CHAPTER

28 RISK MANAGEMENT

KEY CONCEPTS

In his book on risk analysis and management, Robert Charette [Cha89] presents a conceptual definition of risk:

> First, risk concerns future happenings. Today and yesterday are beyond active concern, as we are already reaping what was previously sowed by our past actions. The question is, can we, therefore, by changing our actions today, create an opportunity for a different and hopefully better situation for ourselves tomorrow. This means, second, that risk involves change, such as in changes of mind, opinion, actions, or places. . . . [Third,] risk involves choice, and the uncertainty that choice itself entails. Thus paradoxically, risk, like death and taxes, is one of the few certainties of life.

When you consider risk in the context of software engineering, Charette's three conceptual underpinnings are always in evidence. The future is your

QUICK LOOK

What is it? Risk analysis and management are actions that help a software team to understand and manage uncertainty. Many problems can plague a software project. A risk is a potential problem—it might happen, it might not. But, regardless of the outcome, it's a really good idea to identify it, assess its probability of occurrence, estimate its impact, and establish a contingency plan should the problem actually occur.

Who does it? Everyone involved in the software process—managers, software engineers, and other stakeholders—participate in risk analysis and management.

Why is it important? Think about the Boy Scout motto: "Be prepared." Software is a difficult undertaking. Lots of things can go wrong, and frankly, many often do. It's for this reason that being prepared—understanding the risks and taking proactive measures to avoid or manage them—is a key element of good software project management.

What are the steps? Recognizing what can go wrong is the first step, called "risk identification." Next, each risk is analyzed to determine the likelihood that it will occur and the damage that it will do if it does occur. Once this information is established, risks are ranked, by probability and impact. Finally, a plan is developed to manage those risks that have high probability and high impact.

What is the work product? A risk mitigation, monitoring, and management (RMMM) plan or a set of risk information sheets is produced.

How do I ensure that I've done it right? The risks that are analyzed and managed should be derived from thorough study of the people, the product, the process, and the project. The RMMM should be revisited as the project proceeds to ensure that risks are kept up to date. Contingency plans for risk management should be realistic.

concern—what risks might cause the software project to go awry? Change is your concern—how will changes in customer requirements, development technologies, target environments, and all other entities connected to the project affect timeliness and overall success? Last, you must grapple with choices—what methods and tools should you use, how many people should be involved, how much emphasis on quality is "enough"?

Peter Drucker [Dru75] once said, "While it is futile to try to eliminate risk, and questionable to try to minimize it, it is essential that the risks taken be the right risks." Before you can identify the "right risks" to be taken during a software project, it is important to identify all risks that are obvious to both managers and practitioners.

28.1 Reactive versus Proactive Risk Strategies

Quote:

"If you don't actively attack the risks, they will actively attack you."

Tom Gilb

Reactive risk strategies have been laughingly called the "Indiana Jones school of risk management" [Tho92]. In the movies that carried his name, Indiana Jones, when faced with overwhelming difficulty, would invariably say, "Don't worry, I'll think of something!" Never worrying about problems until they happened, Indy would react in some heroic way.

Sadly, the average software project manager is not Indiana Jones and the members of the software project team are not his trusty sidekicks. Yet, the majority of software teams rely solely on reactive risk strategies. At best, a reactive strategy monitors the project for likely risks. Resources are set aside to deal with them, should they become actual problems. More commonly, the software team does nothing about risks until something goes wrong. Then, the team flies into action in an attempt to correct the problem rapidly. This is often called a *fire-fighting mode.* When this fails, "crisis management" [Cha92] takes over and the project is in real jeopardy.

A considerably more intelligent strategy for risk management is to be proactive. A *proactive* strategy begins long before technical work is initiated. Potential risks are identified, their probability and impact are assessed, and they are ranked by importance. Then, the software team establishes a plan for managing risk. The primary objective is to avoid risk, but because not all risks can be avoided, the team works to develop a contingency plan that will enable it to respond in a controlled and effective manner. Throughout the remainder of this chapter, I discuss a proactive strategy for risk management.

28.2 Software Risks

Although there has been considerable debate about the proper definition for software risk, there is general agreement that risk always involves two characteristics: *uncertainty*—the risk may or may not happen; that is, there are no 100 percent

probable risks[1]—and *loss*—if the risk becomes a reality, unwanted consequences or losses will occur [Hig95]. When risks are analyzed, it is important to quantify the level of uncertainty and the degree of loss associated with each risk. To accomplish this, different categories of risks are considered.

? What types of risks are you likely to encounter as software is built?

Project risks threaten the project plan. That is, if project risks become real, it is likely that the project schedule will slip and that costs will increase. Project risks identify potential budgetary, schedule, personnel (staffing and organization), resource, stakeholder, and requirements problems and their impact on a software project. In Chapter 26, project complexity, size, and the degree of structural uncertainty were also defined as project (and estimation) risk factors.

