Small-Scale Projects)	High Risk (Large, Critical, or Complex Projects)	Additional Tools and Techniques for Consideration
Risk Management Planning 	Project manager establishes the general approach to risk management that the team will follow. May or may not result in a risk management plan.	A formal, written risk management plan is developed and submitted to senior management for review and approval. At predetermined points and as necessary, plan is reviewed to determine if adjustments are necessary. **Tool:** Risk management plan	SWOT analysis Lessons learned
Project Risk Identification 	Conducted by the project manager with input from project team as necessary. **Tool:** Risk checklist	Conducted during a facilitated risk workshop with internal and/or external subject matter experts. **Tool:** Risk register	Affinity diagrams Cause-and-effect maps Retrospective analysis Scenario analysis Expert consensus Root-cause analysis Fishbone Five Whys Cause-and-effect analysis Failure mode and effect analysis Mind mapping
Project Risk Analysis 	Qualitatively assess risks to identify the most critical. **Tool:** Probability and impact matrix worksheet	The team, working collaboratively with independent subject matter experts, reviews and/or validates cost and schedule estimates and identifies, characterizes, and analyzes risks. This process may involve both qualitative and quantitative tools to evaluate and prioritize risks and establish risk-based contingencies. **Tool:** Updated risk register (based on quantitative and/or qualitative analysis) Probabilistic modeling	Failure mode and effects analysis Risk bow tie Decision analysis

(continued on next page)

9.6 Aligning Project Risk Management, Project Management, and Enterprise Risk Management

Ideally, project risk management should become an integral activity in the overall project management process and should not be performed in isolation from other project management activities. Project risk management can enhance project management by providing a structured approach to managing uncertainty to help ensure that project objectives will be met.

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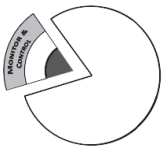
Table 9.2. (Continued).

Step	Low Risk (Simple or Small-Scale Projects)	High Risk (Large, Critical, or Complex Projects)	Additional Tools and Techniques for Consideration
Project Risk Response Planning 	Brainstorming session **Tool:** Updated project plan Existing standard operating procedures	Perform cost–benefit analysis to determine the optimal response strategies **Tool:** Updated risk register	Contingency planning
Project Risk Monitor and Control 	Periodic status meetings, as required, including discussion of progress, issues, etc.	Regularly monitor and record effectiveness of response strategies using the risk register. Conduct formal after-action review workshop to identify lessons learned and best practices to apply to future project. **Tool:** Risk register	Project management Variance and trend analysis Reserve/contingency analysis Risk audits

Staying within the bounds of accepted organizational expectations is good risk management.

Actions employed at the enterprise level to limit risk exposure to key organizational concerns such as safety, security, financial liability, and organizational reputation can influence the identification and analysis of risk at the individual project level. Enterprise risk management can provide risk tolerance levels for project risk management to incorporate into activities throughout the process and foster the organization's risk culture.

Figure 9.3 shows the links between these three programs.

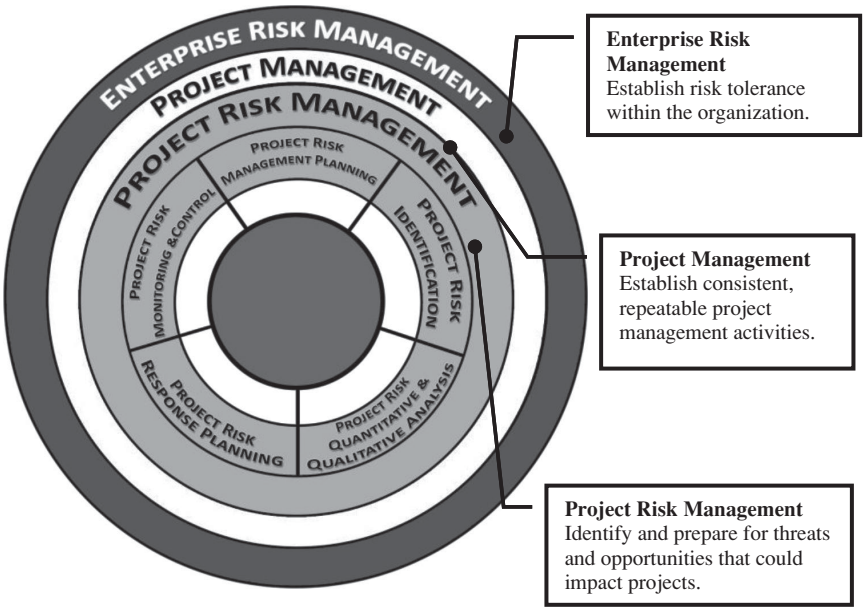


Figure 9.3. Linkages for risk management.

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Glossary

Acceptance A risk response strategy that involves a lack of action related to the risk event prior to the event's occurrence.

Avoidance A risk response strategy where the risk event can no longer have an impact on the objective. Avoidance is often accomplished by eliminating the approach to the objective or eliminating the root cause.

Confidence Level A measure of how reliable a statistical result is, expressed as a percentage that indicates the probability of the result being correct.

Contingency The amount of funds, budget, or time needed above estimated amounts to reduce the risk of overruns of project objectives to a level acceptable to the organization; the portion of the project budget that is available for uncertainty within the project scope but outside the scope of the contract.

Contingency Reserve Funds or time set aside at a project or departmental level to contend with risks within departmental or project purview.

Distribution In statistical analyses, the plotting of data points in a graph to display the relative number of outcomes associated with iterative trials.

