11

PROJECT RISK MANAGEMENT

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project.

Figure 11-1 provides an overview of the Project Risk Management processes, which are as follows:

- **11.1 Plan Risk Management**—The process of defining how to conduct risk management activities for a project.
- **11.2 Identify Risks**—The process of determining which risks may affect the project and documenting their characteristics.
- **11.3 Perform Qualitative Risk Analysis**—The process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact.
- **11.4 Perform Quantitative Risk Analysis**—The process of numerically analyzing the effect of identified risks on overall project objectives.
- **11.5 Plan Risk Responses**—The process of developing options and actions to enhance opportunities and to reduce threats to project objectives.
- **11.6 Control Risks**—The process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project.

These processes interact with each other and with processes in other Knowledge Areas as described in detail in Section 3 and Annex A1.

Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality. A risk may have one or more causes and, if it occurs, it may have one or more impacts. A cause may be a given or potential requirement, assumption, constraint, or condition that creates the possibility of negative or positive outcomes. For example, causes could include the requirement of an environmental permit to do work, or having limited personnel assigned to design the project. The risk is that the permitting agency may take longer than planned to issue a permit; or, in the case of an opportunity, additional development personnel may become available who can participate in design, and they can be assigned to the project. If either of these uncertain events occurs, there may be an impact on the project, scope, cost, schedule, quality, or performance. Risk conditions may include aspects of the project's or organization's environment that contribute to project risk, such as immature project management practices, lack of integrated management systems, concurrent multiple projects, or dependency on external participants who are outside the project's direct control.

Project risk has its origins in the uncertainty present in all projects. Known risks are those that have been identified and analyzed, making it possible to plan responses for those risks. Known risks that cannot be managed proactively, should be assigned a contingency reserve. Unknown risks cannot be managed proactively and therefore may be assigned a management reserve. A negative project risk that has occurred is considered an issue.

Individual project risks are different from overall project risk. Overall project risk represents the effect of uncertainty on the project as a whole. It is more than the sum of the individual risks within a project, since it includes all sources of project uncertainty. It represents the exposure of stakeholders to the implications of variations in project outcome, both positive and negative.

Organizations perceive risk as the effect of uncertainty on projects and organizational objectives. Organizations and stakeholders are willing to accept varying degrees of risk depending on their risk attitude. The risk attitudes of both the organization and the stakeholders may be influenced by a number of factors, which are broadly classified into three themes:

- *Risk appetite*, which is the degree of uncertainty an entity is willing to take on in anticipation of a reward.
- *Risk tolerance*, which is the degree, amount, or volume of risk that an organization or individual will withstand.
- *Risk threshold*, which refers to measures along the level of uncertainty or the level of impact at which a stakeholder may have a specific interest. Below that risk threshold, the organization will accept the risk. Above that risk threshold, the organization will not tolerate the risk.

For example, an organization's risk attitude may include its appetite for uncertainty, its threshold for risk levels that are unacceptable, or its risk tolerance at which point the organization may select a different risk response.

Positive and negative risks are commonly referred to as opportunities and threats. The project may be accepted if the risks are within tolerances and are in balance with the rewards that may be gained by taking the risks. Positive risks that offer opportunities within the limits of risk tolerances may be pursued in order to generate enhanced value. For example, adopting an aggressive resource optimization technique is a risk taken in anticipation of a reward for using fewer resources.

Individuals and groups adopt attitudes toward risk that influence the way they respond. These risk attitudes are driven by perception, tolerances, and other biases, which should be made explicit wherever possible. A consistent approach to risk should be developed for each project, and communication about risk and its handling should be open and honest. Risk responses reflect an organization's perceived balance between risk taking and risk avoidance.

To be successful, an organization should be committed to address risk management proactively and consistently throughout the project. A conscious choice should be made at all levels of the organization to actively identify and pursue effective risk management during the life of the project. Project risk could exist at the moment a project is initiated. Moving forward on a project without a proactive focus on risk management is likely to lead to more problems arising from unmanaged threats.

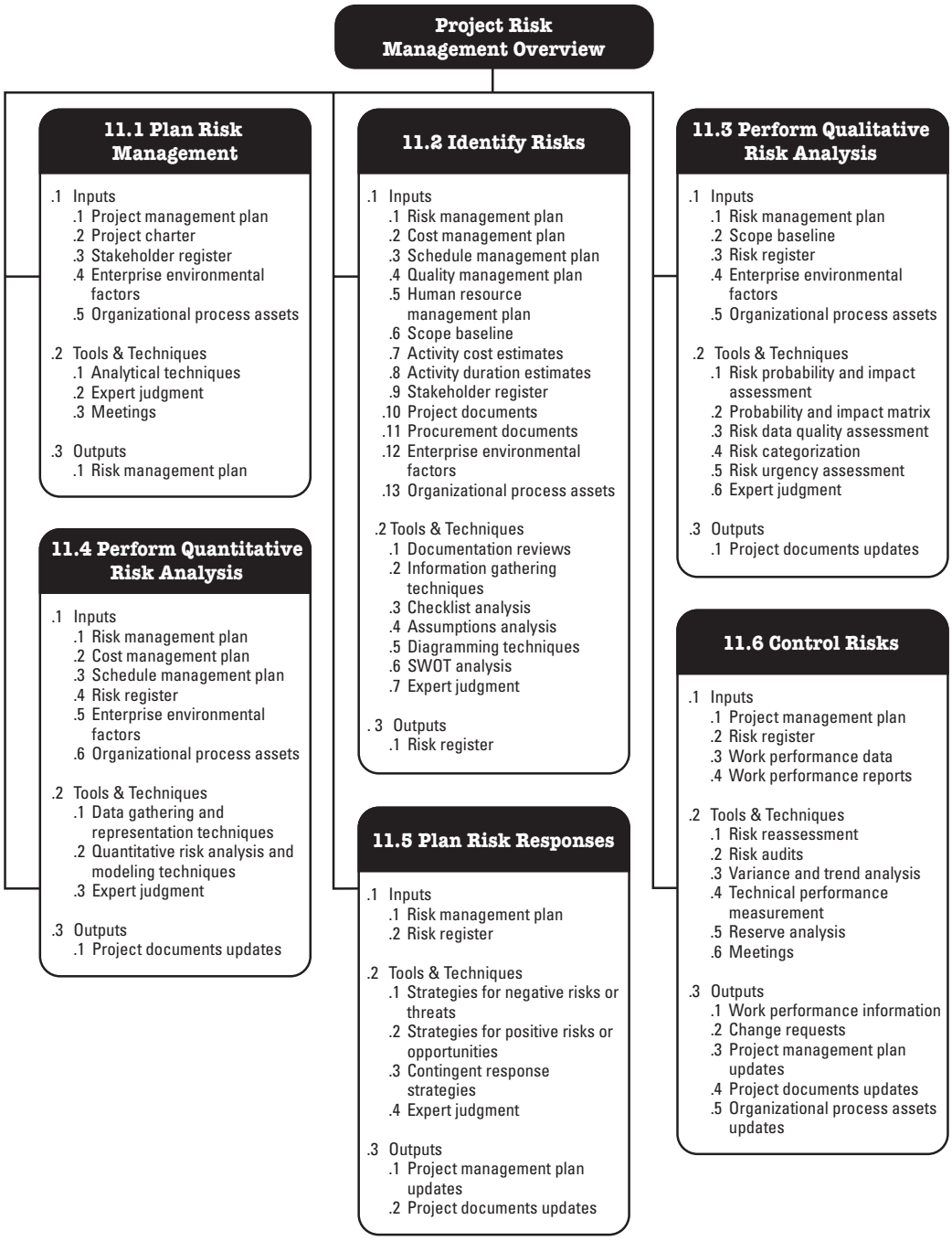


Figure 11-1. Project Risk Management Overview

11.1 Plan Risk Management

Plan Risk Management is the process of defining how to conduct risk management activities for a project. The key benefit of this process is it ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. The risk management plan is vital to communicate with and obtain agreement and support from all stakeholders to ensure the risk management process is supported and performed effectively over the project life cycle. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-2. Figure 11-3 depicts the data flow diagram of the process.

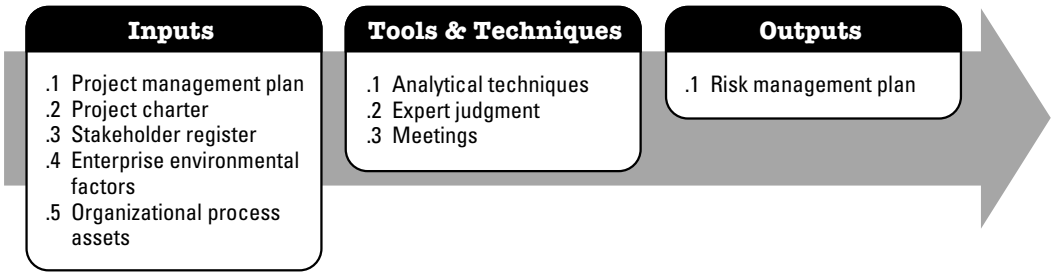


Figure 11-2. Plan Risk Management: Inputs, Tools & Techniques, and Outputs

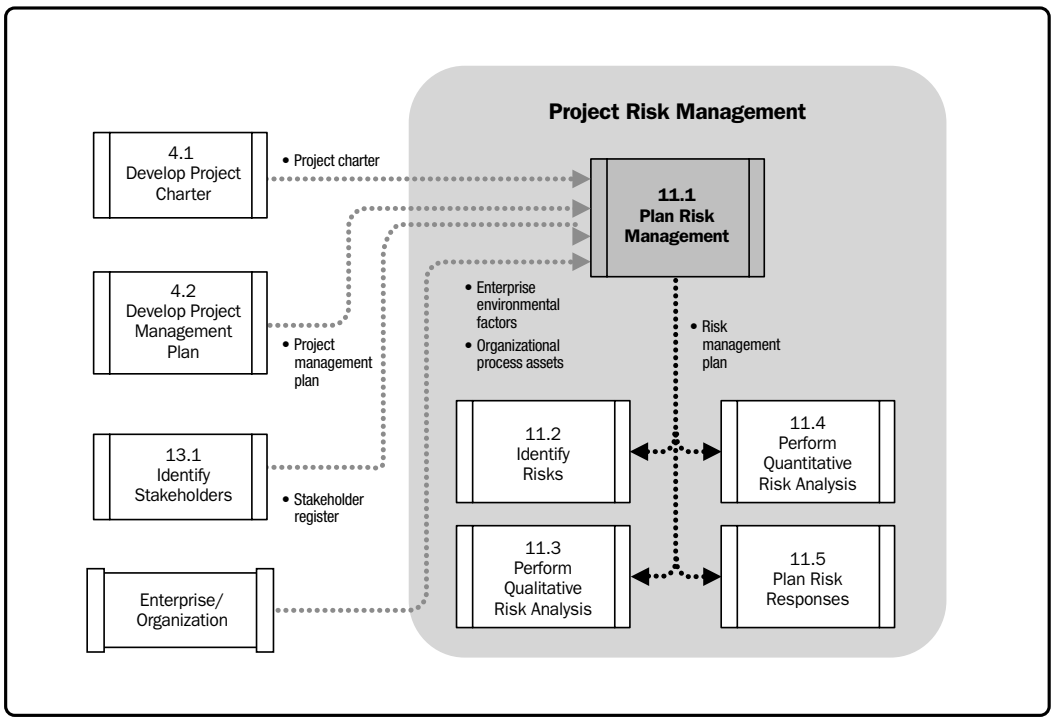


Figure 11-3. Plan Risk Management Data Flow Diagram

Careful and explicit planning enhances the probability of success for other risk management processes. Planning is also important to provide sufficient resources and time for risk management activities and to establish an agreed-upon basis for evaluating risks. The Plan Risk Management process should begin when a project is conceived and should be completed early during project planning.