Technical risks threaten the quality and timeliness of the software to be produced. If a technical risk becomes a reality, implementation may become difficult or impossible. Technical risks identify potential design, implementation, interface, verification, and maintenance problems. In addition, specification ambiguity, technical uncertainty, technical obsolescence, and "leading-edge" technology are also risk factors. Technical risks occur because the problem is harder to solve than you thought it would be.

Business risks threaten the viability of the software to be built and often jeopardize the project or the product. Candidates for the top five business risks are (1) building an excellent product or system that no one really wants (market risk), (2) building a product that no longer fits into the overall business strategy for the company (strategic risk), (3) building a product that the sales force doesn't understand how to sell (sales risk), (4) losing the support of senior management due to a change in focus or a change in people (management risk), and (5) losing budgetary or personnel commitment (budget risks).

It is extremely important to note that simple risk categorization won't always work. Some risks are simply unpredictable in advance.

Quote:

"Projects with no real risks are losers. They are almost always devoid of benefit; that's why they weren't done years ago."

Tom DeMarco and Tim Lister

Another general categorization of risks has been proposed by Charette [Cha89]. *Known risks* are those that can be uncovered after careful evaluation of the project plan, the business and technical environment in which the project is being developed, and other reliable information sources (e.g., unrealistic delivery date, lack of documented requirements or software scope, poor development environment). *Predictable risks* are extrapolated from past project experience (e.g., staff turnover, poor communication with the customer, dilution of staff effort as ongoing maintenance requests are serviced). *Unpredictable risks* are the joker in the deck. They can and do occur, but they are extremely difficult to identify in advance.

---

1 A risk that is 100 percent probable is a constraint on the software project.

INFO

Seven Principles of Risk Management

The Software Engineering Institute (SEI) (**www.sei.cmu.edu**) identifies seven principles that "provide a framework to accomplish effective risk management." They are:

Maintain a global perspective—view software risks within the context of a system in which it is a component and the business problem that it is intended to solve

Take a forward-looking view—think about the risks that may arise in the future (e.g., due to changes in the software); establish contingency plans so that future events are manageable.

Encourage open communication—if someone states a potential risk, don't discount it. If a risk is proposed in an informal manner, consider it. Encourage all stakeholders and users to suggest risks at any time.

Integrate—a consideration of risk must be integrated into the software process.

Emphasize a continuous process—the team must be vigilant throughout the software process, modifying identified risks as more information is known and adding new ones as better insight is achieved.

Develop a shared product vision—if all stakeholders share the same vision of the software, it is likely that better risk identification and assessment will occur.

Encourage teamwork—the talents, skills, and knowledge of all stakeholders should be pooled when risk management activities are conducted.

28.3 RISK IDENTIFICATION

Risk identification is a systematic attempt to specify threats to the project plan (estimates, schedule, resource loading, etc.). By identifying known and predictable risks, the project manager takes a first step toward avoiding them when possible and controlling them when necessary.

Although generic risks are important to consider, it's the product-specific risks that cause the most headaches. Be certain to spend the time to identify as many product-specific risks as possible.

There are two distinct types of risks for each of the categories that have been presented in Section 28.2: generic risks and product-specific risks. *Generic risks* are a potential threat to every software project. *Product-specific risks* can be identified only by those with a clear understanding of the technology, the people, and the environment that is specific to the software that is to be built. To identify product-specific risks, the project plan and the software statement of scope are examined, and an answer to the following question is developed: "What special characteristics of this product may threaten our project plan?"

One method for identifying risks is to create a risk item checklist. The checklist can be used for risk identification and focuses on some subset of known and predictable risks in the following generic subcategories:

- *Product size*—risks associated with the overall size of the software to be built or modified.
- *Business impact*—risks associated with constraints imposed by management or the marketplace.

- *Stakeholder characteristics*—risks associated with the sophistication of the stakeholders and the developer's ability to communicate with stakeholders in a timely manner.
- *Process definition*—risks associated with the degree to which the software process has been defined and is followed by the development organization.
- *Development environment*—risks associated with the availability and quality of the tools to be used to build the product.
- *Technology to be built*—risks associated with the complexity of the system to be built and the "newness" of the technology that is packaged by the system.
- *Staff size and experience*—risks associated with the overall technical and project experience of the software engineers who will do the work.

The risk item checklist can be organized in different ways. Questions relevant to each of the topics can be answered for each software project. The answers to these questions allow you to estimate the impact of risk. A different risk item checklist format simply lists characteristics that are relevant to each generic subcategory. Finally, a set of "risk components and drivers" [AFC88] are listed along with their probability of occurrence. Drivers for performance, support, cost, and schedule are discussed in answer to later questions.

