PROJECT RISK MANAGEMENT

11

Project Risk Management includes the processes concerned with identifying, analyzing, and responding to project risk. It includes maximizing the results of positive events and minimizing the consequences of adverse events. Figure 11–1 provides an overview of the following major processes:

11.1 Risk Identification—determining which risks are likely to affect the project and documenting the characteristics of each.

11.2 Risk Quantification—evaluating risks and risk interactions to assess the range of possible project outcomes.

11.3 Risk Response Development—defining enhancement steps for opportunities and responses to threats.

11.4 Risk Response Control—responding to changes in risk over the course of the project.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process may involve effort from one or more individuals or groups of individuals based on the needs of the project. Each process generally occurs at least once in every project phase.

Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3.

Different application areas often use different names for the processes described here. For example:

- Risk identification and risk quantification are sometimes treated as a single process, and the combined process may be called risk analysis or risk assessment.
- Risk response development is sometimes called response planning or risk mitigation.
- Risk response development and risk response control are sometimes treated as a single process, and the combined process may be called risk management.

11.1 RISK IDENTIFICATION

Risk identification consists of determining which risks are likely to affect the project and documenting the characteristics of each. Risk identification is not a one-time event; it should be performed on a regular basis throughout the project.

Risk identification should address both internal and external risks. Internal risks are things that the project team can control or influence, such as staff assignments and cost estimates. External risks are things beyond the control or influence of the project team, such as market shifts or government action.

Strictly speaking, risk involves only the possibility of suffering harm or loss. In the project context, however, risk identification is also concerned with opportunities (positive outcomes) as well as threats (negative outcomes).

Figure 11–1. Project Risk Management Overview

Project Risk Management

11.1 Risk Identification

.1 Inputs
- .1 Product description
- .2 Other planning outputs
- .3 Historical information

.2 Tools and Techniques
- .1 Checklists
- .2 Flowcharting
- .3 Interviewing

.3 Outputs
- .1 Sources of risk
- .2 Potential risk events
- .3 Risk symptoms
- .4 Inputs to other processes

11.2 Risk Quantification

.1 Inputs
- .1 Stakeholder risk tolerances
- .2 Sources of risk
- .3 Potential risk events
- .4 Cost estimates
- .5 Activity duration estimates

.2 Tools and Techniques
- .1 Expected monetary value
- .2 Statistical sums
- .3 Simulation
- .4 Decision trees
- .5 Expert judgment

.3 Outputs
- .1 Opportunities to pursue, threats to respond to
- .2 Opportunities to ignore, threats to accept

11.3 Risk Response Development

.1 Inputs
- .1 Opportunities to pursue, threats to respond to
- .2 Opportunities to ignore, threats to accept

.2 Tools and Techniques
- .1 Procurement
- .2 Contingency planning
- .3 Alternative strategies
- .4 Insurance

.3 Outputs
- .1 Risk management plan
- .2 Inputs to other processes
- .3 Contingency plans
- .4 Reserves
- .5 Contractual agreements

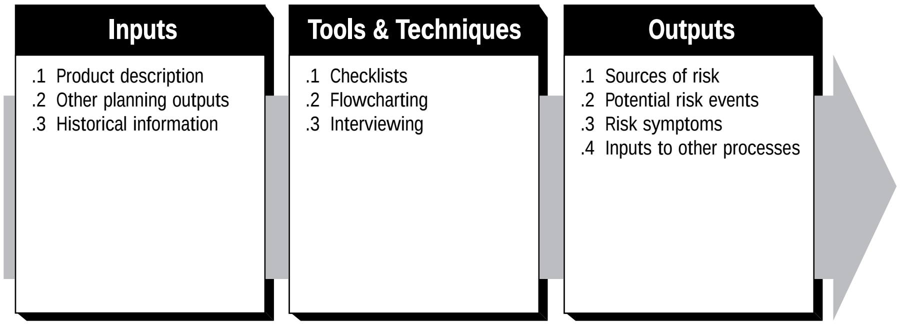
11.4 Risk Response Control

.1 Inputs
- .1 Risk management plan
- .2 Actual risk events
- .3 Additional risk identification

.2 Tools and Techniques
- .1 Workarounds
- .2 Additional risk response development

.3 Outputs
- .1 Corrective action
- .2 Updates to risk management plan

Risk identification may be accomplished by identifying causes-and-effects (what could happen and what will ensue) or effects-and-causes (what outcomes are to be avoided or encouraged and how each might occur).