11.1.1 Plan Risk Management: Inputs

11.1.1.1 Project Management Plan

In planning risk management, all approved subsidiary management plans and baselines should be taken into consideration in order to make the risk management plan consistent with them. The risk management plan is also a component of the project management plan. The project management plan provides baseline or current state of risk-affected areas including scope, schedule, and cost.

11.1.1.2 Project Charter

Described in Section 4.1.3.1. The project charter can provide various inputs such as high-level risks, high-level project descriptions, and high-level requirements.

11.1.1.3 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register, which contains all details related to the project's stakeholders, provides an overview of their roles.

11.1.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Plan Risk Management process include, but are not limited to, risk attitudes, thresholds, and tolerances that describe the degree of risk that an organization will withstand.

11.1.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Plan Risk Management process include, but are not limited to:

- Risk categories,
- Common definitions of concepts and terms,
- Risk statement formats,
- Standard templates,
- Roles and responsibilities,
- Authority levels for decision making, and
- Lessons learned.

11.1.2 Plan Risk Management: Tools and Techniques

11.1.2.1 Analytical Techniques

Analytical techniques are used to understand and define the overall risk management context of the project. Risk management context is a combination of stakeholder risk attitudes and the strategic risk exposure of a given project based on the overall project context. For example, a stakeholder risk profile analysis may be performed to grade and qualify the project stakeholder risk appetite and tolerance. Other techniques, such as the use of strategic risk scoring sheets, are used to provide a high-level assessment of the risk exposure of the project based on the overall project context. Depending on these assessments, the project team can allocate appropriate resources and focus on the risk management activities.

11.1.2.2 Expert Judgment

To ensure a comprehensive establishment of the risk management plan, judgment, and expertise should be considered from groups or individuals with specialized training or knowledge on the subject area, such as:

- Senior management,
- Project stakeholders,
- Project managers who have worked on projects in the same area (directly or through lessons learned),
- Subject matter experts (SMEs) in business or project area,
- Industry groups and consultants, and
- Professional and technical associations.

11.1.2.3 Meetings

Project teams hold planning meetings to develop the risk management plan. Attendees at these meetings may include the project manager, selected project team members and stakeholders, anyone in the organization with responsibility to manage the risk planning and execution activities, and others, as needed.

High-level plans for conducting the risk management activities are defined in these meetings. Risk management cost elements and schedule activities should be developed for inclusion in the project budget and schedule, respectively. Risk contingency reserve application approaches may be established or reviewed. Risk management responsibilities should be assigned. General organizational templates for risk categories and definitions of terms such as levels of risk, probability by type of risk, impact by type of objectives, and the probability and impact matrix will be tailored to the specific project. If templates for other steps in the process do not exist, they may be generated in these meetings. The outputs of these activities are summarized in the risk management plan.

11.1.3 Plan Risk Management: Outputs

11.1.3.1 Risk Management Plan

The risk management plan is a component of the project management plan and describes how risk management activities will be structured and performed. The risk management plan includes the following:

- **Methodology.** Defines the approaches, tools, and data sources that will be used to perform risk management on the project.
- **Roles and responsibilities.** Defines the lead, support, and risk management team members for each type of activity in the risk management plan, and clarifies their responsibilities.
- **Budgeting.** Estimates funds needed, based on assigned resources, for inclusion in the cost baseline and establishes protocols for application of contingency and management reserves.
- **Timing.** Defines when and how often the risk management processes will be performed throughout the project life cycle, establishes protocols for application of schedule contingency reserves, and establishes risk management activities for inclusion in the project schedule.

- **Risk categories.** Provide a means for grouping potential causes of risk. Several approaches can be used, for example, a structure based on project objectives by category. A risk breakdown structure (RBS) helps the project team to look at many sources from which project risk may arise in a risk identification exercise. Different RBS structures will be appropriate for different types of projects. An organization can use a previously prepared custom categorization framework, which may take the form of a simple list of categories or may be structured into an RBS. The RBS is a hierarchical representation of risks according to their risk categories. An example is shown in Figure 11-4.

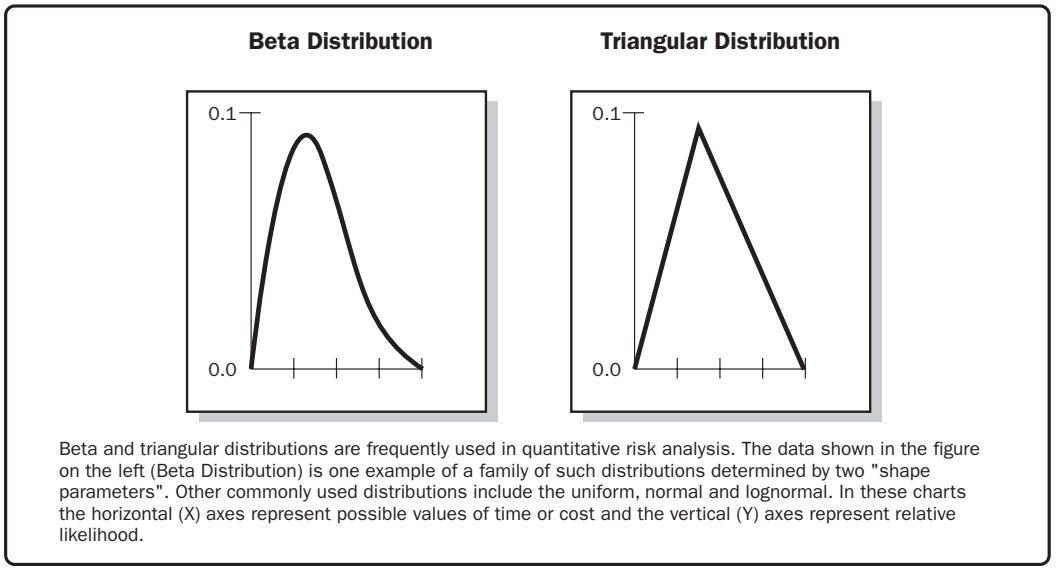


Figure 11-4. Example of a Risk Breakdown Structure (RBS)

- **Definitions of risk probability and impact.** The quality and credibility of the risk analysis requires that different levels of risk probability and impact be defined that are specific to the project context. General definitions of probability levels and impact levels are tailored to the individual project during the Plan Risk Management process for use in subsequent processes. Table 11-1 is an example of definitions of negative impacts that could be used in evaluating risk impacts related to four project objectives. (Similar tables may be established with a positive impact perspective). Table 11-1 illustrates both relative and numerical (in this case, nonlinear) approaches.

Table 11-1. Definition of Impact Scales for Four Project Objectives

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (Examples are shown for negative impacts only)					
	Relative or numerical scales are shown				
Project Objective	Very low /0.05	Low /0.10	Moderate /0.20	High /0.40	Very high /0.80
Cost	Insignificant cost increase	< 10% cost increase	10 – 20% cost increase	20 – 40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5 – 10% time increase	10 – 20% time increase	> 20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

- **Probability and impact matrix.** A probability and impact matrix is a grid for mapping the probability of each risk occurrence and its impact on project objectives if that risk occurs. Risks are prioritized according to their potential implications for having an effect on the project's objectives. A typical approach to prioritizing risks is to use a look-up table or a probability and impact matrix. The specific combinations of probability and impact that lead to a risk being rated as "high," "moderate," or "low" importance are usually set by the organization.
- **Revised stakeholders' tolerances.** Stakeholders' tolerances, as they apply to the specific project, may be revised in the Plan Risk Management process.
- **Reporting formats.** Reporting formats define how the outcomes of the risk management process will be documented, analyzed, and communicated. It describes the content and format of the risk register as well as any other risk reports required.
- **Tracking.** Tracking documents how risk activities will be recorded for the benefit of the current project and how risk management processes will be audited.

11.2 Identify Risks

Identify Risks is the process of determining which risks may affect the project and documenting their characteristics. The key benefit of this process is the documentation of existing risks and the knowledge and ability it provides to the project team to anticipate events. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-5. Figure 11-6 depicts the data flow diagram of the process.