Enhancement An opportunity response strategy that involves efforts to increase the probability or impact (or both) of the opportunity event.

Enterprise Risk Management A holistic approach and process to identify, prioritize, mitigate, manage, and monitor current and emerging risks in an integrated way across the breadth of the enterprise.

Expert Judgment Opinions, advice, recommendations, or commentary proffered by a person or persons recognized, either formally or informally, as having specialized knowledge, proficiency, or training in a specific area.

Exploitation An opportunity response strategy that involves ensuring that an opportunity (which remains a probabilistic event) will definitely come to pass in the organization's favor.

Impact The severity of the outcome that may occur if a risk event happens.

Issue An event that has already occurred.

Likelihood The chance that something may happen, measured objectively or subjectively, and expressed either qualitatively or quantitatively.

Market Conditions Economic influences that may affect the availability of resources or supplies; can include contractors, labor, materials, and supplies.

Mitigation A risk response strategy that involves minimizing either the probability of the threat event or the impact (or both).

Monitoring Continual checking, supervising, critically observing, or determining status in order to identify change from the performance level required or expected.

Opportunity A risk that will have a positive impact on a project objective if it occurs.

Oversight Authority A governing body with responsibility to guide and direct the activities of an organization. In an airport environment, the oversight authority may be a city council, board of commissioners, board of directors, or another governing body.

Probabilistic Modeling An iterative, simulation-based analysis of project outcomes that generates a probability curve on the overall likelihood of achieving objectives.

Probability The likelihood of an event occurring.

Probability and Impact Matrix (P-I Matrix) A spreadsheet or graphic view with probability on the *y*-axis and impact on the *x*-axis used to highlight those risks (evaluated qualitatively) in the higher zones.

Program Risk Management Managing the cumulative risk of all of the projects in a portfolio.

Project Risk An uncertain event or condition that, if it occurs, has a positive or negative impact on at least one project objective.

Project Risk Management Managing risks associated with a specific project, through the iterative steps of identification, analysis, response planning, and monitoring and control.

Qualitative Risk Analysis Subjectively analyzing the risks obtained in the risk identification step and prioritizing for further analysis or determining which risks warrant a response.

Quantitative Risk Analysis Numerically analyzing the effect of risks obtained in the risk identification step and determining which risks warrant a response.

Residual Risk The amount of risk or level of risk impact after the existing control environment has been taken into account. Also referred to as net risk.

Response The activity deliverable or process by which an individual risk will be managed.

Risk The events with varying degrees of uncertainty that may have a positive or negative influence on the project.

Risk Appetite The amount of risk, on a broad level, an entity is willing to accept.

Risk Categories Organized groupings of risks by like topics or natural affinities.

Risk Culture The values and behaviors present throughout an organization that shape risk decisions.

Risk Factor A condition or constraint that makes it more probable that a risk event or opportunity may occur or that can increase the severity of a risk impact.

Risk Identification The process of identifying and documenting the uncertainties that could affect project performance; the first component of the risk management process.

Risk Management The practice of dealing with risks in a process-oriented fashion to keep risks within organizational tolerances.

Risk Management Plan A document outlining the details of risk management approaches, responsibilities, resources, terms, tolerances, timing, and processes.

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Risk Model A mathematical representation of a project that can be used as the basis for quantitative risk analysis.

Risk Monitoring and Control Managing the effectiveness of the selected risk handling approaches.

Risk Owner An individual with responsibility and authority for overseeing and being accountable for a given risk event.

Risk Register Spreadsheet or document providing information about individual risks and their strategies, including event, probability, impact, response, owner, and review dates.

Risk Response Planning Determining the best approach for handling identified risks, such as to accept, transfer, mitigate, or avoid.

Risk Threshold A measure of the level of risk exposure above which action must be taken to address threats and opportunities proactively and below which risks may be accepted.

Risk Tolerance Organizational, project-level, or individual limit beyond which risk events become wholly unacceptable.

Risk Trigger A symptom or warning sign that indicates that a risk is becoming a near-certain event and a contingency/response plan should be implemented.

Senior Management Senior leadership in the organization that sets policy and governance thresholds, up to and including board members.

Sensitivity Analysis A quantitative risk analysis technique used generally within probabilistic modeling analysis to expose key risk drivers by varying one or more parameters within a risk model and determining the extent of the effect on the overall outcome. Results are usually presented using a tornado chart.

Sharing An opportunity response strategy that involves efforts to increase the probability of an opportunity event by shifting some of the risk to a third party.

Subject Matter Expert A person who is an expert in a certain area or topic.