11.1.1 Inputs to Risk Identification

.1 *Product description.* The nature of the product of the project will have a major effect on the risks identified. Products that involve proven technology will, all other things being equal, involve less risk than products which require innovation or invention. Risks associated with the product of the project are often described in terms of their cost and schedule impact. Section 5.1.1.1 has additional information about the product description.

.2 *Other planning outputs.* The outputs of the processes in other knowledge areas should be reviewed to identify possible risks. For example:

- Work breakdown structure—non-traditional approaches to detail deliverables may offer opportunities that were not apparent from the higher-level deliverables identified in the scope statement.
- Cost estimates and duration estimates—aggressive estimates and estimates developed with a limited amount of information entail more risk.
- Staffing plan—identified team members may have unique skills that would be hard to replace or may have other commitments that make their availability tenuous.
- Procurement management plan—market conditions such as a sluggish local economy may offer opportunities to reduce contract costs.

.3 *Historical information.* Historical information about what actually happened on previous projects can be especially helpful in identifying potential risks. Information on historical results is often available from the following sources:

- Project files—one or more of the organizations involved in the project may maintain records of previous project results that are detailed enough to aid in risk identification. In some application areas, individual team members may maintain such records.
- Commercial databases—historical information is available commercially in many application areas.
- Project team knowledge—the individual members of the project team may remember previous occurrences or assumptions. While such recollections may be useful, they are generally less reliable than documented results.

11.1.2 Tools and Techniques for Risk Identification

.1 *Checklists.* Checklists are typically organized by source of risk. Sources include the project context (see Chapter 2), other process outputs (see Section 11.1.1.2), the product of the project or technology issues, and internal sources such as team member skills (or the lack thereof). Some application areas have widely used classification schemes for sources of risk.

2. *Flowcharting.* Flowcharting (described in Section 8.1.2.3) can help the project team better understand the causes and effects of risks.

.3 *Interviewing.* Risk-oriented interviews with various stakeholders may help identify risks not identified during normal planning activities. Records of pre-project interviews (e.g., those conducted during a feasibility study) may also be available.

11.1.3 Outputs from Risk Identification

.1 *Sources of risk.* Sources of risk are categories of possible risk events (e.g., stakeholder actions, unreliable estimates, team turnover) that may affect the project for better or worse. The list of sources should be comprehensive, i.e., it should generally include all identified items regardless of frequency, probability of occurrence, or magnitude of gain or loss. Common sources of risk include:

- Changes in requirements.
- Design errors, omissions, and misunderstandings.
- Poorly defined or understood roles and responsibilities.
- Poor estimates.
- Insufficiently skilled staff.

Descriptions of the sources of risk should generally include estimates of (a) the probability that a risk event from that source will occur, (b) the range of possible outcomes, (c) expected timing, and (d) anticipated frequency of risk events from that source.

Both probabilities and outcomes may be specified as continuous functions (an estimated cost between $100,000 and $150,000) or as discrete ones (a patent either will or will not be granted). In addition, estimates of probabilities and outcomes made during early project phases are likely to have a broader range than those made later in the project.