A number of comprehensive checklists for software project risk are available on the Web (e.g., [Baa07], [NAS07], [Wor04]). You can use these checklists to gain insight into generic risks for software projects.

28.3.1 Assessing Overall Project Risk

The following questions have been derived from risk data obtained by surveying experienced software project managers in different parts of the world [Kei98]. The questions are ordered by their relative importance to the success of a project.

? Is the software project we're working on at serious risk?

1. Have top software and customer managers formally committed to support the project?
2. Are end users enthusiastically committed to the project and the system/product to be built?
3. Are requirements fully understood by the software engineering team and its customers?
4. Have customers been involved fully in the definition of requirements?
5. Do end users have realistic expectations?
6. Is the project scope stable?
7. Does the software engineering team have the right mix of skills?
8. Are project requirements stable?
9. Does the project team have experience with the technology to be implemented?

WebRef

Risk radar is a database and tools that help managers identify, rank, and communicate project risks. It can be found at **www.spmn.com**

10. Is the number of people on the project team adequate to do the job?
11. Do all customer/user constituencies agree on the importance of the project and on the requirements for the system/product to be built?

If any one of these questions is answered negatively, mitigation, monitoring, and management steps should be instituted without fail. The degree to which the project is at risk is directly proportional to the number of negative responses to these questions.

28.3.2 Risk Components and Drivers

The U.S. Air Force [AFC88] has published a pamphlet that contains excellent guidelines for software risk identification and abatement. The Air Force approach requires that the project manager identify the risk drivers that affect software risk components—performance, cost, support, and schedule. In the context of this discussion, the risk components are defined in the following manner:

Quote:

"Risk management is project management for adults."

Tim Lister

- *Performance risk*—the degree of uncertainty that the product will meet its requirements and be fit for its intended use.
- *Cost risk*—the degree of uncertainty that the project budget will be maintained.
- *Support risk*—the degree of uncertainty that the resultant software will be easy to correct, adapt, and enhance.
- *Schedule risk*—the degree of uncertainty that the project schedule will be maintained and that the product will be delivered on time.

The impact of each risk driver on the risk component is divided into one of four impact categories—negligible, marginal, critical, or catastrophic. Referring to Figure 28.1 [Boe89], a characterization of the potential consequences of errors (rows labeled 1) or a failure to achieve a desired outcome (rows labeled 2) are described. The impact category is chosen based on the characterization that best fits the description in the table.

28.4 Risk Projection

Risk projection, also called *risk estimation,* attempts to rate each risk in two ways—(1) the likelihood or probability that the risk is real and (2) the consequences of the problems associated with the risk, should it occur. You work along with other managers and technical staff to perform four risk projection steps:

1. Establish a scale that reflects the perceived likelihood of a risk.
2. Delineate the consequences of the risk.
3. Estimate the impact of the risk on the project and the product.
4. Assess the overall accuracy of the risk projection so that there will be no misunderstandings.

FIGURE 28.1 Impact assessment. Source: [Boe89].

Category \ Components		Performance	Support	Cost	Schedule
Catastrophic	1	Failure to meet the requirement would result in mission failure		Failure results in increased costs and schedule delays with expected values in excess of $500K	
	2	Significant degradation to nonachievement of technical performance	Nonresponsive or unsupportable software	Significant financial shortages, budget overrun likely	Unachievable IOC
Critical	1	Failure to meet the requirement would degrade system performance to a point where mission success is questionable		Failure results in operational delays and/or increased costs with expected value of $100K to $500K	
	2	Some reduction in technical performance	Minor delays in software modifications	Some shortage of financial resources, possible overruns	Possible slippage in IOC
Marginal	1	Failure to meet the requirement would result in degradation of secondary mission		Costs, impacts, and/or recoverable schedule slips with expected value of $1K to $100K	
	2	Minimal to small reduction in technical performance	Responsive software support	Sufficient financial resources	Realistic, achievable schedule
Negligible	1	Failure to meet the requirement would create inconvenience or nonoperational impact		Error results in minor cost and/or schedule impact with expected value of less than $1K	
	2	No reduction in technical performance	Easily supportable software	Possible budget underrun	Early achievable IOC

Note: (1) The potential consequence of undetected software errors or faults.
(2) The potential consequence if the desired outcome is not achieved.

The intent of these steps is to consider risks in a manner that leads to prioritization. No software team has the resources to address every possible risk with the same degree of rigor. By prioritizing risks, you can allocate resources where they will have the most impact.

Think hard about the software you're about to build and ask yourself, "what can go wrong?" Create your own list and ask other members of the team to do the same.

28.4.1 Developing a Risk Table

A risk table provides you with a simple technique for risk projection.[2] A sample risk table is illustrated in Figure 28.2.