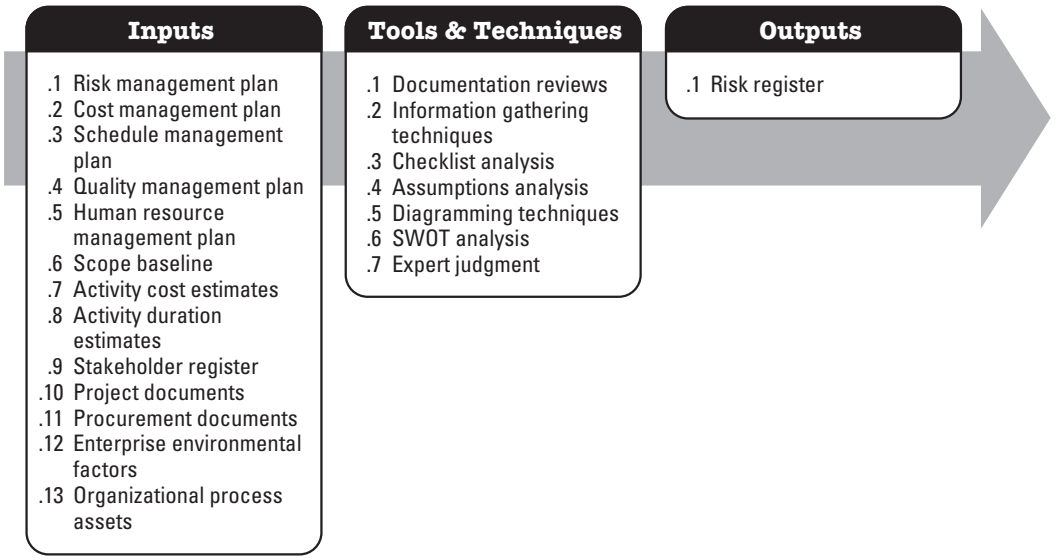


Figure 11-5. Identify Risks: Inputs, Tools & Techniques, and Outputs

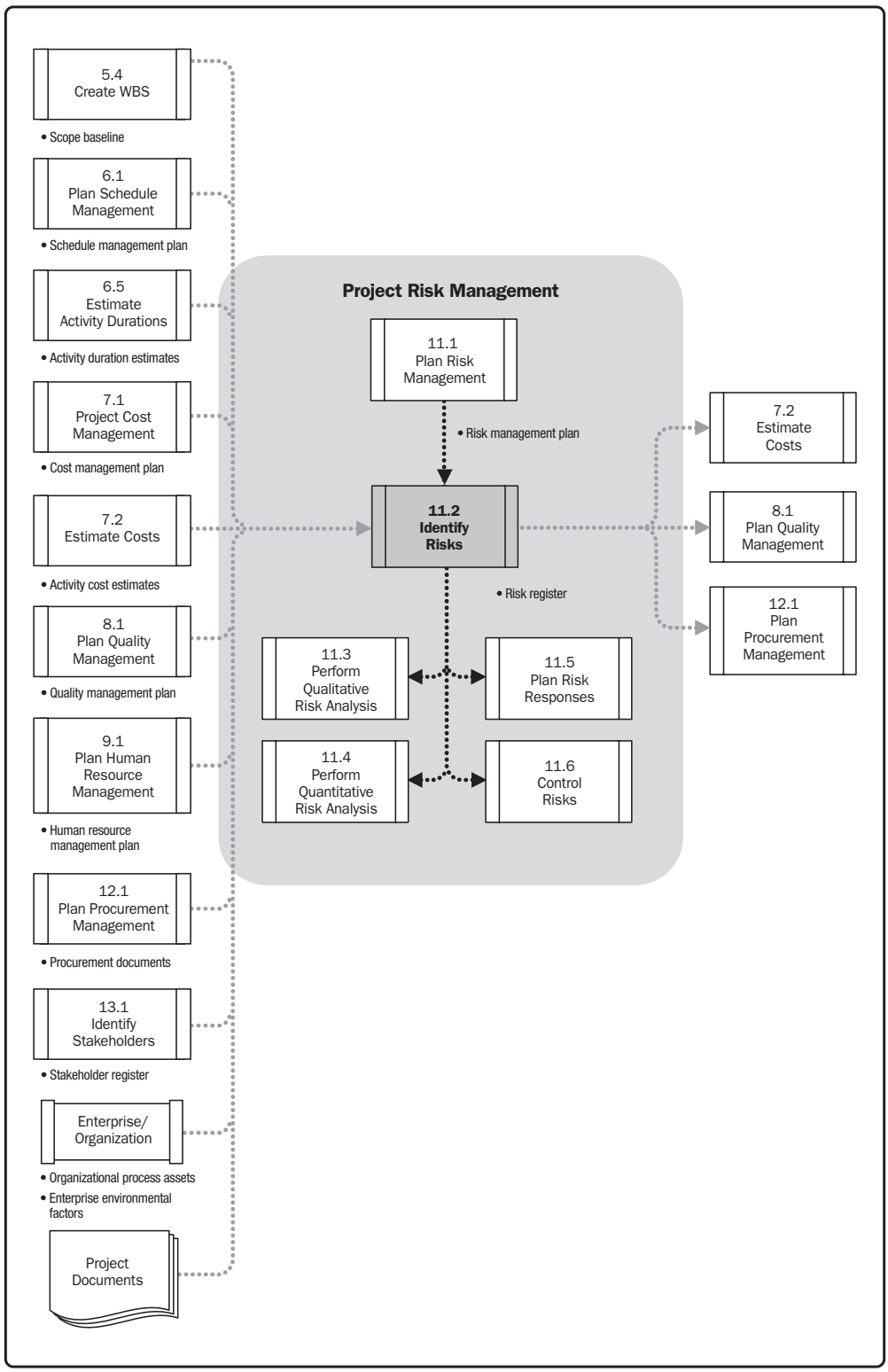


Figure 11-6. Identify Risks Data Flow Diagram

Participants in risk identification activities may include the following: project manager, project team members, risk management team (if assigned), customers, subject matter experts from outside the project team, end users, other project managers, stakeholders, and risk management experts. While these personnel are often key participants for risk identification, all project personnel should be encouraged to identify potential risks.

Identify risks is an iterative process, because new risks may evolve or become known as the project progresses through its life cycle. The frequency of iteration and participation in each cycle will vary by situation. The format of the risk statements should be consistent to ensure that each risk is understood clearly and unambiguously in order to support effective analysis and response development. The risk statement should support the ability to compare the relative effect of one risk against others on the project. The process should involve the project team so they can develop and maintain a sense of ownership and responsibility for the risks and associated risk response actions. Stakeholders outside the project team may provide additional objective information.

11.2.1 Identify Risks: Inputs

11.2.1.1 Risk Management Plan

Described in Section 11.1.3.1. Key elements of the risk management plan that contribute to the Identify Risks process are the assignments of roles and responsibilities, provision for risk management activities in the budget and schedule, and categories of risk, which are sometimes expressed as a risk breakdown structure (Figure 11-4).

11.2.1.2 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan provides processes and controls that can be used to help identify risks across the project.

11.2.1.3 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan provides insight to project time/schedule objectives and expectations which may be impacted by risks (known and unknown).

11.2.1.4 Quality Management Plan

Described in Section 8.1.3.1. The quality management plan provides a baseline of quality measures and metrics for use in identifying risks.

11.2.1.5 Human Resource Management Plan

Described in Section 9.1.3.1. The human resource management plan provides guidance on how project human resources should be defined, staffed, managed, and eventually released. It can also contain roles and responsibilities, project organization charts, and the staffing management plan, which form a key input to identify risk process.

11.2.1.6 Scope Baseline

Described in Section 5.4.3.1. Project assumptions are found in the project scope statement. Uncertainty in project assumptions should be evaluated as potential causes of project risk.

The WBS is a critical input to identifying risks as it facilitates an understanding of the potential risks at both the micro and macro levels. Risks can be identified and subsequently tracked at summary, control account, and/or work package levels.

11.2.1.7 Activity Cost Estimates

Described in Section 7.2.3.1. Activity cost estimate reviews are useful in identifying risks as they provide a quantitative assessment of the likely cost to complete scheduled activities and ideally are expressed as a range, with the width of the range indicating the degree(s) of risk. The review may result in projections indicating the estimate is either sufficient or insufficient to complete the activity (i.e., pose a risk to the project).

11.2.1.8 Activity Duration Estimates

Described in Section 6.5.3.1. Activity duration estimate reviews are useful in identifying risks related to the time allowances for the activities or project as a whole, again with the width of the range of such estimates indicating the relative degree(s) of risk.

11.2.1.9 Stakeholder Register

Described in Section 13.1.3.1. Information about the stakeholders is useful for soliciting inputs to identify risks, as this will ensure that key stakeholders, especially the stakeholder, sponsor, and customer are interviewed or otherwise participate during the Identify Risks process.

11.2.1.10 Project Documents

Project documents provide the project team with information about decisions that help better identify project risks. Project documents improve cross-team and stakeholder communications and include, but are not limited to:

- Project charter,
- Project schedule,
- Schedule network diagrams,
- Issue log,
- Quality checklist, and
- Other information proven to be valuable in identifying risks.

11.2.1.11 Procurement Documents

Defined in Section 12.1.3.3. If the project requires external procurement of resources, procurement documents become a key input to the Identify Risks process. The complexity and the level of detail of the procurement documents should be consistent with the value of, and risks associated with, planned procurement.

11.2.1.12 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors that can influence the Identify Risks process include, but are not limited to:

- Published information, including commercial databases,
- Academic studies,
- Published checklists,
- Benchmarking,
- Industry studies, and
- Risk attitudes.

11.2.1.13 Organizational Process Assets

Described in Section 2.1.4. Organizational process assets that can influence the Identify Risks process include, but are not limited to:

- Project files, including actual data,
- Organizational and project process controls,
- Risk statement formats or templates, and
- Lessons learned.

11.2.2 Identify Risks: Tools and Techniques

11.2.2.1 Documentation Reviews

A structured review of the project documentation may be performed, including plans, assumptions, previous project files, agreements, and other information. The quality of the plans, as well as consistency between those plans and the project requirements and assumptions, may be indicators of risk in the project.

11.2.2.2 Information Gathering Techniques

Examples of information gathering techniques used in identifying risks can include:

- **Brainstorming.** The goal of brainstorming is to obtain a comprehensive list of project risks. The project team usually performs brainstorming, often with a multidisciplinary set of experts who are not part of the team. Ideas about project risk are generated under the leadership of a facilitator, either in a traditional free-form brainstorm session or structured mass interviewing techniques. Categories of risk, such as in a risk breakdown structure, can be used as a framework. Risks are then identified and categorized by type of risk and their definitions are refined.
- **Delphi technique.** The Delphi technique is a way to reach a consensus of experts. Project risk experts participate in this technique anonymously. A facilitator uses a questionnaire to solicit ideas about the important project risks. The responses are summarized and are then recirculated to the experts for further comment. Consensus may be reached in a few rounds of this process. The Delphi technique helps reduce bias in the data and keeps any one person from having undue influence on the outcome.

- **Interviewing.** Interviewing experienced project participants, stakeholders, and subject matter experts helps to identify risks.
- **Root cause analysis.** Root-cause analysis is a specific technique used to identify a problem, discover the underlying causes that lead to it, and develop preventive action.

11.2.2.3 Checklist Analysis

Risk identification checklists are developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information. The lowest level of the RBS can also be used as a risk checklist. While a checklist may be quick and simple, it is impossible to build an exhaustive one, and care should be taken to ensure the checklist is not used to avoid the effort of proper risk identification. The team should also explore items that do not appear on the checklist. Additionally, the checklist should be pruned from time to time to remove or archive related items. The checklist should be reviewed during project closure to incorporate new lessons learned and improve it for use on future projects.

11.2.2.4 Assumptions Analysis

Every project and its plan is conceived and developed based on a set of hypotheses, scenarios, or assumptions. Assumptions analysis explores the validity of assumptions as they apply to the project. It identifies risks to the project from inaccuracy, instability, inconsistency, or incompleteness of assumptions.

11.2.2.5 Diagramming Techniques

Risk diagramming techniques may include:

- **Cause and effect diagrams.** These are also known as Ishikawa or fishbone diagrams and are useful for identifying causes of risks.
- **System or process flow charts.** These show how various elements of a system interrelate and the mechanism of causation.
- **Influence diagrams.** These are graphical representations of situations showing causal influences, time ordering of events, and other relationships among variables and outcomes, as shown in Figure 11-7.

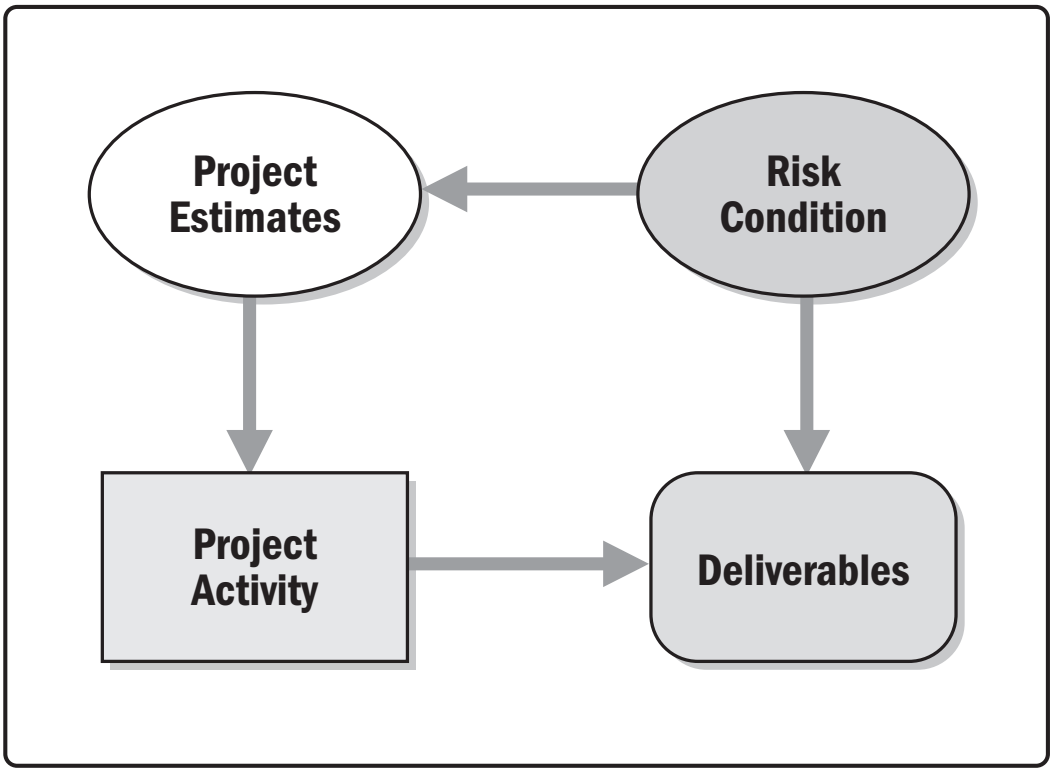


Figure 11-7. Influence Diagram

11.2.2.6 SWOT Analysis

This technique examines the project from each of the strengths, weaknesses, opportunities, and threats (SWOT) perspectives to increase the breadth of identified risks by including internally generated risks. The technique starts with identification of strengths and weaknesses of the organization, focusing on either the project, organization, or the business area in general. SWOT analysis then identifies any opportunities for the project that arise from organizational strengths, and any threats arising from organizational weaknesses. The analysis also examines the degree to which organizational strengths offset threats, as well as identifying opportunities that may serve to overcome weaknesses.