.2 *Potential risk events.* Potential risk events are discrete occurrences such as a natural disaster or the departure of a specific team member that may affect the project. Potential risk events should be identified in addition to sources of risk when the probability of occurrence or magnitude of loss is relatively large ("relatively large" will vary by project). While potential risk events are seldom application-area-specific, a list of *common* risk events usually is. For example:

- Development of new technology that will obviate the need for a project is common in electronics and rare in real estate development.
- Losses due to a major storm are common in construction and rare in biotechnology.

Descriptions of potential risk events should generally include estimates of (a) the probability that the risk event will occur, (b) the alternative possible outcomes, (c) expected timing of the event, and (d) anticipated frequency (i.e., can it happen more than once).

Both probabilities and outcomes may be specified as continuous functions (an estimated cost between $100,000 and $150,000) or as discrete ones (a patent either will or will not be granted). In addition, estimates of probabilities and outcomes made during early project phases are likely to have a broader range than those made later in the project.

.3 *Risk symptoms.* Risk symptoms, sometimes called triggers, are indirect manifestations of actual risk events. For example, poor morale may be an early warning signal of an impending schedule delay or cost overruns on early activities may be indicative of poor estimating.

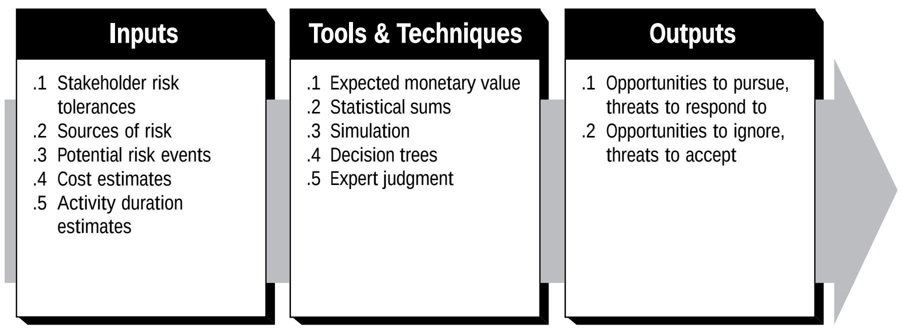
.4 *Inputs to other processes.* The risk identification process may identify a need for further activity in another area. For example, the work breakdown structure may not have sufficient detail to allow adequate identification of risks.

Risks are often input to the other processes as constraints or assumptions.

11.2 RISK QUANTIFICATION

Risk quantification involves evaluating risks and risk interactions to assess the range of possible project outcomes. It is primarily concerned with determining which risk events warrant response. It is complicated by a number of factors including, but not limited to:

- Opportunities and threats can interact in unanticipated ways (e.g., schedule delays may force consideration of a new strategy that reduces overall project duration).
- A single risk event can cause multiple effects, as when late delivery of a key component produces cost overruns, schedule delays, penalty payments, and a lower-quality product.
- Opportunities for one stakeholder (reduced cost) may be threats to another (reduced profits).
- The mathematical techniques used can create a false impression of precision and reliability.



11.2.1 Inputs to Risk Quantification

.1 *Stakeholder risk tolerances.* Different organizations and different individuals have different tolerances for risk. For example:

- A highly profitable company may be willing to spend $500,000 to write a proposal for a $1 billion contract, while a company operating at break-even is not.
- One organization may perceive an estimate that has a 15 percent probability of overrunning as high risk, while another perceives it as low risk.

Stakeholder risk tolerances provide a screen for both inputs and outputs to risk quantification.

.2 *Sources of risk.* Sources of risk are described in Section 11.1.3.1.

.3 *Potential risk events.* Potential risk events are described in Section 11.1.3.2.

.4 *Cost estimates.* Cost estimates are described in Section 7.2.3.1.

.5 *Activity duration estimates.* Activity duration estimates are described in Section 6.3.3.1.

11.2.2 Tools and Techniques for Risk Quantification

.1 *Expected monetary value.* Expected monetary value, as a tool for risk quantification, is the product of two numbers:

- Risk event probability—an estimate of the probability that a given risk event will occur.
- Risk event value—an estimate of the gain or loss that will be incurred if the risk event does occur.