You begin by listing all risks (no matter how remote) in the first column of the table. This can be accomplished with the help of the risk item checklists referenced in Section 28.3. Each risk is categorized in the second column (e.g., PS implies a

2 The risk table can be implemented as a spreadsheet model. This enables easy manipulation and sorting of the entries.

FIGURE 28.2

Sample risk table prior to sorting

Risks	Category	Probability	Impact	RMMM
Size estimate may be significantly low	PS	60%	2	
Larger number of users than planned	PS	30%	3	
Less reuse than planned	PS	70%	2	
End-users resist system	BU	40%	3	
Delivery deadline will be tightened	BU	50%	2	
Funding will be lost	CU	40%	1	
Customer will change requirements	PS	80%	2	
Technology will not meet expectations	TE	30%	1	
Lack of training on tools	DE	80%	3	
Staff inexperienced	ST	30%	2	
Staff turnover will be high	ST	60%	2	
Σ				
Σ				
Σ				

Impact values:
1—catastrophic
2—critical
3—marginal
4—negligible

project size risk, BU implies a business risk). The probability of occurrence of each risk is entered in the next column of the table. The probability value for each risk can be estimated by team members individually. One way to accomplish this is to poll individual team members in round-robin fashion until their collective assessment of risk probability begins to converge.

Next, the impact of each risk is assessed. Each risk component is assessed using the characterization presented in Figure 28.1, and an impact category is determined. The categories for each of the four risk components—performance, support, cost, and schedule—are averaged[3] to determine an overall impact value.

KEY POINT

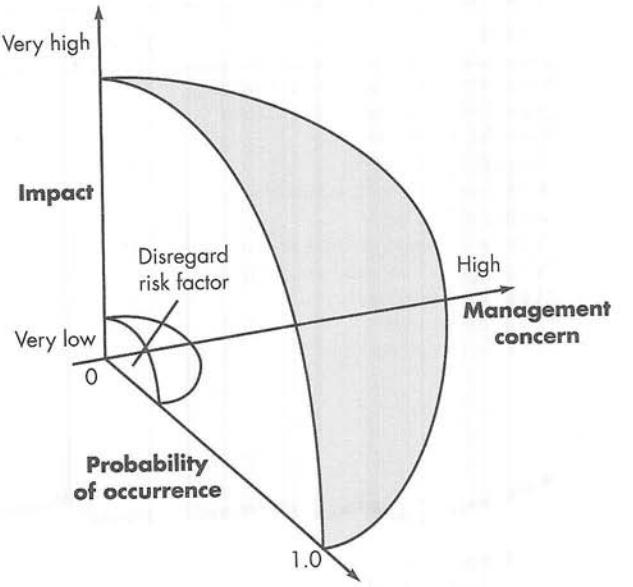
A risk table is sorted by probability and impact to rank risks.

Once the first four columns of the risk table have been completed, the table is sorted by probability and by impact. High-probability, high-impact risks percolate to the top of the table, and low-probability risks drop to the bottom. This accomplishes first-order risk prioritization.

You can study the resultant sorted table and define a cutoff line. The *cutoff line* (drawn horizontally at some point in the table) implies that only risks that lie above the line will be given further attention. Risks that fall below the line are reevaluated to accomplish second-order prioritization. Referring to Figure 28.3, risk impact and

3 A weighted average can be used if one risk component has more significance for a project.

FIGURE 28.3
Risk and management concern



probability have a distinct influence on management concern. A risk factor that has a high impact but a very low probability of occurrence should not absorb a significant amount of management time. However, high-impact risks with moderate to high probability and low-impact risks with high probability should be carried forward into the risk analysis steps that follow.

All risks that lie above the cutoff line should be managed. The column labeled RMMM contains a pointer into a *risk mitigation, monitoring, and management plan* or, alternatively, a collection of risk information sheets developed for all risks that lie above the cutoff. The RMMM plan and risk information sheets are discussed in Sections 28.5 and 28.6.

Quote:

"[Today,] no one has the luxury of getting to know a task so well that it holds no surprises, and surprises mean risk."

Stephen Grey

Risk probability can be determined by making individual estimates and then developing a single consensus value. Although that approach is workable, more sophisticated techniques for determining risk probability have been developed [AFC88]. Risk drivers can be assessed on a qualitative probability scale that has the following values: impossible, improbable, probable, and frequent. Mathematical probability can then be associated with each qualitative value (e.g., a probability of 0.7 to 0.99 implies a highly probable risk).

28.4.2 Assessing Risk Impact

Three factors affect the consequences that are likely if a risk does occur: its nature, its scope, and its timing. The nature of the risk indicates the problems that are likely if it occurs. For example, a poorly defined external interface to customer hardware

(a technical risk) will preclude early design and testing and will likely lead to system integration problems late in a project. The scope of a risk combines the severity (just how serious is it?) with its overall distribution (how much of the project will be affected or how many stakeholders are harmed?). Finally, the timing of a risk considers when and for how long the impact will be felt. In most cases, you want the "bad news" to occur as soon as possible, but in some cases, the longer the delay, the better.