11.2.2.7 Expert Judgment

Risks may be identified directly by experts with relevant experience with similar projects or business areas. Such experts should be identified by the project manager and invited to consider all aspects of the project and suggest possible risks based on their previous experience and areas of expertise. The experts' bias should be taken into account in this process.

11.2.3 Identify Risks: Outputs

11.2.3.1 Risk Register

The primary output from Identify Risks is the initial entry into the risk register. The risk register is a document in which the results of risk analysis and risk response planning are recorded. It contains the outcomes of the other risk management processes as they are conducted, resulting in an increase in the level and type of information contained in the risk register over time. The preparation of the risk register begins in the Identify Risks process with the following information, and then becomes available to other project management and risk management processes:

- **List of identified risks.** The identified risks are described in as much detail as is reasonable. A structure for describing risks using risk statements may be applied, for example, EVENT may occur causing IMPACT, or If CAUSE exists, EVENT may occur leading to EFFECT. In addition to the list of identified risks, the root causes of those risks may become more evident. These are the fundamental conditions or events that may give rise to one or more identified risks. They should be recorded and used to support future risk identification for this and other projects.
- **List of potential responses.** Potential responses to a risk may sometimes be identified during the Identify Risks process. These responses, if identified in this process, should be used as inputs to the Plan Risk Responses process.

11.3 Perform Qualitative Risk Analysis

Perform Qualitative Risk Analysis is the process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact. The key benefit of this process is that it enables project managers to reduce the level of uncertainty and to focus on high-priority risks. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-8. Figure 11-9 depicts the data flow diagram of the process.

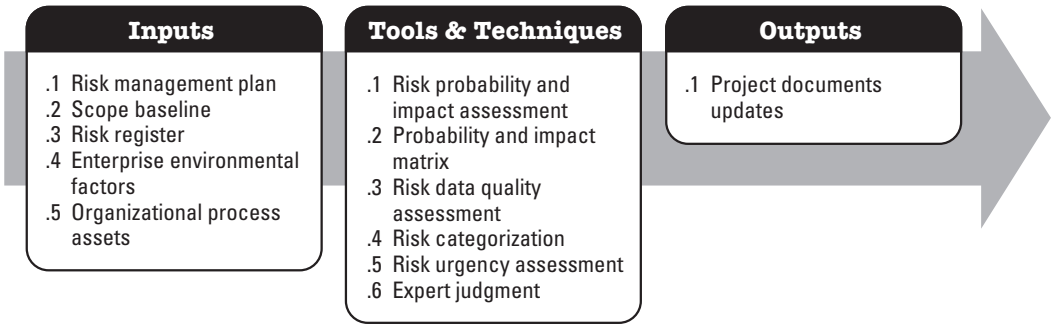


Figure 11-8. Perform Qualitative Risk Analysis: Inputs, Tools & Techniques, and Outputs

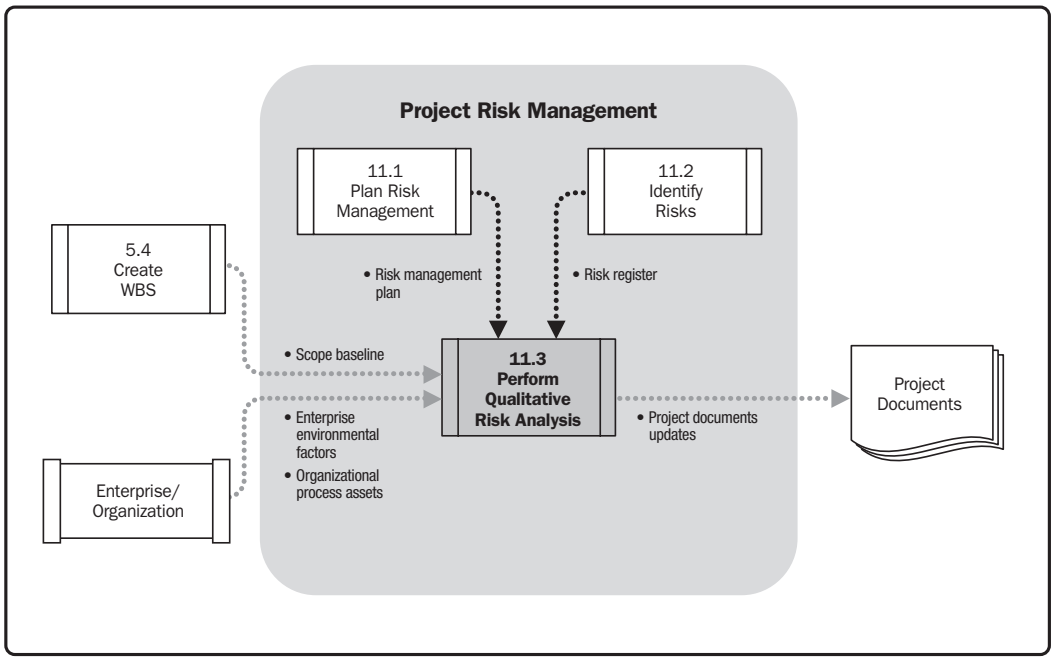


Figure 11-9. Perform Qualitative Risk Analysis Data Flow Diagram

Perform Qualitative Risk Analysis assesses the priority of identified risks using their relative probability or likelihood of occurrence, the corresponding impact on project objectives if the risks occur, as well as other factors such as the time frame for response and the organization's risk tolerance associated with the project constraints of cost, schedule, scope, and quality. Such assessments reflect the risk attitude of the project team and other stakeholders. Effective assessment therefore requires explicit identification and management of the risk approaches of key participants in the Perform Qualitative Risk Analysis process. Where these risk approaches introduce bias into the assessment of identified risks, attention should be paid to identifying bias and correcting for it.

Establishing definitions of the levels of probability and impact can reduce the influence of bias. The time criticality of risk-related actions may magnify the importance of a risk. An evaluation of the quality of the available information on project risks also helps to clarify the assessment of the risk's importance to the project.

Perform Qualitative Risk Analysis is usually a rapid and cost-effective means of establishing priorities for Plan Risk Responses and lays the foundation for Perform Quantitative Risk Analysis, if required. The Perform Qualitative Risk Analysis process is performed regularly throughout the project life cycle, as defined in the project's risk management plan. This process can lead into Perform Quantitative Risk Analysis (Section 11.4) or directly into Plan Risk Responses (Section 11.5).

11.3.1 Perform Qualitative Risk Analysis: Inputs

11.3.1.1 Risk Management Plan

Described in Section 11.1.3.1. Key elements of the risk management plan used in the Perform Qualitative Risk Analysis process include roles and responsibilities for conducting risk management, budgets, schedule activities for risk management, risk categories, definitions of probability and impact, the probability and impact matrix, and revised stakeholders' risk tolerances. These inputs are usually tailored to the project during the Plan Risk Management process. If they are not available, they may be developed during the Perform Qualitative Risk Analysis process.

11.3.1.2 Scope Baseline

Described in Section 5.4.3.1. Projects of a common or recurrent type tend to have more well-understood risks. Projects using state-of-the-art or first-of-its-kind technology, and highly complex projects, tend to have more uncertainty. This can be evaluated by examining the scope baseline.

11.3.1.3 Risk Register

Described in Section 11.2.3.1. The risk register contains the information that will be used to assess and prioritize risks.

11.3.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors may provide insight and context to the risk assessment, such as:

- Industry studies of similar projects by risk specialists, and
- Risk databases that may be available from industry or proprietary sources.

11.3.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Perform Qualitative Risk Analysis process include information on prior, similar completed projects.

11.3.2 Perform Qualitative Risk Analysis: Tools and Techniques

11.3.2.1 Risk Probability and Impact Assessment

Risk probability assessment investigates the likelihood that each specific risk will occur. Risk impact assessment investigates the potential effect on a project objective such as schedule, cost, quality, or performance, including both negative effects for threats and positive effects for opportunities.

Probability and impact are assessed for each identified risk. Risks can be assessed in interviews or meetings with participants selected for their familiarity with the risk categories on the agenda. Project team members and knowledgeable persons external to the project are included.

The level of probability for each risk and its impact on each objective is evaluated during the interview or meeting. Explanatory detail, including assumptions justifying the levels assigned, are also recorded. Risk probabilities and impacts are rated according to the definitions given in the risk management plan. Risks with low ratings of probability and impact will be included within the risk register as part of the watch list for future monitoring.

11.3.2.2 Probability and Impact Matrix

Risks can be prioritized for further quantitative analysis and planning risk responses based on their risk rating. Ratings are assigned to risks based on their assessed probability and impact. Evaluation of each risk's importance and priority for attention is typically conducted using a look-up table or a probability and impact matrix. Such a matrix specifies combinations of probability and impact that lead to rating the risks as low, moderate, or high priority. Descriptive terms or numeric values can be used depending on organizational preference.

Each risk is rated on its probability of occurrence and impact on an objective if it does occur. The organization should determine which combinations of probability and impact result in a classification of high risk, moderate risk, and low risk. In a black-and-white matrix, these conditions are denoted using different shades of gray. Specifically in Figure 11-10, the dark gray area (with the largest numbers) represents high risk: the medium gray area (with the smallest numbers) represents low risk, and the light gray area (with in-between numbers) represents moderate risk. Usually, these risk-rating rules are specified by the organization in advance of the project and included in organizational process assets. Risk rating rules can be tailored in the Plan Risk Management process to the specific project.

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05/ Very Low	0.10/ Low	0.20/ Moderate	0.40/ High	0.80/ Very High	0.80/ Very High	0.40/ High	0.20/ Moderate	0.10/ Low	0.05/ Very Low

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 11-10. Probability and Impact Matrix

As illustrated in Figure 11-10, an organization can rate a risk separately for each objective (e.g., cost, time, and scope). In addition, it may develop ways to determine one overall rating for each risk. Finally, opportunities and threats are handled in the same matrix using definitions of the different levels of impact that are appropriate for each.

The risk score helps guide risk responses. For example, risks that have a negative impact on objectives, otherwise known as threats if they occur, and that are in the high-risk (dark gray) zone of the matrix, may require priority action and aggressive response strategies. Threats found in the low-risk (medium gray) zone may not require proactive management action beyond being placed in the risk register as part of the watch list or adding a contingency reserve. Similarly for opportunities, those in the high-risk (dark gray) zone, which may be obtained most easily and offer the greatest benefit, should be targeted first. Opportunities in the low-risk (medium gray) zone should be monitored.

11.3.2.3 Risk Data Quality Assessment

Risk data quality assessment is a technique to evaluate the degree to which the data about risks is useful for risk management. It involves examining the degree to which the risk is understood and the accuracy, quality, reliability, and integrity of the data about the risk.

The use of low-quality risk data may lead to a qualitative risk analysis of little use to the project. If data quality is unacceptable, it may be necessary to gather better data. Often, the collection of information about risks is difficult, and consumes more time and resources than originally planned. The values used in the example in Figure 11-10 are representative. The numbers of steps in the scale are usually established when defining the risk attitude of the organization.