The risk event value must reflect both tangibles and intangibles. For example, Project A and Project B both identify an equal probability of a tangible loss of $100,000 as an outcome of an aggressively priced proposal. If Project A predicts little or no intangible effect, while Project B predicts that such a loss will put its performing organization out of business, the two risks are not equivalent.

Figure 11–2. Summing Probability Distributions

Activity Name	Low	Most Likely	High	Mean	Sigma	Variance
	a	m	b	$\bar{x}$	σ	σ^2
Triangular Distribution						
Initial draft						
Gather information	40	45	80	55.0	8.9	79.2
Write sections	35	50	100	61.7	13.9	193.1
Review informally	10	15	30	18.3	4.2	18.1
Inspection						
Inspectors inspect	18	25	50	31.0	6.9	47.2
Prepare defects/issues list	10	20	40	23.3	6.2	38.9
Resolve defects/issues	10	25	60	31.7	10.5	109.7
Make necessary changes	15	20	40	25.0	5.4	29.2
Estimated Project Totals:		200		246.0	22.7 ←	515.2

Mean = (a + m + b) / 3 Variance = $[(b - a)^2 + (m - a)(m - b)] / 18$

Activity Name	Low	Most Likely	High	Mean	Sigma	Variance
Beta Distribution (using PERT approximations)						
Initial draft						
Gather information	40	45	80	50.0	6.7	44.4
Write sections	35	50	100	55.8	10.8	117.4
Review informally	10	15	30	16.7	3.3	11.1
Inspection						
Inspectors inspect	18	25	50	28.0	5.3	28.4
Prepare defects/issues list	10	20	40	21.7	5.0	25.0
Resolve defects/issues	10	25	60	28.3	8.3	69.4
Make necessary changes	15	20	40	22.5	4.2	17.4
Estimated Project Totals:		200		223.0	17.7 ←	313.2

Mean = (a + 4m + b) / 6 Variance = $[(b - a) / 6]^2$

When summing probability distributions:

- If the distributions are skewed to the left as in this illustration, the project mean will always be significantly higher than the sum of the most likely estimates.
- Distributions can be mixed and matched at will. The same distribution was used for all activities to simplify this illustration.

In order to sum probability distributions, calculate:

- The mean, sigma (standard deviation), and variance for each individual activity based on the formula for that distribution (i.e., beta, triangular, flat, etc.).
- The project mean as the sum of the individual activity means.
- The project variance as the sum of the individual activity variances.
- The project sigma (standard deviation) as the square root of the project variance.

In similar fashion, failure to include intangibles in this calculation can severely distort the result by equating a small loss with a high probability to a large loss with a small probability.

The expected monetary value is generally used as input to further analysis (e.g., in a decision tree) since risk events can occur individually or in groups, in parallel or in sequence.

.2 *Statistical sums.* Statistical sums can be used to calculate a range of total project costs from the cost estimates for individual work items. (Calculating a range of probable project completion dates from the activity duration estimates requires simulation as described in Section 11.2.2.3).

The range of total project costs can be used to quantify the relative risk of alternative project budgets or proposal prices. Figure 11–2 illustrates the use of the “method of moments” technique to calculate project range estimates.

.3 *Simulation.* Simulation uses a representation or model of a system to analyze the behavior or performance of the system. The most common form of simulation on a project is schedule simulation using the project network as the model of the project. Most schedule simulations are based on some form of Monte Carlo analysis. This technique, adapted from general management, “performs” the project many times to provide a statistical distribution of the calculated results as illustrated in Figure 11–3.

The results of a schedule simulation may be used to quantify the risk of various schedule alternatives, different project strategies, different paths through the network, or individual activities.

Schedule simulation should be used on any large or complex project since traditional mathematical analysis techniques such as the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) do not account for path convergence (see Figure 11–4) and thus tend to underestimate project durations.