How do we assess the consequences of a risk?

Returning once more to the risk analysis approach proposed by the U.S. Air Force [AFC88], you can apply the following steps to determine the overall consequences of a risk: (1) determine the average probability of occurrence value for each risk component; (2) using Figure 28.1, determine the impact for each component based on the criteria shown, and (3) complete the risk table and analyze the results as described in the preceding sections.

The overall *risk exposure* RE is determined using the following relationship [Hal98]:

$$\text{RE} = P \times C$$

where P is the probability of occurrence for a risk, and C is the cost to the project should the risk occur.

For example, assume that the software team defines a project risk in the following manner:

Risk identification. Only 70 percent of the software components scheduled for reuse will, in fact, be integrated into the application. The remaining functionality will have to be custom developed.

Risk probability. 80 percent (likely).

Risk impact. Sixty reusable software components were planned. If only 70 percent can be used, 18 components would have to be developed from scratch (in addition to other custom software that has been scheduled for development). Since the average component is 100 LOC and local data indicate that the software engineering cost for each LOC is $14.00, the overall cost (impact) to develop the components would be $18 \times 100 \times 14 = \$25{,}200$.

Risk exposure. RE = $0.80 \times 25{,}200 \sim \$20{,}200$.

Compare RE for all risks to the cost estimate for the project. If RE is greater than 50 percent of the project cost, the viability of the project must be evaluated.

Risk exposure can be computed for each risk in the risk table, once an estimate of the cost of the risk is made. The total risk exposure for all risks (above the cutoff in the risk table) can provide a means for adjusting the final cost estimate for a project. It can also be used to predict the probable increase in staff resources required at various points during the project schedule.

The risk projection and analysis techniques described in Sections 28.4.1 and 28.4.2 are applied iteratively as the software project proceeds. The project team

should revisit the risk table at regular intervals, reevaluating each risk to determine when new circumstances cause its probability and impact to change. As a consequence of this activity, it may be necessary to add new risks to the table, remove some risks that are no longer relevant, and change the relative positions of still others.

SafeHome

Risk Analysis

The scene: Doug Miller's office prior to the initiation of the *SafeHome* software project.

The players: Doug Miller (manager of the *SafeHome* software engineering team) and Vinod Raman, Jamie Lazar, and other members of the product software engineering team.

The conversation:

Doug: I'd like to spend some time brainstorming risks for the *SafeHome* project.

Jamie: As in what can go wrong?

Doug: Yep. Here are a few categories where things can go wrong. [He shows everyone the categories noted in the introduction to Section 28.3.]

Vinod: Umm . . . do you want us to just call them out, or . . .

Doug: No here's what I thought we'd do. Everyone make a list of risks . . . right now . . ."

[Ten minutes pass, everyone is writing.]

Doug: Okay, stop.

Jamie: But I'm not done!

Doug: That's okay. We'll revisit the list again. Now, for each item on your list, assign a percent likelihood that the risk will occur. Then, assign an impact to the project on a scale of 1 (minor) to 5 (catastrophic).

Vinod: So if I think that the risk is a coin flip, I specify a 50 percent likelihood, and if I think it'll have a moderate project impact, I specify a 3, right?

Doug: Exactly.

[Five minutes pass, everyone is writing.]

Doug: Okay, stop. Now we'll make a group list on the white board. I'll do the writing; we'll call out one entry from your list in round-robin format.

[Fifteen minutes pass; the list is created.]

Jamie (pointing at the board and laughing): Vinod, that risk (pointing toward an entry on the board) is ridiculous. There's a higher likelihood that we'll all get hit by lightning. We should remove it.

Doug: No, let's leave it for now. We consider all risks, no matter how weird. Later we'll winnow the list.

Jamie: But we already have over 40 risks . . . how on earth can we manage them all?

Doug: We can't. That's why we'll define a cut-off after we sort these guys. I'll do that off-line and we'll meet again tomorrow. For now, get back to work . . . and in your spare time, think about any risks that we've missed.

28.5 Risk Refinement

During early stages of project planning, a risk may be stated quite generally. As time passes and more is learned about the project and the risk, it may be possible to refine the risk into a set of more detailed risks, each somewhat easier to mitigate, monitor, and manage.

? What's a good way to describe a risk?

One way to do this is to represent the risk in *condition-transition-consequence* (CTC) format [Glu94]. That is, the risk is stated in the following form:

Given that <condition> then there is concern that (possibly) <consequence>.