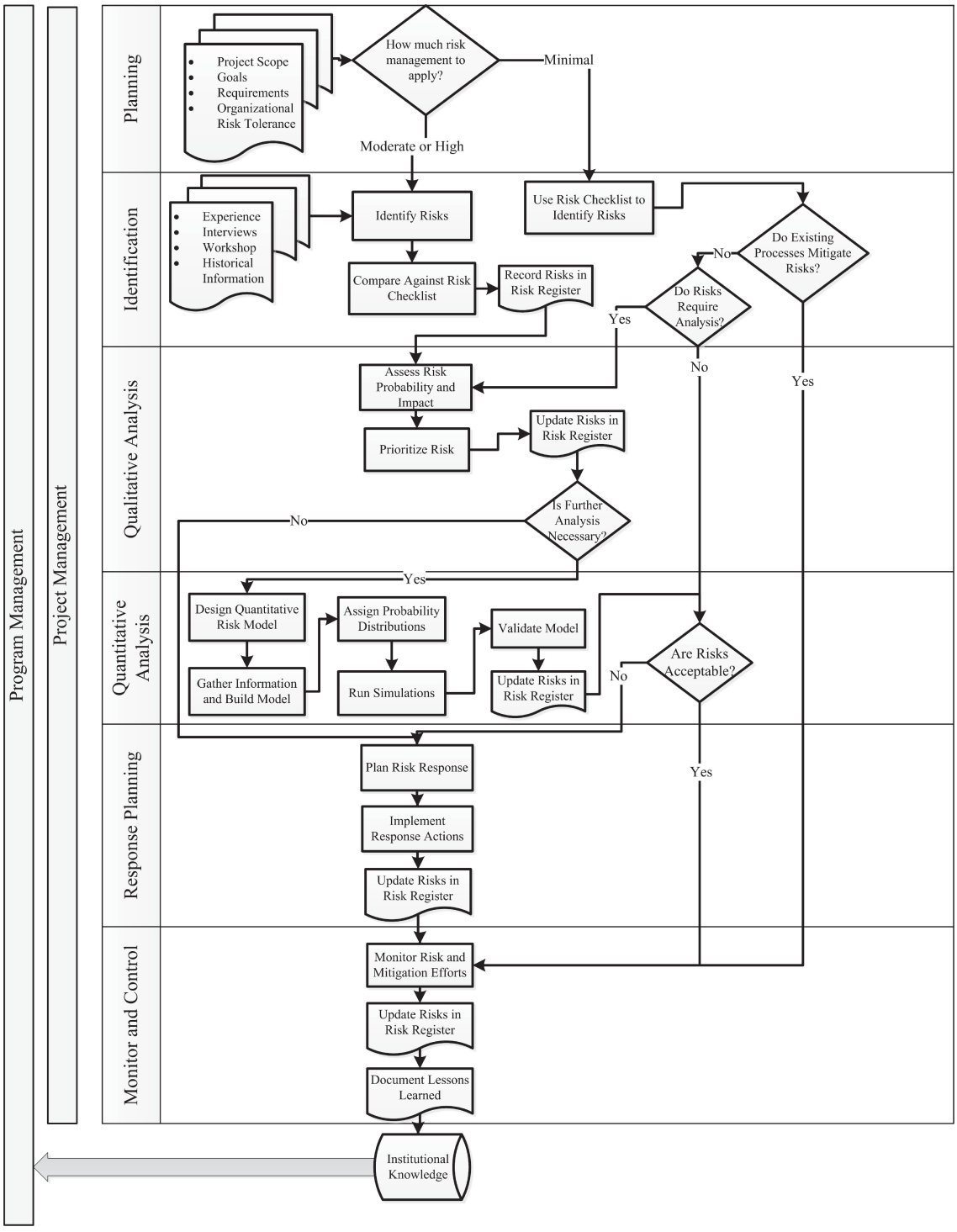
Tornado Chart An output from a quantitative risk analysis using probabilistic modeling analysis that shows the main risk drivers in descending order of importance. A tornado chart is useful for comparing relative importance and impact of variables that have a high degree of uncertainty to those that are more stable.

Transfer A risk response strategy that involves shifting the burden of a risk (either in whole or part) to a third party.