11.3.2.4 Risk Categorization

Risks to the project can be categorized by sources of risk (e.g., using the RBS), the area of the project affected (e.g., using the WBS), or other useful categories (e.g., project phase) to determine the areas of the project most exposed to the effects of uncertainty. Risks can also be categorized by common root causes. This technique helps determine work packages, activities, project phases or even roles in the project, which can lead to the development of effective risk responses.

11.3.2.5 Risk Urgency Assessment

Risks requiring near-term responses may be considered more urgent to address. Indicators of priority may include probability of detecting the risk, time to affect a risk response, symptoms and warning signs, and the risk rating. In some qualitative analyses, the assessment of risk urgency is combined with the risk ranking that is determined from the probability and impact matrix to give a final risk severity rating.

11.3.2.6 Expert Judgment

Expert judgment is required to assess the probability and impact of each risk to determine its location in the matrix shown in Figure 11-10. Experts generally are those having experience with similar, recent projects. Gathering expert judgment is often accomplished with the use of risk facilitation workshops or interviews. The experts' bias should be taken into account in this process.

11.3.3 Perform Qualitative Risk Analysis: Outputs

11.3.3.1 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- **Risk register updates.** As new information becomes available through the qualitative risk assessment, the risk register is updated. Updates to the risk register may include assessments of probability and impacts for each risk, risk ranking or scores, risk urgency information or risk categorization, and a watch list for low probability risks or risks requiring further analysis.
- **Assumptions log updates.** As new information becomes available through the qualitative risk assessment, assumptions could change. The assumptions log needs to be revisited to accommodate this new information. Assumptions may be incorporated into the project scope statement or in a separate assumptions log.

11.4 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis is the process of numerically analyzing the effect of identified risks on overall project objectives. The key benefit of this process is that it produces quantitative risk information to support decision making in order to reduce project uncertainty. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-11. Figure 11-12 depicts the data flow diagram of the process.

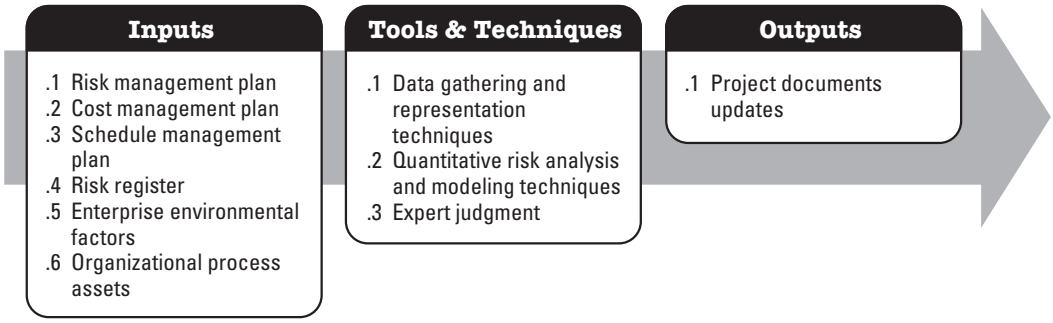


Figure 11-11. Perform Quantitative Risk Analysis: Inputs, Tools & Techniques, and Outputs

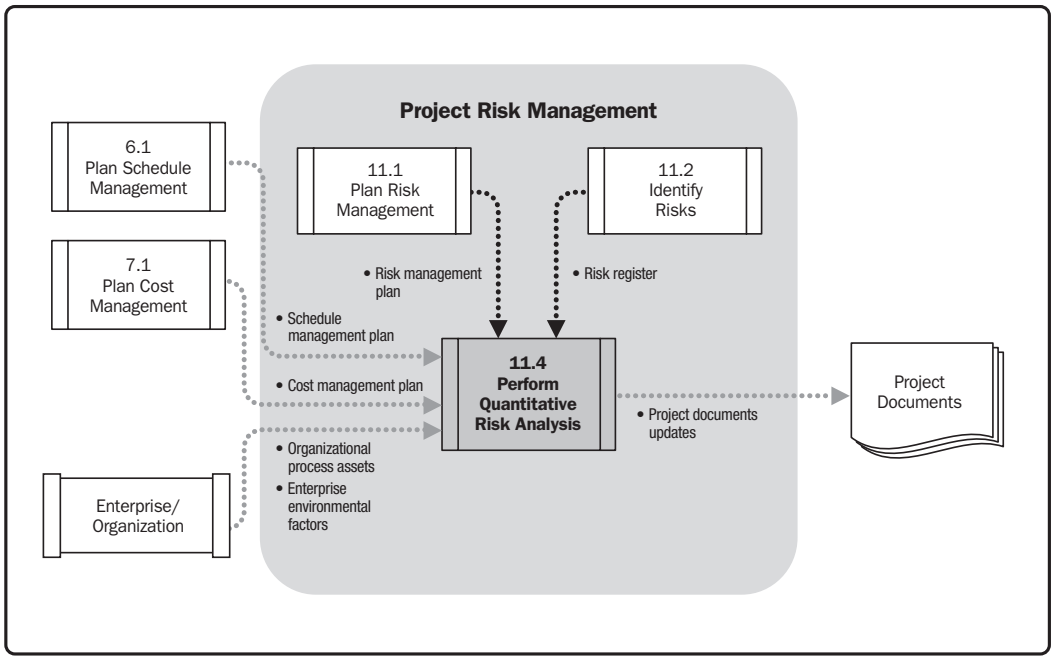


Figure 11-12. Perform Quantitative Risk Analysis Data Flow Diagram

Perform Quantitative Risk Analysis is performed on risks that have been prioritized by the Perform Qualitative Risk Analysis process as potentially and substantially impacting the project's competing demands. The Perform Quantitative Risk Analysis process analyzes the effect of those risks on project objectives. It is used mostly to evaluate the aggregate effect of all risks affecting the project. When the risks drive the quantitative analysis, the process may be used to assign a numerical priority rating to those risks individually.

Perform Quantitative Risk Analysis generally follows the Perform Qualitative Risk Analysis process. In some cases, it may not be possible to execute the Perform Quantitative Risk Analysis process due to lack of sufficient data to develop appropriate models. The project manager should exercise expert judgment to determine the need for and the viability of quantitative risk analysis. The availability of time and budget, and the need for qualitative or quantitative statements about risk and impacts, will determine which method(s) to use on any particular project. Perform Quantitative Risk Analysis should be repeated, as needed, as part of the Control Risks process to determine if the overall project risk has been satisfactorily decreased. Trends may indicate the need for more or less focus on appropriate risk management activities.

11.4.1 Perform Quantitative Risk Analysis: Inputs

11.4.1.1 Risk Management Plan

Described in Section 11.1.3.1. The risk management plan provides guidelines, methods, and tools to be used in quantitative risk analysis.

11.4.1.2 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan provides guidelines on establishing and managing risk reserves.

11.4.1.3 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan provides guidelines on establishing and managing risk reserves.

11.4.1.4 Risk Register

Described in Section 11.2.3.1. The risk register is used as a reference point for performing quantitative risk analysis.

11.4.1.5 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors may provide insight and context to the risk analysis, such as:

- Industry studies of similar projects by risk specialists, and
- Risk databases that may be available from industry or proprietary sources.

11.4.1.6 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Perform Quantitative Risk Analysis process include information from prior, similar completed projects.

11.4.2 Perform Quantitative Risk Analysis: Tools and Techniques

11.4.2.1 Data Gathering and Representation Techniques

- **Interviewing.** Interviewing techniques draw on experience and historical data to quantify the probability and impact of risks on project objectives. The information needed depends upon the type of probability distributions that will be used. For instance, information would be gathered on the optimistic (low), pessimistic (high), and most likely scenarios for some commonly used distributions. Examples of three-point estimates for cost are shown in Figure 11-13. Additional information on three-point estimates appears in Estimate Activity Durations (Section 6.5) and Estimate Costs (Section 7.2). Documenting the rationale of the risk ranges and the assumptions behind them are important components of the risk interview because they can provide insight on the reliability and credibility of the analysis.

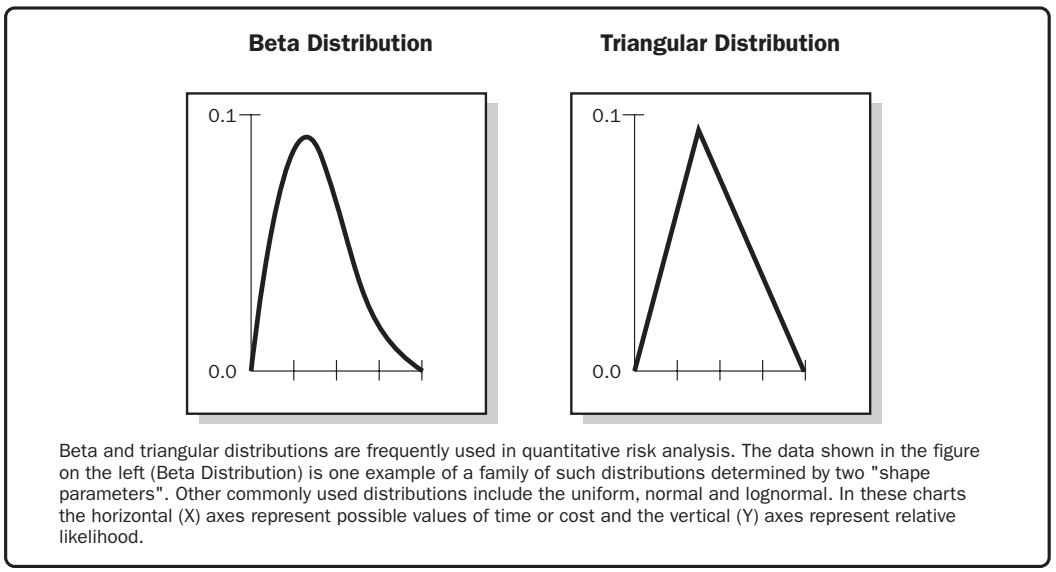
Range of Project Cost Estimates

WBS Element	Low	Most Likely	High
Design	$4M	$6M	$10M
Build	$16M	$20M	$35M
Test	$11M	$15M	$23M
Total Project	$31M	$41M	$68M

Interviewing relevant stakeholders helps determine the three-point estimates for each WBS element for triangular, beta or other distributions. In this example, the likelihood of completing the project at or below the most likely estimate of $41 million is relatively small as shown in the simulation results in Figure 11-17 (Cost Risk Simulation Results).

Figure 11-13. Range of Project Cost Estimates Collected During the Risk Interview

- **Probability distributions.** Continuous probability distributions, which are used extensively in modeling and simulation, represent the uncertainty in values such as durations of schedule activities and costs of project components. Discrete distributions can be used to represent uncertain events, such as the outcome of a test or a possible scenario in a decision tree. Two examples of widely used continuous distributions are shown in Figure 11-14. These distributions depict shapes that are compatible with the data typically developed during the quantitative risk analysis. Uniform distributions can be used if there is no obvious value that is more likely than any other between specified high and low bounds, such as in the early concept stage of design.



Beta and triangular distributions are frequently used in quantitative risk analysis. The data shown in the figure on the left (Beta Distribution) is one example of a family of such distributions determined by two "shape parameters". Other commonly used distributions include the uniform, normal and lognormal. In these charts the horizontal (X) axes represent possible values of time or cost and the vertical (Y) axes represent relative likelihood.