Using the CTC format for the reuse risk noted in Section 28.4.2, you could write:

> Given that all reusable software components must conform to specific design standards and that some do not conform, then there is concern that (possibly) only 70 percent of the planned reusable modules may actually be integrated into the as-built system, resulting in the need to custom engineer the remaining 30 percent of components.

This general condition can be refined in the following manner:

> **Subcondition 1.** Certain reusable components were developed by a third party with no knowledge of internal design standards.
>
> **Subcondition 2.** The design standard for component interfaces has not been solidified and may not conform to certain existing reusable components.
>
> **Subcondition 3.** Certain reusable components have been implemented in a language that is not supported on the target environment.

The consequences associated with these refined subconditions remain the same (i.e., 30 percent of software components must be custom engineered), but the refinement helps to isolate the underlying risks and might lead to easier analysis and response.

28.6 Risk Mitigation, Monitoring, and Management

Quote:

"If I take so many precautions, it is because I leave nothing to chance."

Napolean

All of the risk analysis activities presented to this point have a single goal—to assist the project team in developing a strategy for dealing with risk. An effective strategy must consider three issues: risk avoidance, risk monitoring, and risk management and contingency planning.

If a software team adopts a proactive approach to risk, avoidance is always the best strategy. This is achieved by developing a plan for *risk mitigation*. For example, assume that high staff turnover is noted as a project risk r_1. Based on past history and management intuition, the likelihood l_1 of high turnover is estimated to be 0.70 (70 percent, rather high) and the impact x_1 is projected as critical. That is, high turnover will have a critical impact on project cost and schedule.

To mitigate this risk, you would develop a strategy for reducing turnover. Among the possible steps to be taken are:

? What can we do to mitigate a risk?

- Meet with current staff to determine causes for turnover (e.g., poor working conditions, low pay, competitive job market).
- Mitigate those causes that are under your control before the project starts.
- Once the project commences, assume turnover will occur and develop techniques to ensure continuity when people leave.
- Organize project teams so that information about each development activity is widely dispersed.

- Define work product standards and establish mechanisms to be sure that all models and documents are developed in a timely manner.
- Conduct peer reviews of all work (so that more than one person is "up to speed").
- Assign a backup staff member for every critical technologist.

As the project proceeds, *risk-monitoring* activities commence. The project manager monitors factors that may provide an indication of whether the risk is becoming more or less likely. In the case of high staff turnover, the general attitude of team members based on project pressures, the degree to which the team has jelled, interpersonal relationships among team members, potential problems with compensation and benefits, and the availability of jobs within the company and outside it are all monitored.

In addition to monitoring these factors, a project manager should monitor the effectiveness of risk mitigation steps. For example, a risk mitigation step noted here called for the definition of work product standards and mechanisms to be sure that work products are developed in a timely manner. This is one mechanism for ensuring continuity, should a critical individual leave the project. The project manager should monitor work products carefully to ensure that each can stand on its own and that each imparts information that would be necessary if a newcomer were forced to join the software team somewhere in the middle of the project.

Risk management and contingency planning assumes that mitigation efforts have failed and that the risk has become a reality. Continuing the example, the project is well under way and a number of people announce that they will be leaving. If the mitigation strategy has been followed, backup is available, information is documented, and knowledge has been dispersed across the team. In addition, you can temporarily refocus resources (and readjust the project schedule) to those functions that are fully staffed, enabling newcomers who must be added to the team to "get up to speed." Those individuals who are leaving are asked to stop all work and spend their last weeks in "knowledge transfer mode." This might include video-based knowledge capture, the development of "commentary documents or Wikis," and/or meeting with other team members who will remain on the project.

If RE for a specific risk is less than the cost of risk mitigation, don't try to mitigate the risk but continue to monitor it.

It is important to note that risk mitigation, monitoring, and management (RMMM) steps incur additional project cost. For example, spending the time to back up every critical technologist costs money. Part of risk management, therefore, is to evaluate when the benefits accrued by the RMMM steps are outweighed by the costs associated with implementing them. In essence, you perform a classic cost-benefit analysis. If risk aversion steps for high turnover will increase both project cost and duration by an estimated 15 percent, but the predominant cost factor is "backup," management may decide not to implement this step. On the other hand, if the risk aversion steps are projected to increase costs by 5 percent and duration by only 3 percent, management will likely put all into place.

For a large project, 30 or 40 risks may be identified. If between three and seven risk management steps are identified for each, risk management may become a project in itself! For this reason, you should adapt the Pareto 80–20 rule to software risk. Experience indicates that 80 percent of the overall project risk (i.e., 80 percent of the potential for project failure) can be accounted for by only 20 percent of the identified risks. The work performed during earlier risk analysis steps will help you to determine which of the risks reside in that 20 percent (e.g., risks that lead to the highest risk exposure). For this reason, some of the risks identified, assessed, and projected may not make it into the RMMM plan—they don't fall into the critical 20 percent (the risks with highest project priority).