APPENDIX A

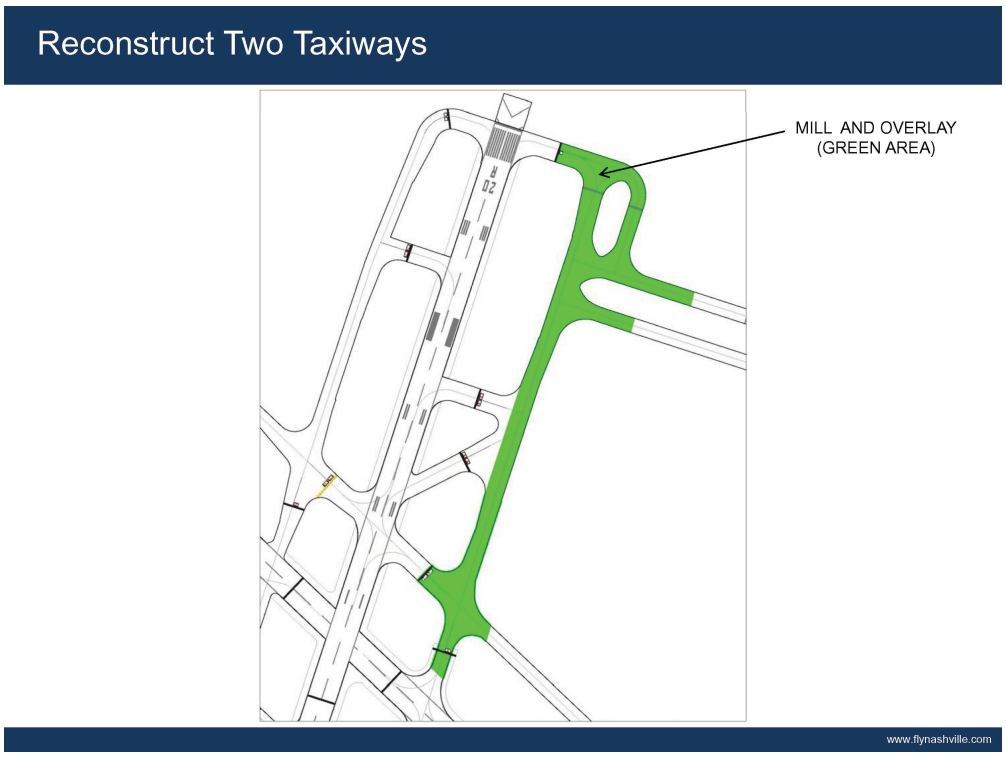
Case Study I: Taxiway Reconstruction

The taxiway reconstruction project case study includes additional information in the case study material not used in the main portion of the guidebook in order to demonstrate the entire practice of the process of project risk management. Using the following flowchart as an organizer, the taxiway reconstruction example follows the flow of a moderate- to high-risk project and connects the project risk management process to the overall organization practice of project management and program management. By completing a project debrief and lessons-learned review, the organization can complete the cycle of project risk management and embed the lessons learned into institutional knowledge, which completes the project and embeds it into the program.



Project Overview

A medium-hub airport was preparing to conduct taxiway reconstruction as defined in the airport's master plan.



The project was scheduled to begin design in June, with construction expected to begin 6 months later. The reconstruction project was scheduled in alignment with FAA funding schedules in anticipation of receiving funds in time to begin and conduct construction.

The taxiway project was originally scoped for 4,000 ft of asphalt pavement with an estimated $6 million budget funded by the FAA and airport passenger facility charges in a 75/25 ratio.

The funding for this project was fixed, so scope and schedule were the areas that were affected by the risks and risk mitigations.

The project was managed by an internal airport project manager, designed by consultants, constructed by contractors, and inspected by consultants.

For the scope of this project, the design–bid–build construction process was selected.

The project risk management process was included in the project management of the project. Many risks were realized through the project duration and will be highlighted at each phase throughout this case study.

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Step 1: Taxiway Reconstruction—Risk Identification

Background of Airport

The airport was managing multiple construction projects at the same time using a combination of internal and contract staff. The airport operates two runways and receives funding based on medium-hub status. Operations are primarily origination-and-destination traffic.

The airfield does not operate at full capacity; however, all maintenance downtime must be carefully scheduled to avoid any air traffic delays.

The airport typically outsources construction design to outside experts. The internal procurement process works in accordance to federal regulations.

Risk Identification Step

The project team performed the identification of risks in a risk workshop using an outside facilitator to conduct the session. The entire internal project team was present, along with the contracted resources that would be performing project work.

Risks and opportunities identified through this workshop were captured in a risk register. Each risk was assigned an owner who would take responsibility for the risk analysis and response plan and would provide monitoring and control reviews.

The risk workshop took approximately 4 hours to complete and included the risk analysis process. The identification of risks took less than 1 hour, from which a list of risks was generated.

Risk Register

Project Name: Taxiway Reconstruction

Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways Will require descoping because budget is fixed Circular #?
2	Limited number of local bidders, resulting in higher cost and schedule uncertainty	Paul Jones	10/27/2012	4	2	8	Mitigate	Industry outreach to energize bidder pool	None		
3	Competing priorities among current project, ongoing airport operations, and other projects results in schedule delays	Sue Johnson	10/27/2012	4	4	16	Mitigate	Formal prioritization of projects at program level Stakeholder outreach	Negligible	Standing program review meetings set for every Monday	
4	Construction vehicle access and traffic flow may be limited to accommodate ongoing airport operations, resulting in schedule delays and inefficiency	Sue Johnson	10/27/2012	5	3	15	Mitigate	Minimize traffic disruption by optimizing construction phasing plan	Negligible		
5	Unforeseen conditions delays schedule and impacts budget	John Norman	10/27/2012	1	4	4	Mitigate	Additional field investigation	$40,000		As of 3/14/2013, additional field investigations indicated underground utility line prompting redesign
6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	Avoid	Training Barriers Markings	$100,000	Training completed on 11/30	

Step 2: Taxiway Reconstruction—Risk Analysis

Risk Analysis

Once the risks were identified, analysis was performed using the risk register. A rating of 1–5 was assigned to qualitatively analyze the probability of a risk occurring as well as its impact on the project. The risk rating applied was the product of the probability multiplied by the impact. This equation was used to produce a ranked list of risks for the response planning discussion. The results of this analysis allowed the team to focus on the highest combined impact and probability risks in order to determine actions for responses.

Risk Register

Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identifie	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
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6	Airfield incursion resulting in work stoppage	Mike Allen	10/27/2012	3	5	15	void	Training Barriers Markings	$100,000	Training completed on 11/30	

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Step 3: Taxiway Reconstruction—Risk Response Planning

Risk Response Plan

During the risk workshop, after analysis was complete, actions were identified and captured in the risk register to respond to risks according to their perceived severity and the probability of each risk occurring. The response was determined to be either avoidance, transference, mitigation, or acceptance. A clear action to be taken was then documented, along with an estimated cost for the response itself. Status was updated as the response activity occurred throughout the project's progress.

Risk Register

Project Name: Taxiway Reconstruction Review Date: 7/19/2012

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
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Step 4: Taxiway Reconstruction—Risk Monitoring and Control

Risk Monitoring and Control

The monitor and control step was managed in daily project progress meetings, with all stakeholders attending. These meetings included risk review and project issues reporting. The results captured in the risk register were solely the risk review items. Project issues were documented and shared with the whole team through project management status reporting. Project progress issues were identified and conflict resolved as much as possible in the meeting.