Figure 11-14. Examples of Commonly Used Probability Distributions

11.4.2.2 Quantitative Risk Analysis and Modeling Techniques

Commonly used techniques use both event-oriented and project-oriented analysis approaches, including:

- **Sensitivity analysis.** Sensitivity analysis helps to determine which risks have the most potential impact on the project. It helps to understand how the variations in project's objectives correlate with variations in different uncertainties. Conversely, it examines the extent to which the uncertainty of each project element affects the objective being studied when all other uncertain elements are held at their baseline values. One typical display of sensitivity analysis is the tornado diagram (Figure 11-15), which is useful for comparing relative importance and impact of variables that have a high degree of uncertainty to those that are more stable. The Tornado diagram is also helpful in analyzing risk-taking scenarios enabled on specific risks whose quantitative analysis highlights possible benefits greater than corresponding identified negative impacts. A tornado diagram is a special type of bar chart used in sensitivity analysis for comparing the relative importance of the variables. In a tornado diagram, the Y-axis contains each type of uncertainty at base values, and the X-axis contains the spread or correlation of the uncertainty to the studied output. In this figure, each uncertainty contains a horizontal bar and is ordered vertically to show uncertainties with a decreasing spread from the base values.

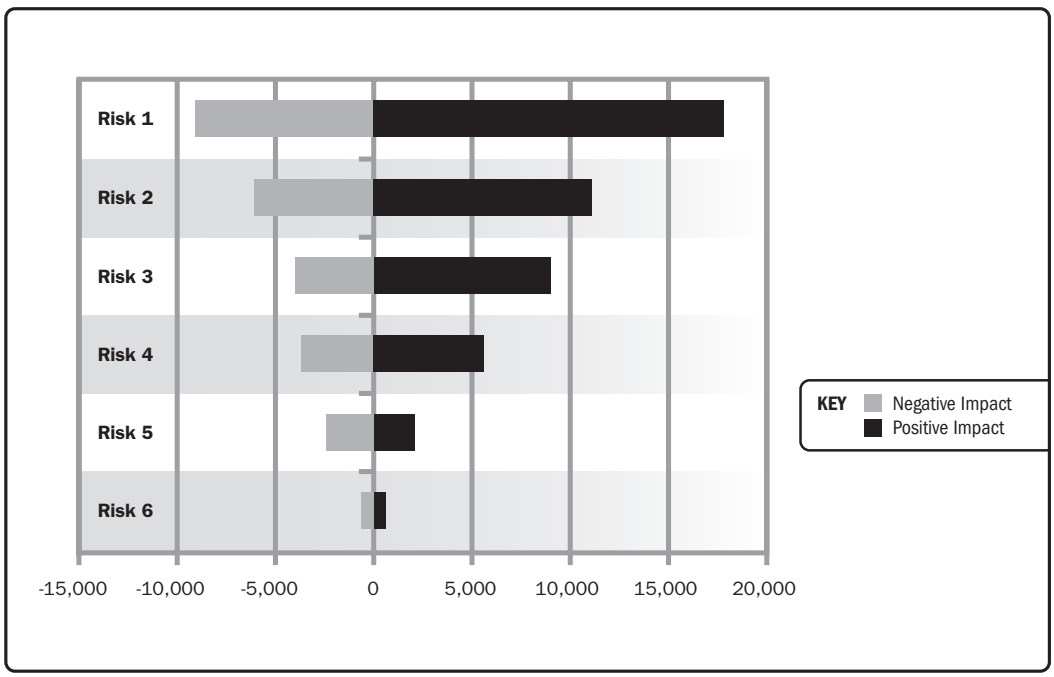
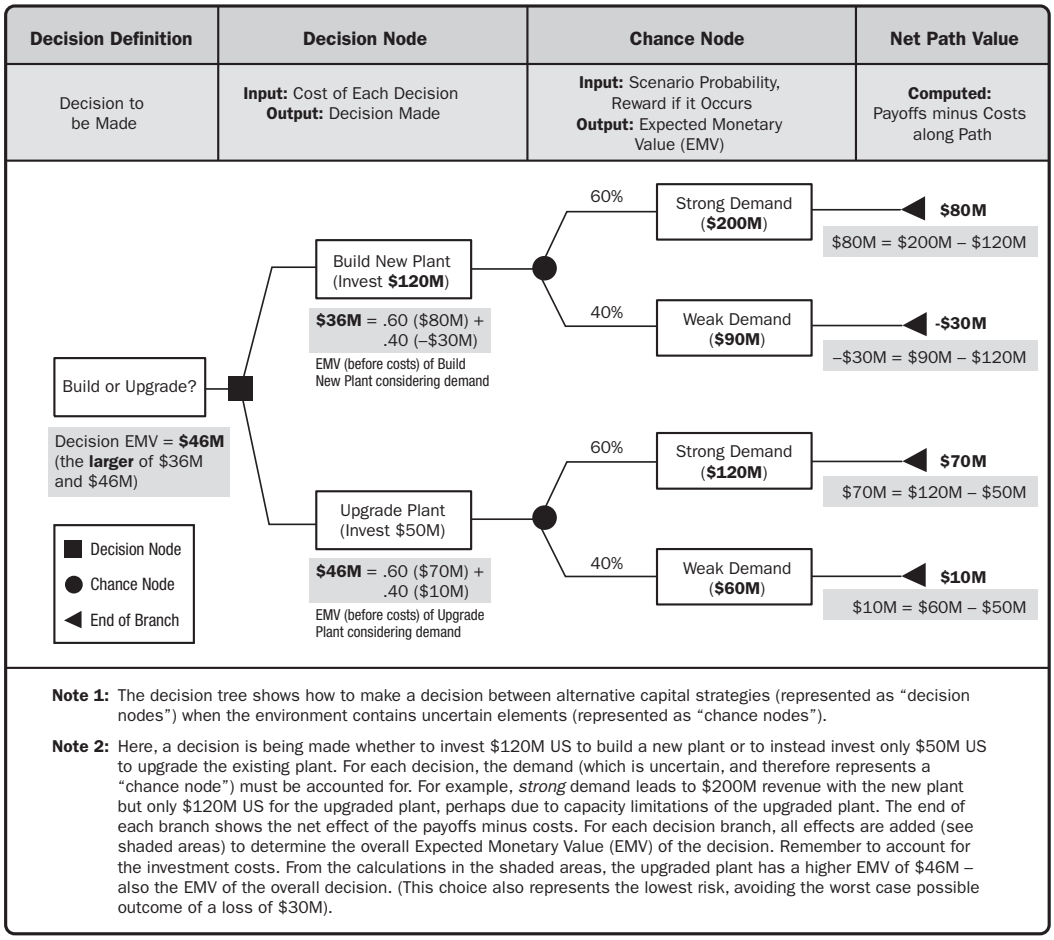


Figure 11-15. Example of Tornado Diagram

- **Expected monetary value analysis.** Expected monetary value (EMV) analysis is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (i.e., analysis under uncertainty). The EMV of opportunities are generally expressed as positive values, while those of threats are expressed as negative values. EMV requires a risk-neutral assumption—neither risk averse nor risk seeking. EMV for a project is calculated by multiplying the value of each possible outcome by its probability of occurrence and adding the products together. A common use of this type of analysis is a decision tree analysis (Figure 11-16).

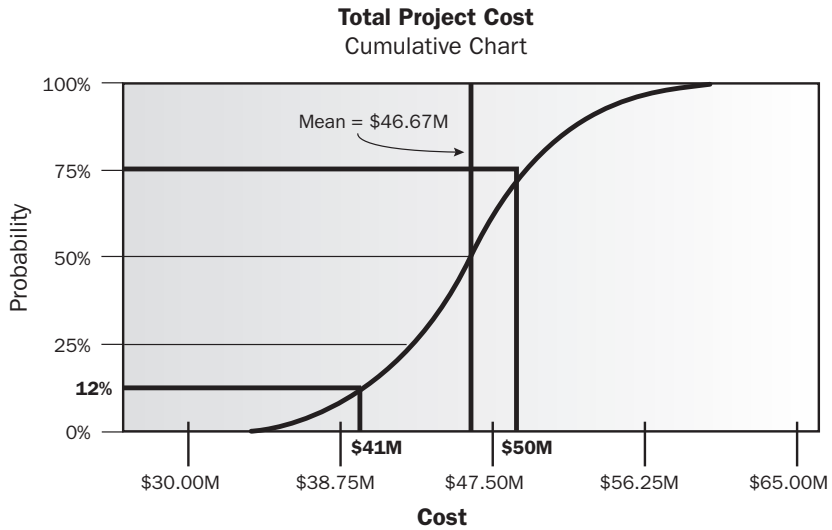


Note 1: The decision tree shows how to make a decision between alternative capital strategies (represented as "decision nodes") when the environment contains uncertain elements (represented as "chance nodes").

Note 2: Here, a decision is being made whether to invest $120M US to build a new plant or to instead invest only $50M US to upgrade the existing plant. For each decision, the demand (which is uncertain, and therefore represents a "chance node") must be accounted for. For example, *strong* demand leads to $200M revenue with the new plant but only $120M US for the upgraded plant, perhaps due to capacity limitations of the upgraded plant. The end of each branch shows the net effect of the payoffs minus costs. For each decision branch, all effects are added (see shaded areas) to determine the overall Expected Monetary Value (EMV) of the decision. Remember to account for the investment costs. From the calculations in the shaded areas, the upgraded plant has a higher EMV of $46M – also the EMV of the overall decision. (This choice also represents the lowest risk, avoiding the worst case possible outcome of a loss of $30M).

Figure 11-16. Decision Tree Diagram

- **Modeling and simulation.** A project simulation uses a model that translates the specified detailed uncertainties of the project into their potential impact on project objectives. Simulations are typically performed using the Monte Carlo technique. In a simulation, the project model is computed many times (iterated), with the input values (e.g., cost estimates or activity durations) chosen at random for each iteration from the probability distributions of these variables. A histogram (e.g., total cost or completion date) is calculated from the iterations. For a cost risk analysis, a simulation uses cost estimates. For a schedule risk analysis, the schedule network diagram and duration estimates are used. The output from a cost risk simulation using the three-element model and risk ranges is shown in Figure 11-17. It illustrates the respective probability of achieving specific cost targets. Similar curves can be developed for other project objectives.



This cumulative distribution, assuming the data ranges in Figure 11-13 and triangular distributions, shows that the project is only 12 percent likely to meet the $41 million most likely cost estimate. If a conservative organization wants a 75% likelihood of success, a budget of $50 million (a contingency of nearly 22 % ($50M - $41M)/$41M)) is required.

Figure 11-17. Cost Risk Simulation Results

11.4.2.3 Expert Judgment

Expert judgment (ideally using experts with relevant, recent experience) is required to identify potential cost and schedule impacts, to evaluate probability, and to define inputs such as probability distributions into the tools.

Expert judgment also comes into play in the interpretation of the data. Experts should be able to identify the weaknesses of the tools as well as their strengths. Experts may determine when a specific tool may or may not be more appropriate given the organization's capabilities and culture.

11.4.3 Perform Quantitative Risk Analysis: Outputs

11.4.3.1 Project Documents Updates

Project documents are updated with information resulting from quantitative risk analysis. For example, risk register updates could include:

- **Probabilistic analysis of the project.** Estimates are made of potential project schedule and cost outcomes listing the possible completion dates and costs with their associated confidence levels. This output, often expressed as a cumulative frequency distribution, is used with stakeholder risk tolerances to permit quantification of the cost and time contingency reserves. Such contingency reserves are needed to bring the risk of overrunning stated project objectives to a level acceptable to the organization.
- **Probability of achieving cost and time objectives.** With the risks facing the project, the probability of achieving project objectives under the current plan can be estimated using quantitative risk analysis results. For instance, in Figure 11-17, the likelihood of achieving the cost estimate of US$41 million is about 12%.
- **Prioritized list of quantified risks.** This list includes those risks that pose the greatest threat or present the greatest opportunity to the project. These include the risks that may have the greatest effect on cost contingency and those that are most likely to influence the critical path. These risks may be evaluated, in some cases, through a tornado diagram generated as a result of the simulation analysis.
- **Trends in quantitative risk analysis results.** As the analysis is repeated, a trend may become apparent that leads to conclusions affecting risk responses. Organizational historical information on project schedule, cost, quality, and performance should reflect new insights gained through the Perform Quantitative Risk Analysis process. Such history may take the form of a quantitative risk analysis report. This report may be separate from, or linked to, the risk register.