Monte Carlo analysis and other forms of simulation can also be used to assess the range of possible cost outcomes.

.4 *Decision trees.* A decision tree is a diagram that depicts key interactions among decisions and associated chance events as they are understood by the decision maker. The branches of the tree represent either decisions (shown as boxes) or chance events (shown as circles). Figure 11–5 is an example of a decision tree.

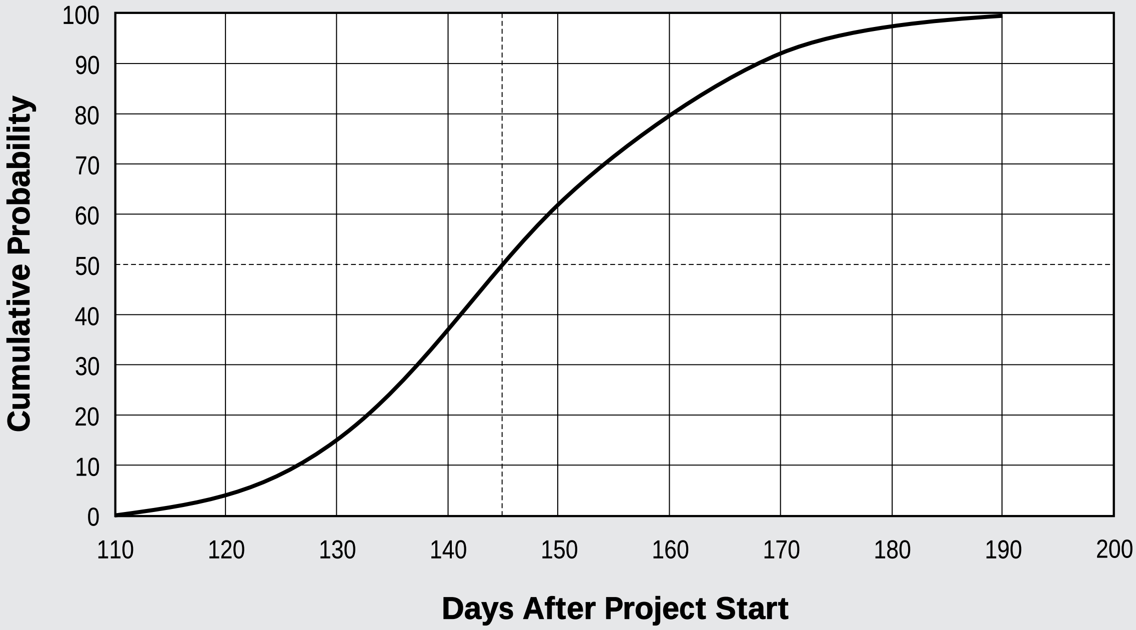
.5 *Expert judgment.* Expert judgement can often be applied in lieu of or in addition to the mathematical techniques described above. For example, risk events could be described as having a high, medium, or low probability of occurrence and a severe, moderate, or limited impact.

11.2.3 Outputs from Risk Quantification

.1 *Opportunities to pursue, threats to respond to.* The major output from risk quantification is a list of opportunities that should be pursued and threats that require attention.