Project monitoring and control followed the project life-cycle phases, and project issues that occurred that were not identified as risks early in the planning process caused a need to revisit the project risk management plan and conduct a brief version of identification, analysis, and response to update the risk register.

At the completion of the project, the project manager conducted a final project close-out session, including discussing lessons learned, where all of the monitoring and control items were reviewed, discussed, and captured in an institutional knowledge database for reference and input to the next project.

Risk Register

Project Name: Taxiway Reconstruction Review Date: 7/19/20 2

Risk Identification				Risk Analysis			Response Planning				Monitoring and Control
#	Risk Description	Owner	Date Identified	Probability	Impact	Risk Ranking	Response	Action to be Taken	Cost to Respond	Status	Date, Status, and Review Comments
1	Regulatory change impacts design, affecting project scope, budget, and schedule	John Smith	10/27/2012	2	3	6	Accept	Liaison with FAA to remain apprised of upcoming changes	None	Meeting with FAA held on 2/13/2013	As of 2/13/2013, FAA advised of changes to paving requirements on taxiways Will require descoping because budget is fixed Circular #?
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Lessons Learned: Taxiway Reconstruction Project Debrief

In the project debrief meeting, the data captured in the monitor and control section of the risk register were reviewed. In addition to those items, other discussions included project issues that occurred that were not anticipated.

Issue Review and Discussion

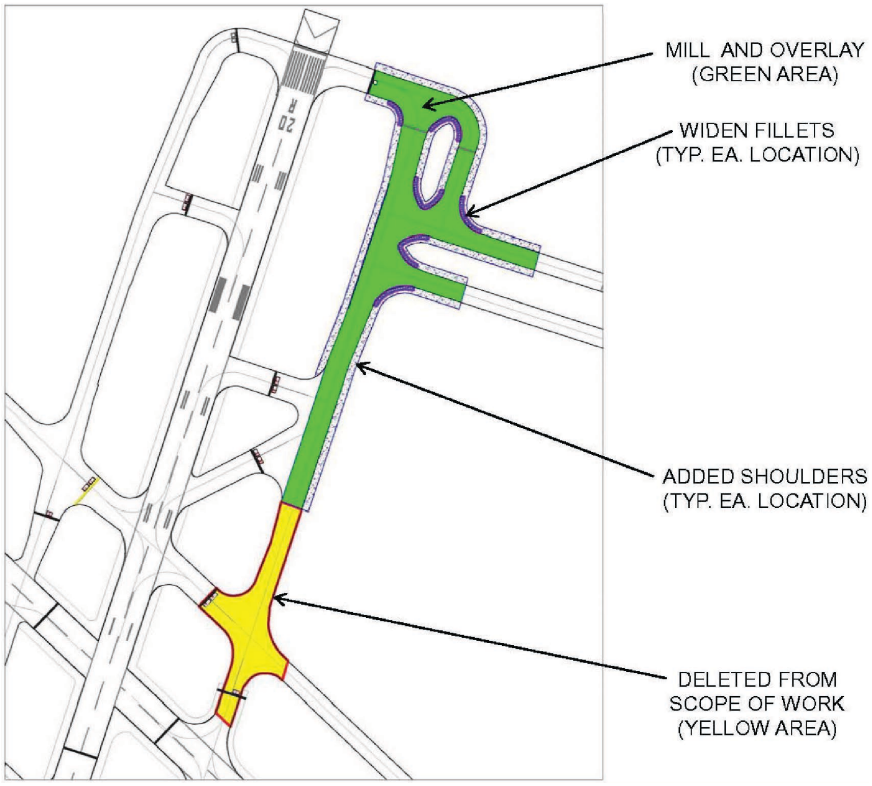
One of the project issues was that the FAA asphalt requirements to pave a taxiway reduced bidding to only one local provider that could meet the requirements. This caused a delay in the bidding process since it caused additional scrutiny by the airport board. The schedule slipped a month due to the delay.

Additionally, an FAA requirement change affected taxiway paved shoulder requirements from **recommended** to **required** that they be paved. An action the airport project managers took to attempt to mitigate this change was a request for a modification of standards to allow shoulders to remain unpaved based on the type of air traffic at the airport, but this was denied. This changed the scope of the taxiway reconstruction because the budget was fixed. The scope of the taxiway reconstruction was reduced to 2,500 ft.

Another issue discussed was an FAA turning-radius requirement for the taxiway. The FAA required an increase to the fillet size. The response of the project team was again to change the scope and also the schedule because the budget was fixed. The project needed to add in geotechnical activities and change the design of the taxiway project, which extended the schedule.

Another issue debriefed in the project review was the federal government shutdown in 2013. When the government suspended nonessential operations, it delayed the funding for the project, which, in turn, delayed the schedule and the availability of resources. This resulted in a rephasing of the project because air traffic could not be impeded, and the time of year the project was to be performed would have been an issue for deicing pad access.

The final project scope was as follows:



Lessons Learned

- Changed bid process to ask for both asphalt and concrete for all future taxiway projects in order to have multiple bids.
- Applied rescoping to all future taxiway projects to include paved shoulders, which has affected original plan of 5 years and $58 million budget, now increased to 9 years and $88.2 million.
- Applied seasonal impacts and traffic implications—stop-work order by the FAA.

APPENDIX B

Case Study II: Office Build-Out

The TSA recently mandated a change to the passenger screening process. In order to accommodate this mandate, a small-hub airport needed to perform an internal build-out to reconstruct the physical space where staff are located in order to create the required space. This small-hub airport serves commercial air traffic and has 52 employees and a $30 million operating budget.