Risk is not limited to the software project itself. Risks can occur after the software has been successfully developed and delivered to the customer. These risks are typically associated with the consequences of software failure in the field.

Software safety and hazard analysis (e.g., [Dun02], [Her00], [Lev95]) are software quality assurance activities (Chapter 16) that focus on the identification and assessment of potential hazards that may affect software negatively and cause an entire system to fail. If hazards can be identified early in the software engineering process, software design features can be specified that will either eliminate or control potential hazards.

28.7 The RMMM Plan

A risk management strategy can be included in the software project plan, or the risk management steps can be organized into a separate *risk mitigation, monitoring, and management plan* (RMMM). The RMMM plan documents all work performed as part of risk analysis and is used by the project manager as part of the overall project plan.

Some software teams do not develop a formal RMMM document. Rather, each risk is documented individually using a *risk information sheet* (RIS) [Wil97]. In most cases, the RIS is maintained using a database system so that creation and information entry, priority ordering, searches, and other analysis may be accomplished easily. The format of the RIS is illustrated in Figure 28.4.

Once RMMM has been documented and the project has begun, risk mitigation and monitoring steps commence. As I have already discussed, risk mitigation is a problem avoidance activity. Risk monitoring is a project tracking activity with three primary objectives: (1) to assess whether predicted risks do, in fact, occur; (2) to ensure that risk aversion steps defined for the risk are being properly applied; and (3) to collect information that can be used for future risk analysis. In many cases, the problems that occur during a project can be traced to more than one risk. Another job of risk monitoring is to attempt to allocate origin [what risk(s) caused which problems throughout the project].

FIGURE 28.4
Risk information sheet.
Source: [Wil97].

Risk information sheet			
Risk ID: P02-4-32	Date: 5/9/09	Prob: 80%	Impact: high
Description: Only 70 percent of the software components scheduled for reuse will, in fact, be integrated into the application. The remaining functionality will have to be custom developed.			
Refinement/context: Subcondition 1: Certain reusable components were developed by a third party with no knowledge of internal design standards. Subcondition 2: The design standard for component interfaces has not been solidified and may not conform to certain existing reusable components. Subcondition 3: Certain reusable components have been implemented in a language that is not supported on the target environment.			
Mitigation/monitoring: 1. Contact third party to determine conformance with design standards. 2. Press for interface standards completion; consider component structure when deciding on interface protocol. 3. Check to determine number of components in subcondition 3 category; check to determine if language support can be acquired.			
Management/contingency plan/trigger: *RE* computed to be $20,200. Allocate this amount within project contingency cost. Develop revised schedule assuming that 18 additional components will have to be custom built; allocate staff accordingly. Trigger: Mitigation steps unproductive as of 7/1/09.			
Current status: 5/12/09: Mitigation steps initiated.			
Originator: D. Gagne		Assigned: B. Laster	

SOFTWARE TOOLS

Risk Management

Objective: The objective of risk management tools is to assist a project team in defining risks, assessing their impact and probability, and tracking risks throughout a software project.

Mechanics: In general, risk management tools assist in generic risk identification by providing a list of typical project and business risks, provide checklists or other "interview" techniques that assist in identifying project specific risks, assign probability and impact to each risk, support risk mitigation strategies, and generate many different risk-related reports.

Representative Tools:[4]

@risk, developed by Palisade Corporation (**www.palisade.com**), is a generic risk analysis tool that uses Monte Carlo simulation to drive its analytical engine.

Riskman, distributed by ABS Consulting (**www.absconsulting.com/riskmansoftware/index.html**), is a risk evaluation expert system that identifies project-related risks.

Risk Radar, developed by SPMN (**www.spmn.com**), assists project managers in identifying and managing project risks.

4 Tools noted here do not represent an endorsement, but rather a sampling of tools in this category. In most cases, tool names are trademarked by their respective developers.

Risk+, developed by Deltek (**www.deltek.com**), integrates with Microsoft Project to quantify cost and schedule uncertainty.

X:PRIMER, developed by GrafP Technologies (**www.grafp.com**) is a generic Web-based tool that predicts what can go wrong on a project and identifies root causes for potential failures and effective countermeasures.

28.8 Summary

Whenever a lot is riding on a software project, common sense dictates risk analysis. And yet, most software project managers do it informally and superficially, if they do it at all. The time spent identifying, analyzing, and managing risk pays itself back in many ways—less upheaval during the project, a greater ability to track and control a project, and the confidence that comes with planning for problems before they occur.

Risk analysis can absorb a significant amount of project planning effort. Identification, projection, assessment, management, and monitoring all take time. But the effort is worth it. To quote Sun Tzu, a Chinese general who lived 2500 years ago, "If you know the enemy and know yourself, you need not fear the result of a hundred battles." For the software project manager, the enemy is risk.