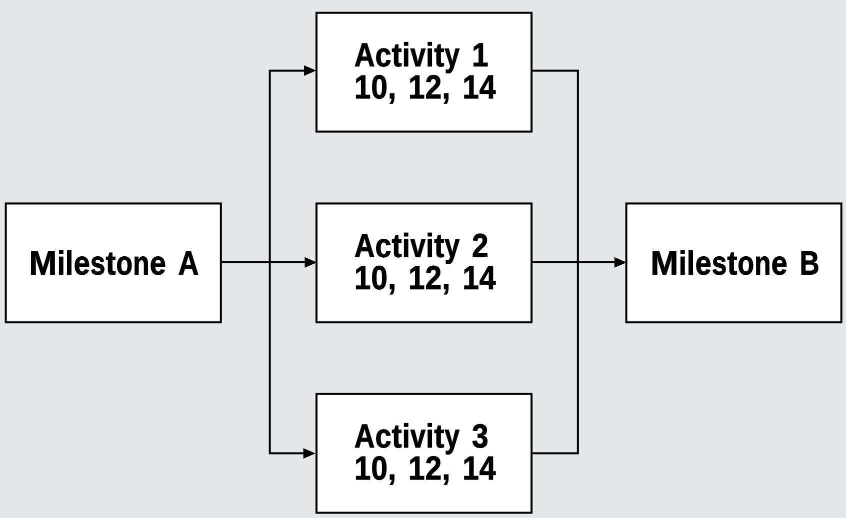
.2 *Opportunities to ignore, threats to accept.* The risk quantification process should also document (a) those sources of risk and risk events that the project management team has consciously decided to accept or ignore and (b) who made the decision to do so.

Figure 11–3. Results from a Monte Carlo Simulation of a Project Schedule



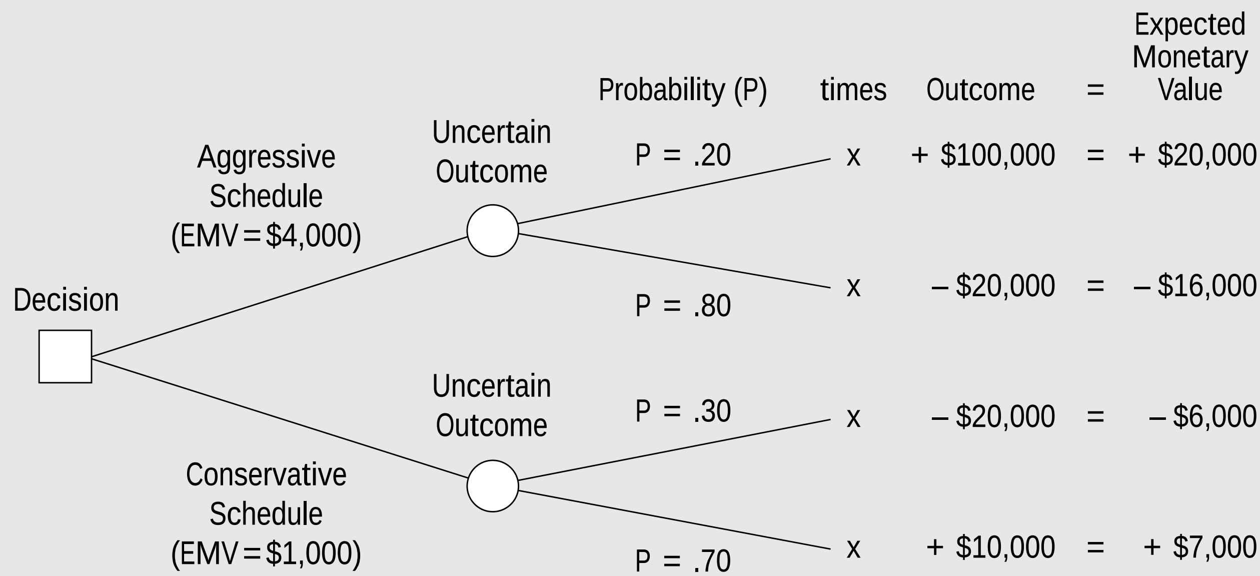
This S-curve shows the cumulative probability of project completion by a particular date. For example,the intersection of the dashed lines shows that there is a 50 percent probability that the project will be finished within 145 days of its start. Project completion dates toward the left have higher risk while those toward the right have lower risk.

Figure 11–4. Path Convergence



Activities 1, 2, and 3 all have an expected duration of 12 days, ± 2 days. The CPM calculated duration of Milestone A to Milestone B is, therefore, 12 days. However, the actual duration will be greater than 12 days if any one of the activities is delayed. This is true even if the other activities finish in less than 12 days.