The internal build-out is determined to be an operating project using internal maintenance staff. The changes require minor demolition to existing walls and build-out of two offices with access to the passenger concourse. Scope includes replacement of ceiling tiles, flooring, walls, power lines, data cables, and HVAC adjustments. The area affected is approximately 400 square feet.

The maintenance operating budget is $8 million, and this project is one of many in the course of the year that will be performed to maintain functional operations for the staff at the airport. A project of this scope should not exceed $12,000 in material costs and should not involve more than 3 weeks of construction time. The work effort is approximately two full-time resources for the 3 weeks, although the resources will be different talent and expertise over the duration of the project.

Internal resources used include maintenance manager, superintendent, electrician, and HVAC, carpentry, and general maintenance staff. The maintenance manager assumed the role of project manager for this project.

The project constraints for this office build-out are determined as schedule and budget.

The maintenance manager determined that the project was relatively low risk based on the experience of the resources assigned to the project and the scope identified for the build-out. He decided to use a probability–impact matrix with the project team to identify and rank the risks. The maintenance manager conducted a project kickoff session in which the team brainstormed a list of risks, and then ranked and prioritized the risks using the probability–impact matrix in order to determine if more project risk management might be needed.

The project kickoff session included the team of internal resources used to perform the project activities. During the discussion, the maintenance manager described the scope of the project, and the whole group reflected on past experiences with the customer as well as the type of work to identify preventative risks and reactive impacts.

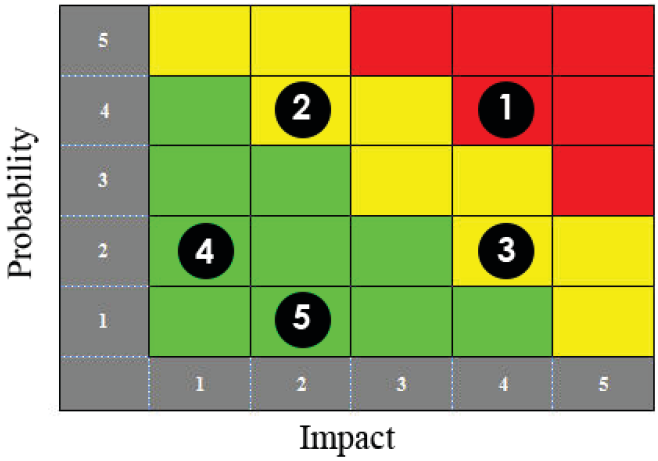
The following risks were identified:

- Customer slow in making decisions about design, which affects schedule.
- Competing priorities for project work team will affect schedule and budget.
- Unforeseen conditions found in demolition affect scope and may cause redesign.
- Need for permits to perform construction activities may affect schedule.
- Long lead time for selected materials causes delay in start of project.

The following probability and impact scores were applied:

Risk Description Summary	Probability Value	Impact Value
Customer slow in making decisions about design, which affects schedule.	4	4
Competing priorities for project work team will affect schedule and budget.	4	2
Unforeseen conditions found in demolition affect scope and may cause redesign.	2	4
Need for permits to perform construction activities may affect schedule.	2	1
Long lead time for selected materials causes delay in start of project.	1	2

The risks were plotted on the P-I matrix according to their values, and discussion was held to analyze the overall results.



The results of the discussion determined that all of the risks identified could be controlled by managing the schedule of the project very closely. The team determined to plan a schedule with realistic timelines and contingency days included. The maintenance manager also determined that clear communication was needed with the stakeholders of the project to discuss the schedule, the realistic timelines, and the risks associated to the project in order to increase awareness up front. The maintenance manager committed to a meeting with stakeholders and to holding regular progress meetings with the team as a result of this risk review. With these activities and commitments determined, no additional project risk management was determined to be necessary at this point.

APPENDIX C

Probabilistic Modeling

Probabilistic Modeling

One of the most widely accepted quantitative analysis techniques is probabilistic modeling, a computer-driven methodology of simultaneously evaluating the impact of all identified risks to arrive at defined probability distribution of the project's cost, completion date, or other key project inputs or objectives. The overall process is depicted in Figure C-1.

Probabilistic modeling simulation generally requires use of specialized risk analysis software packages and possibly outside risk analysts if such expertise is unavailable in-house. However, the associated investment of time and resources can be warranted if:

- Enough information is known about the risks to perform the analysis (i.e., the analysis is only as good as the input values),
- The project is highly complex or critical, and
- Given project conditions and constraints, there is little flexibility or tolerance for cost or schedule overruns.

The theory and specific how-to procedures related to performing a probabilistic modeling risk analysis are well established. The general steps involved are described here to provide an indication of both the power of this technique and the level of effort involved.

1. **Define the Desired Output from the Analysis.** At the outset, the project team should identify the goals of the analysis, bearing in mind that the question to be answered must be well-suited to mathematical modeling for the simulation to be effective. Cost, schedule, and integrated cost/schedule models have been widely used by several organizations, including the Port Authority of New York and New Jersey, the FTA, and various state departments of transportation across the United States, to develop risk-based project contingencies, refine project plans, and prioritize and define optimum risk response plans.
2. **Validate the Project Scope, Cost, and Schedule.** Before the effects of risk can be evaluated, the project team must have a clear understanding of the project's base scope, cost, and schedule. If an objective of the quantitative analysis is to develop a transparent, risk-based contingency reserve, the cost and schedule must be carefully reviewed to ensure that no excess reserves remain hidden in the cost or schedule.
3. **Prioritize the Identified Risks.** Referring to the risk register developed during the risk identification step, identify the main risks and uncertainties that could threaten or enhance project success. Qualitative techniques may be used to support this activity.
4. **Build a Base Model.** Quantitative risk analysis starts with a model of the project, such as its schedule or cost estimate, depending on the problem to be addressed. As most of the commercially available risk analysis software packages act as plug-ins to programs such as Microsoft Excel, it is often best to prepare the model using a spreadsheet.