11.5 Plan Risk Responses

Plan Risk Responses is the process of developing options and actions to enhance opportunities and to reduce threats to project objectives. The key benefit of this process is that it addresses the risks by their priority, inserting resources and activities into the budget, schedule and project management plan as needed. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-18. Figure 11-19 depicts the data flow diagram of the process.

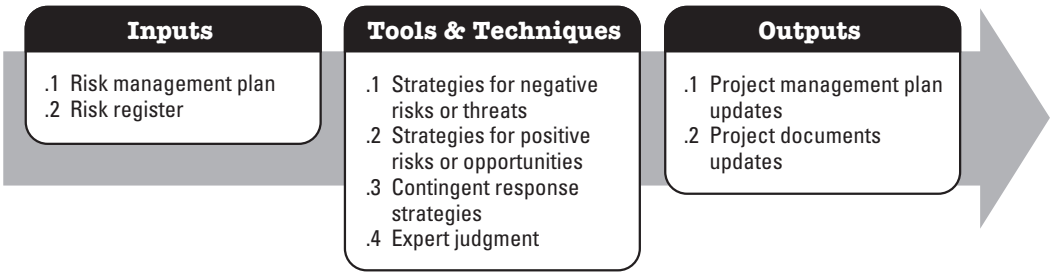


Figure 11-18. Plan Risk Responses: Inputs, Tools & Techniques, and Outputs

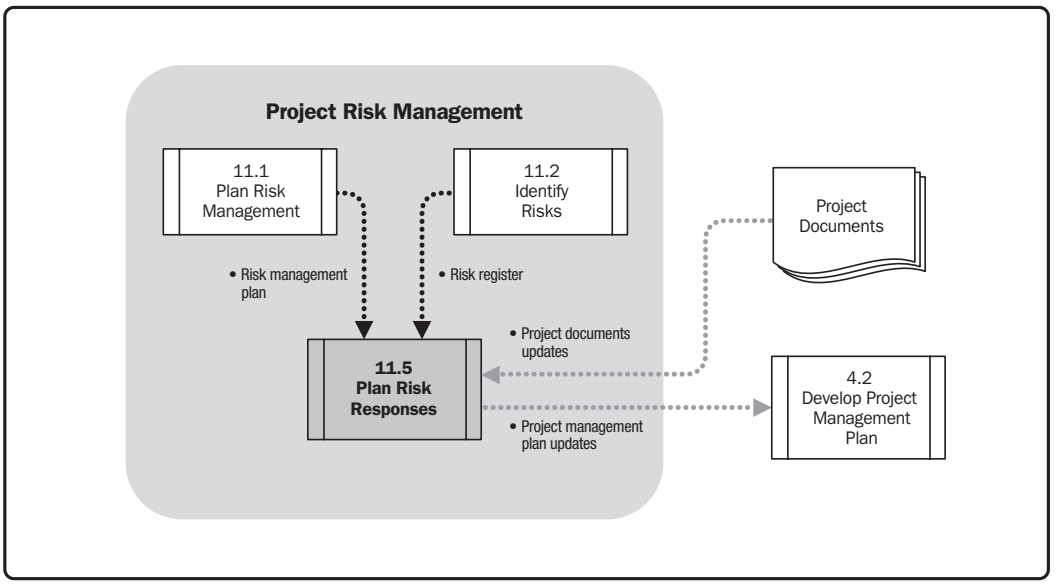


Figure 11-19. Plan Risk Responses Data Flow Diagram

The Plan Risk Responses process follows the Perform Quantitative Risk Analysis process (if used). Each risk response requires an understanding of the mechanism by which it will address the risk. This is the mechanism used to analyze if the risk response plan is having the desired effect. It includes the identification and assignment of one person (an owner for risk response) to take responsibility for each agreed-to and funded risk response. Risk responses should be appropriate for the significance of the risk, cost-effective in meeting the challenge, realistic within the project context, agreed upon by all parties involved, and owned by a responsible person. Selecting the optimum risk response from several options is often required.

The Plan Risk Responses process presents commonly used approaches to planning responses to the risks. Risks include threats and opportunities that can affect project success, and responses are discussed for each.

11.5.1 Plan Risk Responses: Inputs

11.5.1.1 Risk Management Plan

Important components of the risk management plan include roles and responsibilities, risk analysis definitions, timing for reviews (and for eliminating risks from review), and risk thresholds for low, moderate, and high risks. Risk thresholds help identify those risks for which specific responses are needed.

11.5.1.2 Risk Register

The risk register refers to identified risks, root causes of risks, lists of potential responses, risk owners, symptoms and warning signs, the relative rating or priority list of project risks, risks requiring responses in the near term, risks for additional analysis and response, trends in qualitative analysis results, and a watch list, which is a list of low-priority risks within the risk register.

11.5.2 Plan Risk Responses: Tools and Techniques

Several risk response strategies are available. The strategy or mix of strategies most likely to be effective should be selected for each risk. Risk analysis tools, such as decision tree analysis (Section 11.4.2.2), can be used to choose the most appropriate responses. Specific actions are developed to implement that strategy, including primary and backup strategies, as necessary. A fallback plan can be developed for implementation if the selected strategy turns out not to be fully effective or if an accepted risk occurs. Secondary risks should also be reviewed. Secondary risks are risks that arise as a direct result of implementing a risk response. A contingency reserve is often allocated for time or cost. If developed, it may include identification of the conditions that trigger its use.

11.5.2.1 Strategies for Negative Risks or Threats

Three strategies, which typically deal with threats or risks that may have negative impacts on project objectives if they occur, are: *avoid*, *transfer*, and *mitigate*. The fourth strategy, *accept*, can be used for negative risks or threats as well as positive risks or opportunities. Each of these risk response strategies have varied and unique influence on the risk condition. These strategies should be chosen to match the risk's probability and impact on the project's overall objectives. Avoidance and mitigation strategies are usually good strategies for critical risks with high impact, while transference and acceptance are usually good strategies for threats that are less critical and with low overall impact. The four strategies for dealing with negative risks or threats are further described as follows:

- **Avoid.** Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact. It usually involves changing the project management plan to eliminate the threat entirely. The project manager may also isolate the project objectives from the risk's impact or change the objective that is in jeopardy. Examples of this include extending the schedule, changing the strategy, or reducing scope. The most radical avoidance strategy is to shut down the project entirely. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.
- **Transfer.** Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response. Transferring the risk simply gives another party responsibility for its management—it does not eliminate it. Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement. Risk transference nearly always involves payment of a risk premium to the party taking on the risk. Transferring liability for risk is most effective in dealing with financial risk exposure. Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc. Contracts or agreements may be used to transfer liability for specified risks to another party. For example, when a buyer has capabilities that the seller does not possess, it may be prudent to transfer some work and its concurrent risk contractually back to the buyer. In many cases, use of a cost-plus contract may transfer the cost risk to the buyer, while a fixed-price contract may transfer risk to the seller.

- **Mitigate.** Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. Taking early action to reduce the probability and/or impact of a risk occurring on the project is often more effective than trying to repair the damage after the risk has occurred. Adopting less complex processes, conducting more tests, or choosing a more stable supplier are examples of mitigation actions. Mitigation may require prototype development to reduce the risk of scaling up from a bench-scale model of a process or product. Where it is not possible to reduce probability, a mitigation response might address the risk impact by targeting linkages that determine the severity. For example, designing redundancy into a system may reduce the impact from a failure of the original component.
- **Accept.** Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs. This strategy is adopted where it is not possible or cost-effective to address a specific risk in any other way. This strategy indicates that the project team has decided not to change the project management plan to deal with a risk, or is unable to identify any other suitable response strategy. This strategy can be either passive or active. Passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly. The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the risks.

11.5.2.2 Strategies for Positive Risks or Opportunities

Three of the four responses are suggested to deal with risks with potentially positive impacts on project objectives. The fourth strategy, *accept*, can be used for negative risks or threats as well as positive risks or opportunities. These strategies, described below, are to exploit, share, enhance, and accept.

- **Exploit.** The exploit strategy may be selected for risks with positive impacts where the organization wishes to ensure that the opportunity is realized. This strategy seeks to eliminate the uncertainty associated with a particular upside risk by ensuring the opportunity definitely happens. Examples of directly exploiting responses include assigning an organization's most talented resources to the project to reduce the time to completion or using new technologies or technology upgrades to reduce cost and duration required to realize project objectives.

- **Enhance.** The enhance strategy is used to increase the probability and/or the positive impacts of an opportunity. Identifying and maximizing key drivers of these positive-impact risks may increase the probability of their occurrence. Examples of enhancing opportunities include adding more resources to an activity to finish early.
- **Share.** Sharing a positive risk involves allocating some or all of the ownership of the opportunity to a third party who is best able to capture the opportunity for the benefit of the project. Examples of sharing actions include forming risk-sharing partnerships, teams, special-purpose companies, or joint ventures, which can be established with the express purpose of taking advantage of the opportunity so that all parties gain from their actions.
- **Accept.** Accepting an opportunity is being willing to take advantage of the opportunity if it arises, but not actively pursuing it.

11.5.2.3 Contingent Response Strategies

Some responses are designed for use only if certain events occur. For some risks, it is appropriate for the project team to make a response plan that will only be executed under certain predefined conditions, if it is believed that there will be sufficient warning to implement the plan. Events that trigger the contingency response, such as missing intermediate milestones or gaining higher priority with a supplier, should be defined and tracked. Risk responses identified using this technique are often called contingency plans or fallback plans and include identified triggering events that set the plans in effect.

11.5.2.4 Expert Judgment

Expert judgment is input from knowledgeable parties pertaining to the actions to be taken on a specific and defined risk. Expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training in establishing risk responses.

11.5.3 Plan Risk Responses: Outputs

11.5.3.1 Project Management Plan Updates

Elements of the project management plan that may be updated as a result of carrying out this process include, but are not limited to:

- **Schedule management plan.** The schedule management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to resource loading and leveling, as well as updates to the schedule strategy.
- **Cost management plan.** The cost management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to cost accounting, tracking, and reports, as well as updates to the budget strategy and how contingency reserves are consumed.
- **Quality management plan.** The quality management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to requirements, quality assurance, or quality control, as well as updates to the requirements documentation.
- P**rocurement management plan.** The procurement management plan may be updated to reflect changes in strategy, such as alterations in the make-or-buy decision or contract type(s) driven by the risk responses.
- **Human resource management plan.** The staffing management plan, part of the human resource management plan, is updated to reflect changes in project organizational structure and resource applications driven by the risk responses. This may include changes in tolerance or behavior related to staff allocation, as well as updates to the resource loading.
- **Scope baseline.** Because of new, modified or omitted work generated by the risk responses, the scope baseline may be updated to reflect those changes.
- **Schedule baseline.** Because of new work (or omitted work) generated by the risk responses, the schedule baseline may be updated to reflect those changes.
- **Cost baseline.** Because of new work (or omitted work) generated by the risk responses, the cost baseline may be updated to reflect those changes.