Problems and Points to Ponder

28.1. Provide five examples from other fields that illustrate the problems associated with a reactive risk strategy.

28.2. Describe the difference between "known risks" and "predictable risks."

28.3. Add three additional questions or topics to each of the risk item checklists presented at the SEPA website.

28.4. You've been asked to build software to support a low-cost video editing system. The system accepts digital video as input, stores the video on disk, and then allows the user to do a wide range of edits to the digitized video. The result can then be output to DVD or other media. Do a small amount of research on systems of this type and then make a list of technology risks that you would face as you begin a project of this type.

28.5. You're the project manager for a major software company. You've been asked to lead a team that's developing "next generation" word-processing software. Create a risk table for the project.

28.6. Describe the difference between risk components and risk drivers.

28.7. Develop a risk mitigation strategy and specific risk mitigation activities for three of the risks noted in Figure 28.2.

28.8. Develop a risk monitoring strategy and specific risk monitoring activities for three of the risks noted in Figure 28.2. Be sure to identify the factors that you'll be monitoring to determine whether the risk is becoming more or less likely.

28.9. Develop a risk management strategy and specific risk management activities for three of the risks noted in Figure 28.2.

28.10. Attempt to refine three of the risks noted in Figure 28.2, and then create risk information sheets for each.

28.11. Represent three of the risks noted in Figure 28.2 using a CTC format.

28.12. Recompute the risk exposure discussed in Section 28.4.2 when cost/LOC is $16 and the probability is 60 percent.

28.13. Can you think of a situation in which a high-probability, high-impact risk would not be considered as part of your RMMM plan?

28.14. Describe five software application areas in which software safety and hazard analysis would be a major concern.

Further Readings and Information Sources

The software risk management literature has expanded significantly over the past few decades. Vun (*Modeling Risk,* Wiley, 2006) presents a detailed mathematical treatment of risk analysis that can be applied to software projects. Crohy and his colleagues (*The Essentials of Risk Management,* McGraw-Hill, 2006), Mulcahy (*Risk Management, Tricks of the Trade for Project Managers,* RMC Publications, Inc., 2003), Kendrick (*Identifying and Managing Project Risk,* American Management Association, 2003), and Marrison (*The Fundamentals of Risk Measurement,* McGraw-Hill, 2002) present useful methods and tools that every project manager can use.

DeMarco and Lister (*Dancing with Bears,* Dorset House, 2003) have written an entertaining and insightful book that guides software managers and practitioners through risk management. Moynihan (*Coping with IT/IS Risk Management,* Springer-Verlag, 2002) presents pragmatic advice from project managers who deal with risk on a continuing basis. Royer (*Project Risk Management,* Management Concepts, 2002) and Smith and Merritt (*Proactive Risk Management,* Productivity Press, 2002) suggest a proactive process for risk management. Karolak (*Software Engineering Risk Management,* Wiley, 2002) has written a guidebook that introduces an easy-to-use risk analysis model with worthwhile checklists and questionnaires supported by a software package.

Capers Jones (*Assessment and Control of Software Risks,* Prentice Hall, 1994) presents a detailed discussion of software risks that includes data collected from hundreds of software projects. Jones defines 60 risk factors that can affect the outcome of software projects. Boehm [Boe89] suggests excellent questionnaire and checklist formats that can prove invaluable in identifying risk. Charette [Cha89] presents a detailed treatment of the mechanics of risk analysis, calling on probability theory and statistical techniques to analyze risks. In a companion volume, Charette (*Application Strategies for Risk Analysis,* McGraw-Hill, 1990) discusses risk in the context of both system and software engineering and suggests pragmatic strategies for risk management. Gilb (*Principles of Software Engineering Management,* Addison-Wesley, 1988) presents a set of "principles" (which are often amusing and sometimes profound) that can serve as a worthwhile guide for risk management.

Ewusi-Mensah (*Software Development Failures: Anatomy of Abandoned Projects,* MIT Press, 2003) and Yourdon (*Death March,* Prentice Hall, 1997) discuss what happens when risks overwhelm a software project team. Bernstein (*Against the Gods,* Wiley, 1998) presents an entertaining history of risk that goes back to ancient times.

The Software Engineering Institute has published many detailed reports and guidebooks on risk analysis and management. The Air Force Systems Command pamphlet AFSCP 800-45 [AFC88] describes risk identification and reduction techniques. Every issue of the *ACM Software Engineering Notes* has a section entitled "Risks to the Public" (editor, P. G. Neumann). If you want the latest and best software horror stories, this is the place to go.

A wide variety of information sources on software risk management is available on the Internet. An up-to-date list of World Wide Web references relevant to risk management can be found at the SEPA website: **www.mhhe.com/engcs/compsci/pressman/professional/olc/ser.htm**.