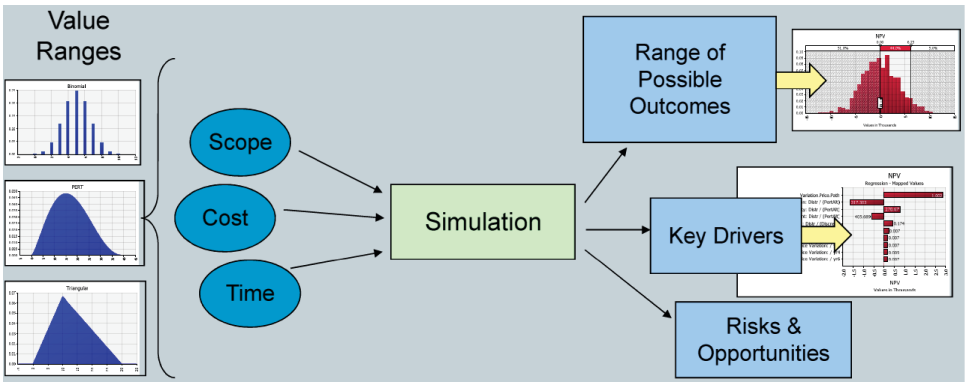


Figure C-1. Simulation inputs and outputs.

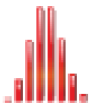
5. **Define Input Distributions.** Inputs into the schedule or cost models are represented by probability distributions since the actual cost or duration of each item is more accurately represented by a range of values than a single point estimate. Possible probability distributions are summarized in Table C-1; however, the selection of the most appropriate distribution for a given situation is best done with the assistance of a skilled risk analyst with knowledge of the project environment.

   For each project cost or schedule element, the probability distributions are usually specified in terms of three points: the minimum, most likely, and maximum values. These values are often identified in a workshop setting with input provided by subject matter experts.
6. **Run the Simulation.** A number of commercially available software packages are available to perform the actual simulation process, which entails iterating the project schedule or cost estimate computation multiple times and randomly drawing duration or cost values for each iteration from the probability distribution inputs.

   The resulting output of the simulation is a probability distribution function of possible project outputs (e.g., completion dates, project costs) and their likelihood of occurrence. For example, the sample output shown in Figure C-2 indicates that at a 90% confidence level, the project's finish date will be June 19, 2017 (assuming the identified risks remain unmitigated). (Interestingly, when evaluated using traditional deterministic scheduling techniques, the projected completion date for the project shown in this figure was September 22, 2016, almost 9 months earlier. The risk-based analysis revealed that the project had less than a 1% chance of meeting this date.)
7. **Explore Results Using Sensitivity Analysis.** The risk model can also be used to determine those tasks that are most responsible for affecting project output (e.g., driving up costs, increasing the overall project schedule) or otherwise positively or negatively affecting project objectives.

   A popular visual tool used to display such sensitivity analysis results is a tornado diagram, shown in Figure C-3. The diagram can be used to clearly prioritize and communicate those factors whose uncertainty has the largest influence on project success. For example, in the figure, delays in receiving environmental permits drive longer schedules 57% of the time, followed by restricted work hours, at 40%. Identifying the main risk drivers in this manner allows the project team to effectively target its proactive risk response strategies toward the most critical variables.

Table C-1. Possible probability distributions.

Distribution Type	Circumstances for Application
 Binomial	• You want to describe the number of times an event occurs in a fixed number of events. • For each event, only two outcomes are possible. • Events are independent of each other. • Probability is the same from trial to trial.
 Lognorm	• You have a situation where values are positively skewed, but cannot be negative. • The upper limit is unlimited, and the lower limit is zero. • Most values are near the lower limit.
 Normal	• The mean value is the most likely outcome. • Other values appear to be symmetrical around the most likely outcome. • Other values are more likely to be closer to the mean. • The distribution is defined by the mean and standard deviation.
 Uniform	• You know the range, and all possible values are equally likely. • Minimum value and maximum value are fixed. • All values in the range are equally likely to occur.
 TriGen	• Minimum, maximum, and most likely values are known. • High and low thresholds are of equal distance to expected outcome.
 Pert	• You know the minimum, maximum, and most likely values. • Values are fixed at the minimum and maximum. • Pert interprets the minimum, most likely, and maximum values with a smooth curve that places less emphasis on the extremes.