Figure 11–5. Decision Tree

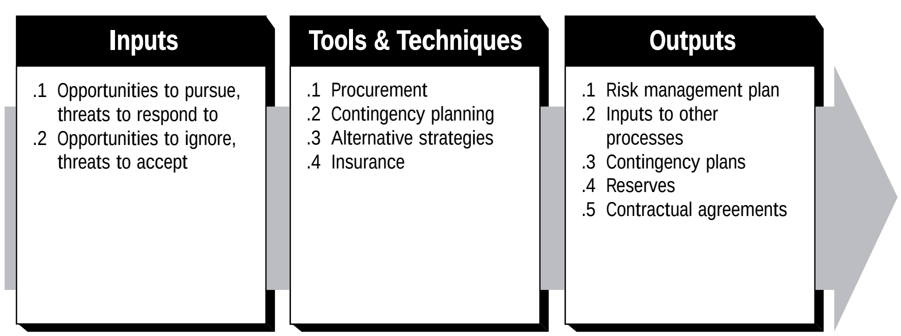


- Expected monetary value (EMV) of result = Outcome x Probability of that outcome.
- Expected monetary value of a decision = sum of EMVs of all Outcomes stemming from that decision.
- Aggressive schedule has expected monetary value of $4,000 and is “preferred” over conservative schedule with expected monetary value of $1,000.

11.3 RISK RESPONSE DEVELOPMENT

Risk response development involves defining enhancement steps for opportunities and responses to threats. Responses to threats generally fall into one of three categories:

- Avoidance—eliminating a specific threat, usually by eliminating the cause. The project management team can never eliminate all risk, but specific risk events can often be eliminated.
- Mitigation—reducing the expected monetary value of a risk event by reducing the probability of occurrence (e.g., using proven technology to lessen the probability that the product of the project will not work), reducing the risk event value (e.g., buying insurance), or both.
- Acceptance—accepting the consequences. Acceptance can be active (e.g., by developing a contingency plan to execute should the risk event occur) or passive (e.g., by accepting a lower profit if some activities overrun).



11.3.1 Inputs to Risk Response Development

.1 *Opportunities to pursue, threats to respond to.* These are described in Section 11.2.3.1.

.2 *Opportunities to ignore, threats to accept.* These are described in Section 11.2.3.2. These items are input to the risk response development process because they should be documented in the risk management plan (described in Section 11.3.3.1).

11.3.2 Tools and Techniques for Risk Response Development

.1 *Procurement.* Procurement, acquiring goods or services from outside the immediate project organization, is often an appropriate response to some types of risk. For example, risks associated with using a particular technology may be mitigated by contracting with an organization that has experience with that technology.

Procurement often involves exchanging one risk for another. For example, mitigating cost risk with a fixed price contract may create schedule risk if the seller is unable to perform. In similar fashion, trying to transfer all technical risk to the seller may result in an unacceptably high cost proposal.

Project Procurement Management is described in Chapter 12.

.2 *Contingency planning.* Contingency planning involves defining action steps to be taken if an identified risk event should occur (see also the discussion of workarounds in Section 11.4.2.1).

.3 *Alternative strategies.* Risk events can often be prevented or avoided by changing the planned approach. For example, additional design work may decrease the number of changes which must be handled during the implementation or construction phase. Many application areas have a substantial body of literature on the potential value of various alternative strategies.

.4 *Insurance.* Insurance or an insurance-like arrangement such as bonding is often available to deal with some categories of risk. The type of coverage available and the cost of coverage varies by application area.

11.3.3 Outputs from Risk Response Development

.1 *Risk management plan.* The risk management plan should document the procedures that will be used to manage risk throughout the project. In addition to documenting the results of the risk identification and risk quantification processes, it should cover who is responsible for managing various areas of risk, how the initial identification and quantification outputs will be maintained, how contingency plans will be implemented, and how reserves will be allocated.

A risk management plan may be formal or informal, highly detailed or broadly framed, based on the needs of the project. It is a subsidiary element of the overall project plan (described in Section 4.1).

.2 *Inputs to other processes.* Selected or suggested alternative strategies, contingency plans, anticipated procurements, and other risk-related outputs must all be fed back into the appropriate processes in the other knowledge areas.

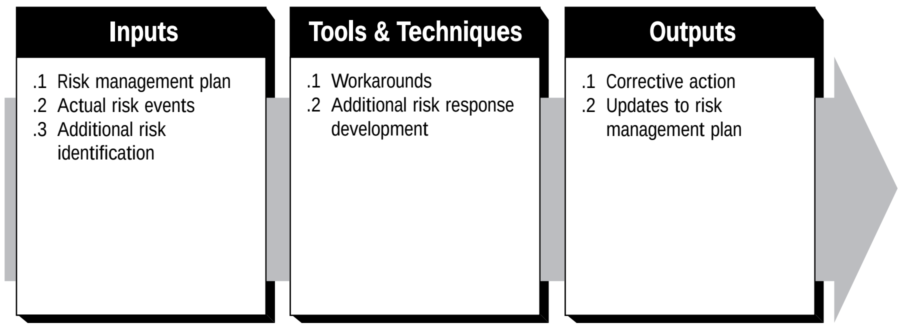
.3 *Contingency plans.* Contingency plans are pre-defined action steps to be taken if an identified risk event should occur. Contingency plans are generally part of the risk management plan, but they may also be integrated into other parts of the overall project plan (e.g., as part of a scope management plan or quality management plan).

.4 *Reserves.* A reserve is a provision in the project plan to mitigate cost and/or schedule risk. The term is often used with a modifier (e.g., management reserve, contingency reserve, schedule reserve) to provide further detail on what types of risk are meant to be mitigated. The specific meaning of the modified terms often varies by application area. In addition, use of a reserve, and the definition of what may be included in a reserve, is also application-area-specific.

.5 *Contractual agreements.* Contractual agreements may be entered into for insurance, services, and other items as appropriate in order to avoid or mitigate threats. Contractual terms and conditions will have a significant effect on the degree of risk reduction.

11.4 RISK RESPONSE CONTROL

Risk response control involves executing the risk management plan in order to respond to risk events over the course of the project. When changes occur, the basic cycle of identify, quantify, and respond is repeated. It is important to understand that even the most thorough and comprehensive analysis cannot identify all risks and probabilities correctly; control and iteration are required.



11.4.1 Inputs to Risk Response Control

.1 *Risk management plan.* The risk management plan is described in Section 11.3.3.1.

.2 *Actual risk events.* Some of the identified risk events will occur, others will not. The ones that do are actual risk events or sources of risk, and the project management team must recognize that one has occurred so that the response developed can be implemented.

.3 *Additional risk identification.* As project performance is measured and reported (discussed in Section 10.3), potential risk events or sources of risk not previously identified may surface.

11.4.2 Tools and Techniques for Risk Response Control

.1 *Workarounds.* Workarounds are unplanned responses to negative risk events. Workarounds are unplanned only in the sense that the response was not defined in advance of the risk event occurring.

.2 *Additional risk response development.* If the risk event was not anticipated, or the effect is greater than expected, the planned response may not be adequate, and it will be necessary to repeat the response development process and perhaps the risk quantification process as well.

11.4.3 Outputs from Risk Response Control

.1 *Corrective action.* Corrective action consists primarily of performing the planned risk response (e.g., implementing contingency plans or workarounds).

.2 *Updates to risk management plan.* As anticipated risk events occur or fail to occur, and as actual risk event effects are evaluated, estimates of probabilities and value, as well as other aspects of the risk management plan, should be updated.

Notes