11.5.3.2 Project Documents Updates

In the Plan Risk Responses process, several project documents are updated as needed. For example, when appropriate risk responses are chosen and agreed upon, they are included in the risk register. The risk register should be written to a level of detail that corresponds with the priority ranking and the planned response. Often, the high and moderate risks are addressed in detail. Risks judged to be of low priority are included in a watch list for periodic monitoring. Updates to the risk register can include, but are not limited to:

- Risk owners and assigned responsibilities;
- Agreed-upon response strategies;
- Specific actions to implement the chosen response strategy;
- Trigger conditions, symptoms, and warning signs of a risk occurrence;
- Budget and schedule activities required to implement the chosen responses;
- Contingency plans and triggers that call for their execution;
- Fallback plans for use as a reaction to a risk that has occurred and the primary response proves to be inadequate;
- Residual risks that are expected to remain after planned responses have been taken, as well as those that have been deliberately accepted;
- Secondary risks that arise as a direct outcome of implementing a risk response; and
- Contingency reserves that are calculated based on the quantitative risk analysis of the project and the organization's risk thresholds.

Other project documents updated could include:

- **Assumptions log updates.** As new information becomes available through the application of risk responses, assumptions could change. The assumptions log needs to be revisited to accommodate this new information.
- **Technical documentation updates.** As new information becomes available through the application of risk responses, technical approaches and physical deliverables may change. Any supporting documentation needs to be revisited to accommodate this new information.
- **Change requests.** Planning for possible risk responses can often result in recommendations for changes to the resources, activities, cost estimates, and other items identified during other planning processes. When such recommendations are identified, change requests are generated and processed through the Perform Integrated Change Control process.

11.6 Control Risks

Control Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project. The key benefit of this process is that it improves efficiency of the risk approach throughout the project life cycle to continuously optimize risk responses. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-20. Figure 11-21 depicts the data flow diagram of the process.

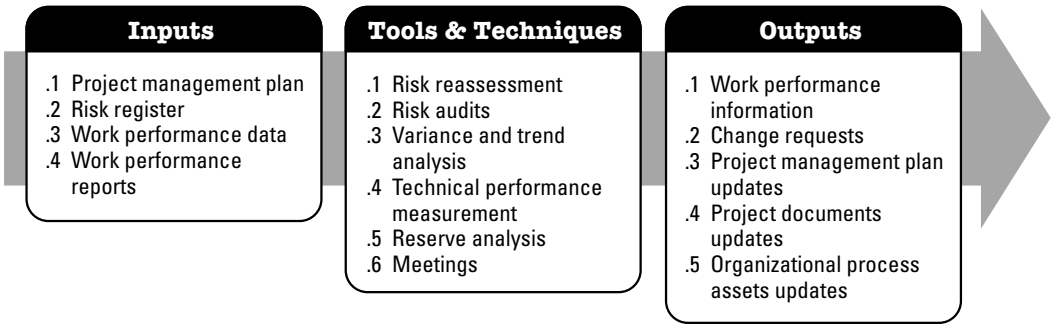


Figure 11-20. Control Risks: Inputs, Tools & Techniques, and Outputs

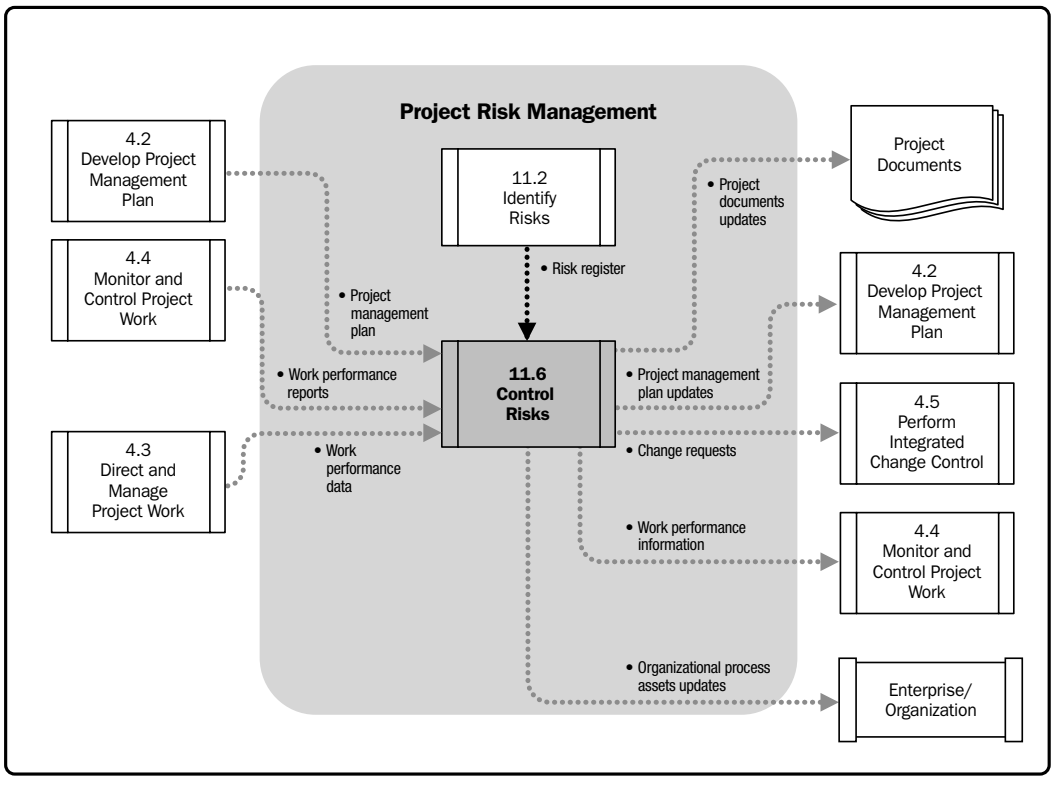


Figure 11-21. Control Risks Data Flow Diagram

Planned risk responses that are included in the risk register are executed during the life cycle of the project, but the project work should be continuously monitored for new, changing, and outdated risks.

The Control Risks process applies techniques, such as variance and trend analysis, which require the use of performance information generated during project execution. Other purposes of the Control Risks process are to determine if:

- Project assumptions are still valid,
- Analysis shows an assessed risk has changed or can be retired,
- Risk management policies and procedures are being followed, and
- Contingency reserves for cost or schedule should be modified in alignment with the current risk assessment.

Control Risks can involve choosing alternative strategies, executing a contingency or fallback plan, taking corrective action, and modifying the project management plan. The risk response owner reports periodically to the project manager on the effectiveness of the plan, any unanticipated effects, and any correction needed to handle the risk appropriately. Control Risks also includes updating the organizational process assets, including project lessons learned databases and risk management templates, for the benefit of future projects.

11.6.1 Control Risks: Inputs

11.6.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan, which includes the risk management plan, provides guidance for risk monitoring and controlling.

11.6.1.2 Risk Register

The risk register has key inputs that include identified risks and risk owners, agreed-upon risk responses, control actions for assessing the effectiveness of response plans, risk responses, specific implementation actions, symptoms and warning signs of risk, residual and secondary risks, a watch list of low-priority risks, and the time and cost contingency reserves. The watch list is within the risk register and provides a list of low-priority risks.

11.6.1.3 Work Performance Data

Described in Section 4.3.3.2. Work performance data related to various performance results possibly impacted by risks includes, but is not limited to:

- Deliverable status,
- Schedule progress, and
- Costs incurred.

11.6.1.4 Work Performance Reports

Described in Section 4.4.3.2. Work performance reports take information from performance measurements and analyze it to provide project work performance information including variance analysis, earned value data, and forecasting data. These data points could be impactful in controlling performance related risks.

11.6.2 Control Risks: Tools and Techniques

11.6.2.1 Risk Reassessment

Control Risks often results in identification of new risks, reassessment of current risks, and the closing of risks that are outdated. Project risk reassessments should be regularly scheduled. The amount and detail of repetition that are appropriate depends on how the project progresses relative to its objectives.

11.6.2.2 Risk Audits

Risk audits examine and document the effectiveness of risk responses in dealing with identified risks and their root causes, as well as the effectiveness of the risk management process. The project manager is responsible for ensuring that risk audits are performed at an appropriate frequency, as defined in the project's risk management plan. Risk audits may be included during routine project review meetings, or the team may choose to hold separate risk audit meetings. The format for the audit and its objectives should be clearly defined before the audit is conducted.

11.6.2.3 Variance and Trend Analysis

Many control processes employ variance analysis to compare the planned results to the actual results. For the purposes of controlling risks, trends in the project's execution should be reviewed using performance information. Earned value analysis and other methods of project variance and trend analysis may be used for monitoring overall project performance. Outcomes from these analyses may forecast potential deviation of the project at completion from cost and schedule targets. Deviation from the baseline plan may indicate the potential impact of threats or opportunities.

11.6.2.4 Technical Performance Measurement

Technical performance measurement compares technical accomplishments during project execution to the schedule of technical achievement. It requires the definition of objective, quantifiable measures of technical performance, which can be used to compare actual results against targets. Such technical performance measures may include weight, transaction times, number of delivered defects, storage capacity, etc. Deviation, such as demonstrating more or less functionality than planned at a milestone, can help to forecast the degree of success in achieving the project's scope.

11.6.2.5 Reserve Analysis

Throughout execution of the project, some risks may occur with positive or negative impacts on budget or schedule contingency reserves. Reserve analysis compares the amount of the contingency reserves remaining to the amount of risk remaining at any time in the project in order to determine if the remaining reserve is adequate.

11.6.2.6 Meetings

Project risk management should be an agenda item at periodic status meetings. The amount of time required for that item will vary, depending upon the risks that have been identified, their priority, and difficulty of response. The more often risk management is practiced, the easier it becomes. Frequent discussions about risk make it more likely that people will identify risks and opportunities.

11.6.3 Control Risks: Outputs

11.6.3.1 Work Performance Information

Work performance information, as a Control Risks output, provides a mechanism to communicate and support project decision making.

11.6.3.2 Change Requests

Implementing contingency plans or workarounds sometimes results in a change request. Change requests are prepared and submitted to the Perform Integrated Change Control process (Section 4.5). Change requests can include recommended corrective and preventive actions as well.

- **Recommended corrective actions.** These are activities that realign the performance of the project work with the project management plan. They include contingency plans and workarounds. The latter are responses that were not initially planned, but are required to deal with emerging risks that were previously unidentified or accepted passively.
- **Recommended preventive actions.** These are activities that ensure that future performance of the project work is aligned with the project management plan.

11.6.3.3 Project Management Plan Updates

If the approved change requests have an effect on the risk management processes, the corresponding component documents of the project management plan are revised and reissued to reflect the approved changes. The elements of the project management plan that may be updated are the same as those in the Plan Risk Responses process.

11.6.3.4 Project Documents Updates

Project documents that may be updated as a result of the Control Risk process include, but are not limited to the risk register. Risk register updates may include:

- **Outcomes of risk reassessments, risk audits, and periodic risk reviews.** These outcomes may include identification of new risks, updates to probability, impact, priority, response plans, ownership, and other elements of the risk register. Outcomes can also include closing risks that are no longer applicable and releasing their associated reserves.
- **Actual outcomes of the project's risks and of the risk responses.** This information can help project managers to plan for risk throughout their organizations, as well as on future projects.

11.6.3.5 Organizational Process Assets Updates

The risk management processes produce information that may be used for future projects, and should be captured in the organizational process assets. The organizational process assets that may be updated include, but are not limited to:

- Templates for the risk management plan, including the probability and impact matrix and risk register,
- Risk breakdown structure, and
- Lessons learned from the project risk management activities.

These documents should be updated as needed and at project closure. Final versions of the risk register and the risk management plan templates, checklists, and risk breakdown structure are included.