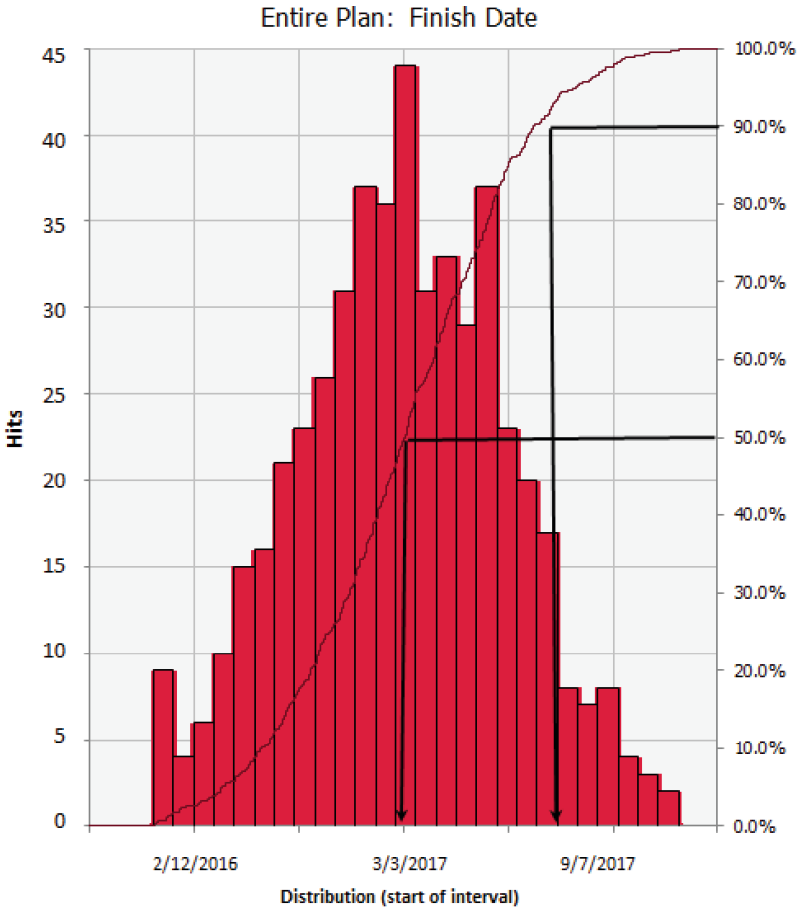


Figure C-2. Example output of probabilistic modeling simulation.

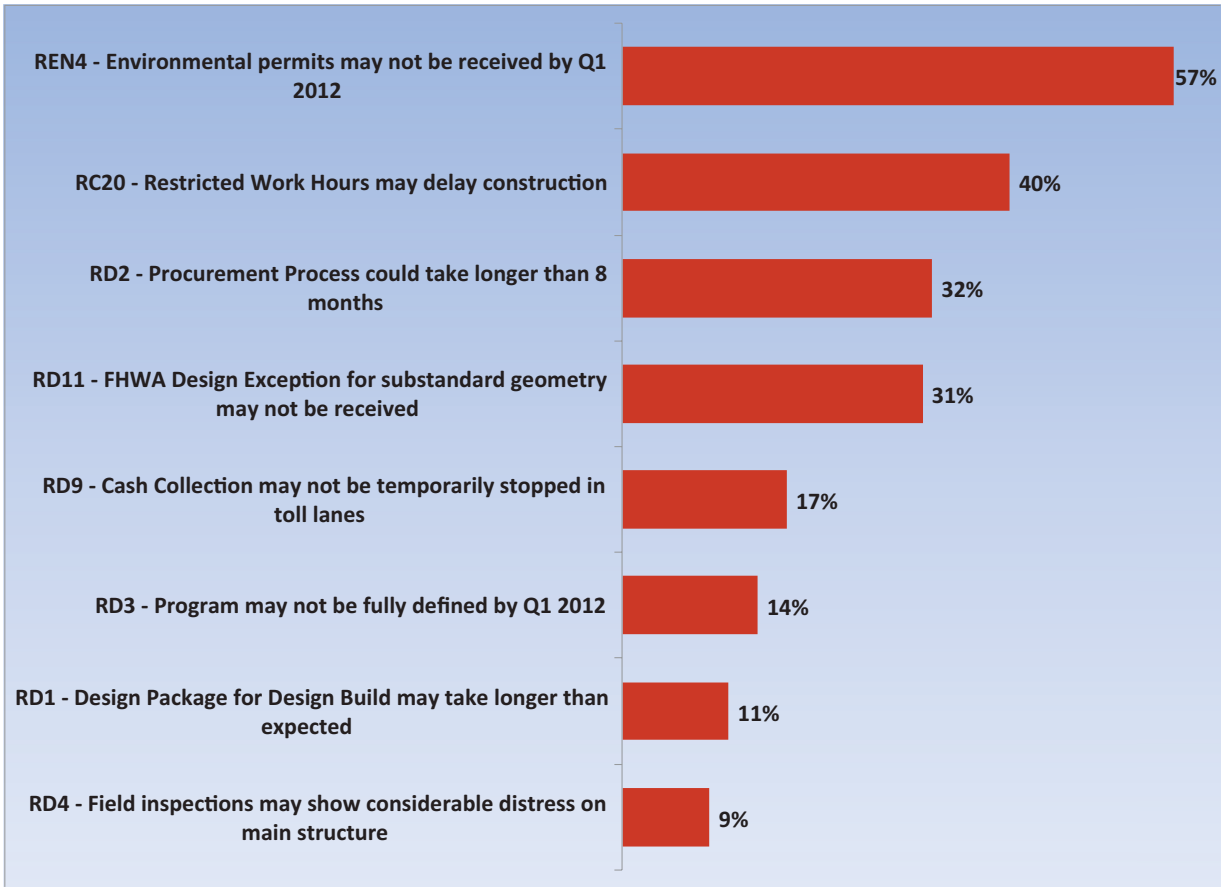


Figure C-3. Example sensitivity output using a tornado diagram.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation