PROJECT RISK MANAGEMENT

- Simplified concepts and tools to assess, rank, and manage high-risk projects and tasks
- Clear templates and models
- Proven methods of integrating risk management into business and project planning
- Techniques for monitoring risk using earned value
- Practical models for strategic and project risk planning

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Chapter

3

Doable Tools: Applying Tools Strategically

There is a practical way to integrate risk into project planning and control and there are project tools that effectively support risk management. Once risks are identified as business risks, risk assessment and management are integrated into the project planning process. The purpose of this chapter is to illustrate the process. The process described below *embeds* risk into many of the traditional project planning and control steps, simplified and "demystified" for practical use.

Organizing a project from scratch and integrating risk involves seven basic steps:

1. Customer requirements
2. Work breakdown structure
3. Task list with estimated durations, linkages, and resources
4. Risk matrix
5. Network diagram
6. Time-based network diagram
7. Gantt chart (schedule)

We will use a building project as our case. The deliverable in this case is an office building and the customer is a real estate property manager.

Customer Requirements

Requirements are customer-driven and so are risks. A customer-driven project has the best likelihood of success simply because the process focuses continuously on defining and redefining customer needs, requirements, and expectations first and then defining the scope of work.

The customer requirements document is the project manager's definition of customer requirements, developed from information gleaned from the customer. The customer requirements document is not the same as the project deliverable document or scope of work. The requirements document addresses the customer's business setting and needs and expectations for a project solution.

The scope of work or deliverable document is the project firm's plan to address risk in the production of a solution to the customer need. This document is used to anchor the project tasks, but it is aligned with the customer requirements—and constantly realigned during the progress of the project.

In our case, the customer—a property manager—has a "vision" of success, which must be captured in the customer requirement document. This is not simply a building design and specification, but a description of the customer's vision of how the building will look and perform for its tenants, and produce profitability for its owners.

Work Breakdown Structure

First level: the deliverable

The first step in defining the work necessary to produce the deliverable is to complete a *work breakdown structure* (WBS) from the top (the deliverable) down to the third or fourth level of tasks. You do this in outline form. The top of the WBS is the first level of this *organization chart of the work*. It represents the final product or service outcome of the project, performing to specification and accepted by the sponsor, client, and/or user. In our case it is the building itself. The "building" at the top of the WBS implies a finished product accepted by the user or customer.

Second level: summary tasks

The second level across the organization chart of the deliverable includes the five or six basic "chunks" of high-level work that serve as the basic components of the project—the summary tasks which are integrated at the end of the project to complete the job. For our building project these chunks of work might include the architectural drawing, building supplies, ventilation systems, water, and electrical systems. (For a software project these chunks might include hardware platform, software, interfaces, training program, and financing. For a health management system they might include the clinic population, health information system, medical personnel, space, and equipment.)

It is important to see summary tasks not only in terms of producing the deliverable but also in terms of activities to address risk and contingency needs. This is where risk and contingency planning starts—in identifying and describing risks and what contingencies need to be scheduled.

Third level: subtasks

The third level includes a breakdown of the summary tasks outlined above into two or more subtasks, which would be necessary to complete to produce the second level summary task. For our building project, under the summary task "architectural drawing," this might include three tasks—get an architect, prepare preliminary blueprint, and check against standard blueprint template.

Fourth level: work package

The fourth level is another level of detail at the real tasking level—the work package. These are the individual tasks assigned to team members. For instance, breaking down the summary task "get an architect" to the fourth level, we identify nine work packages—build list of candidate architects, develop criteria for selection, screen candidates, interview candidates, conduct reference checks, compile candidate information, distribute candidate information, convene meeting, and conduct process of selection.

It is this last level that is used to create the task list and identify risks, the actual work assignments that will be necessary to schedule and the risks that the work will not make schedule, cost, and/or quality requirements. These are the "schedulable" tasks and these are the tasks that involve risk; each faces some constraint or resource problem that could create task failure.

The resultant WBS outline (can be shown as an organization chart) looks like this:

The building

1. Architectural drawings
   a. Get an architect
      (1) Build list of candidate architects
      (2) Develop criteria for selection
         (a) Risk action: involve the customer in developing criteria
      (3) Screen candidates
         (b) Risk action: conduct a peer review on candidates to offset biases in project team
      (4) Interview candidates, conduct reference checks
         (c) Risk action: confirm references with second opinion
      (5) Compile candidate information
         (d) Risk action: scrub information to assure credibility
      (6) Distribute candidate information
      (7) Convene meeting
      (8) Conduct process of selection
   b. Prepare preliminary blueprint
   c. Check standard blueprint template
2. Building supplies
3. Ventilation system
4. Water system
5. Electrical system

Note that risk actions are designed into the task structure for tasks which have been identified as high-risk in the development of a risk matrix.

Of course, in this case we have filled out only one summary task to the fourth level; all levels are filled out in a real project. The concept is that all the project tasks at the lowest level of the WBS "roll up" to produce the deliverable.

Task List

The task list includes the fourth level of the building project referenced. This step defines the "work" for several purposes:

- To serve as the basic definition of the "work" of each task, consistent with the definition of work in MS Project (Work = duration × resource)
- To serve as the basis for the network diagram—each task will be an arrow in the network diagram
- To serve as the basis for identifying risks—the first opportunity to identify high-risk tasks

Tasks are listed and durations for each estimated by the task manager who will be accountable for that task, along with dependencies (predecessors) and assigned resources (Table 3.1).

Next is a risk matrix, the fundamental risk template that captures the essential risk information in a project (Table 3.2).

Network Diagram

Having identified the basic tasks of this summary task, you now build a network diagram of this summary task, which is later integrated with other summary task diagrams to create the whole project network, as follows.

TABLE 3.1 Task List

ID	Task	Duration (total estimated elapsed time) (weeks)	Predecessor (linkage or dependencies)	Resources
A	Build candidate list	6	0	HR specialist plans department
B	Define criteria for selection	3	0	Project manager and architectural drawing task manager
C	Screen candidates	50	A	Architectural drawing task manager
D	Interview candidates	30	A, B	Project manager
E	Conduct reference checks	25	B	HR specialist
F	Compile information	35	C	HR specialist
G	Distribute information	3	F	HR specialist
H	Conduct selection process	3	E, G	Project manager

TABLE 3.2 Risk Matrix

Task	Risk definition	Impact (1 to 10)	Probability (1 to 10)	P × I (1 to 100)	Contingency plan
Build list of candidate architects	List does not contain high-quality, available architects	8	8	64	Focus on industry-leading architect and negotiate a contract
Develop criteria for selection	Criteria do not include key factors of success	8	2	16	Forget criteria for selection and go find the best architect in the field, as in above
Screen candidates	Screening process does not uncover weaknesses or availability issues	5	1	5	Forget screening and pursue best in class architect
Interview candidates, conduct reference checks		10	5	50	Don't interview any more candidates
Compile candidate information		10	1	10	Don't compile candidate information
Distribute candidate information		9	2	18	Don't distribute information again
Convene meeting		5	10	50	Have meeting, but focus on one target contractor
Conduct process of selection					Sole source

Start with a network template. Always start your network diagramming with a template or model of the "typical" network, and adjust it to the project you are planning. A typical template looks like this (Fig. 3.1), with three paths and parallel activities ending in one task.

Then tailor your model to your project as shown in Fig. 3.2.

Project paths

A, C, F, G, H = 6 + 50 + 35 + 3 + 3 = 97 weeks (critical path)

A, D, G, H = 6 + 30 + 3 + 3 = 42 weeks

B, E, H = 3 + 25 + 3 = 31 weeks

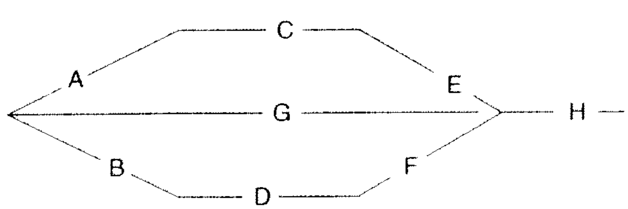

Figure 3.1 Generic network diagram.

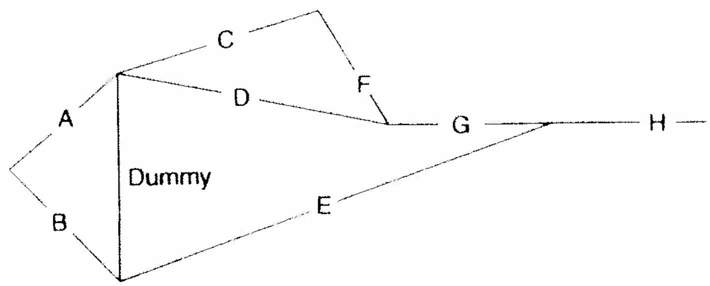

Figure 3.2 Tailored network diagram. (The "dummy" arrow connecting A and B is not a task but a link. This arrow shows that A and B are interdependent with D. D is dependent on *both* A and B, not just A).

Time-Based Network Diagram

Here you simply place the network diagram on a time-based graph. Draw the length of the arrows representing each task to equate with their actual durations as aligned with the bottom calendar of 97 days. Note that Fig. 3.3 shows *float*, or *slack*, the dotted lines that represent the flexibility in what *time slot* you determine to do the noncritical path tasks. Note also that the path, A, C, F, G, and H, a continuous arrow with no breaks, represents the critical path.

Analysis of early and late starts and slack

In order to determine what slack you have in the project plan to move tasks that are not on the critical path do an analysis of early and late starts and early and late finishes, and slack, as shown in Table 3.3.

Project paths

A, C, F, G, H = 6 + 50 + 35 + 3 + 3 = 97 weeks (critical path)

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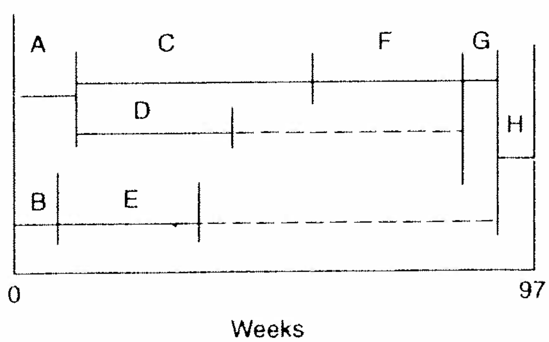

Figure 3.3 Time-based network diagram.

TABLE 3.3 Early and Late Start Analysis

ID	Task	Duration (total estimated elapsed time) (weeks)	Early start (week)	Late start	Early finish	Late finish	Slack
A	Build candidate list	6	0	0	6	6	0
B	Define criteria for selection	3	0	66	3	69	66
C	Screen candidates	50	6	6	56	56	0
D	Interview candidates	30	6	66	36	96	60
E	Conduct reference checks	25	3	69	28	94	66
F	Compile information	35	56	56	91	91	0
G	Distribute information	3	91	91	94	94	0
H	Conduct selection process	3	94	94	97	97	0

Gantt Chart

The final *Gantt chart* (MS Project) takes the task list information entries and builds a bar chart representing the whole project graphically, based on linkages and durations (Fig. 3.4).

This process, from initial requirement through the Gantt chart, is the core process of project risk management. This is where risks are captured and identified, as part of the project planning process.

ID	❶	Task name	Duration	Start	Finish
1		A Build candidate list	6 wks	Mon 7/28/03	Fri 9/5/03
2		B Define criteria for selection	3 wks	Mon 7/28/03	Fri 8/15/03
3		C Screen candidates	50 wks	Mon 9/8/03	Fri 8/20/04
4		D Interview candidates	30 wks	Mon 9/8/03	Fri 4/2/04
5		E Reference checks	25 wks	Mon 8/18/03	Fri 2/6/04
6		F Compile information	35 wks	Mon 8/23/04	Fri 4/22/05
7		G Distribute information	3 wks	Mon 4/25/05	Fri 5/13/05
8		H Conduct selection process	3 wks	Mon 5/16/05	Fri 6/3/05
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24			1 day	Mon 7/28/03	Mon 7/28/03

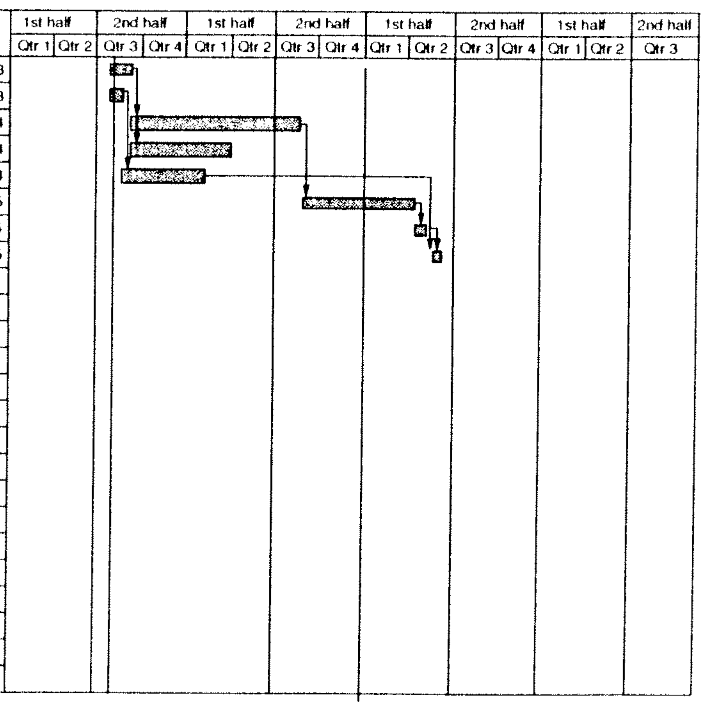

Figure 3.4 Gantt chart.

A Risk Story: Tradeoffs in Risk

Let's say that an electronics firm is facing a major decision in the use of an integrated printed wiring board (PWB) as part of its avionics instrument product line. The risks in that decision are inherent to the business itself and to any new product project. The background is instructive to the issue of demystifying risk and cost management.

The firm can gain a $500 price reduction from a new supplier if it chooses to purchase the new PWB that is assembled as a single unit, which appears to perform better than the old PWB, which is assembled from parts. But there are risks in the decision because at the same time that the new PWB can perform more effectively and meets government certification requirements, it has never been installed in a revenue aircraft and thus is still considered in the field to be in *test*. Thus there is some concern that customers will stay with the old PWB simply because of the current safety record of the old PWB in use.

Another complication in the project is the fact that the firm's manufacturing unit workforce is raising major concerns about the new PWB. The firm's production assemblers would not have a job should the firm go to the new PWB, simply because assembly and *bonding* of the card would no longer be necessary. The union representing 20 *bonders* has threatened legal action if any bonders are terminated because of this decision. Thus there is added risk and uncertainty in a major nonmonetary factor—workforce objection.

This is a good example of a project risk that is intertwined with a company-wide business risk—the probability of disruptive union action triggered by a major product development risk decision. If the project manager is accountable only for the delivery of the product prototype, then the risk of union action is of little interest in making the product decision. The project manager will proceed with the new PWB circuit board because it offers benefits in performance and cost reduction, and will take his or her chances with the marketing issue because he or she is not responsible for sales or cash flow. However, if the project manager is accountable for the whole cycle—product development, manufacturing, and successful marketing—then the PWB decision is liable to go the other way. The manager may not want to endanger the success of a proven product because of possible union and workforce disruption that could stop the production process.

Thus definition of the project (is it simply producing the prototype or is it getting the product manufactured and assembled and marketed?); its organization (who is responsible for what in that cycle and who do they report to?); and assignment of responsibility to the project manager (how is the project manager's performance going to be evaluated?); can all create the conditions for how tradeoffs of risk and cost are made.

Further, the business itself is vulnerable because of the precarious position of the manufacturing workforce. Without any alternative way to use the bonders, the company has no contingency for moving the bonders into other valuable roles and functions, thus a key product enhancement opportunity is lost.

The risk demystifying message is this: no amount of quantitative analysis and probability estimates will make this project management decision easier to make unless the organizational and accountability issues are resolved first. Even then the critical decision is subjective. The actual decisions are liable to be made in conversations among the project manager, the program manager, and stakeholders, and the "rank ordering" that results will develop a priority that will be clear to all.

Business and project risk

Thus project risk management does not start with the project; it starts with the business itself. As indicated before, it is quite apparent that many of the key forces in creating project risk are external, not internal, and are uncovered early in business strategic planning and environmental scanning. Many of the key factors in the success or failure of any project are the broad business factors for success and failure and the process of selecting the project in the first place.

The first step in project risk management is understanding the broad approach to the business you are in, the market, the strategy, the viability of the business organization and support system for project management, and the outcomes of SWOT analysis—strengths, weaknesses, opportunities, and threats. This is not a mysterious process that can be performed only by select corporate planners and sophisticated modeling. The process simply requires that the business purpose and strategy be made clear, and that *the risks and threats faced by the business are integrated into all project plans and systems.*

Market. Market analysis involves the investigation into potential markets and business opportunities. Projects interface directly with marketing in the sense that projects are designed to produce products and services that are consistent with the marketing plan. Marketing generates accelerated product development by spurring product concepts and making "deals" with customers and clients to deliver to their needs.

Projects implement business marketing and strategic objectives. Therefore, whether or not the marketing analysis is formal and documented, projects are typically conceived to implement the purpose and direction of the business. "Projects are what business does to improve." It is also possible that businesses take on projects to enter new fields and develop new business opportunities so the interrelationship between business strategy and project selection is actually reciprocal.

Client setting. The client setting is important because the boundaries of risk and uncertainty are set in the business setting itself. For instance, if a business is an exclusive provider of a particular product or component, the risks are less in any project involving that product or component than they would be if there were no exclusivity. A business that is meeting an increasing demand for a particular product but facing major competition will try to reduce costs and enhance price while maintaining quality and service. In that setting, a product development project that increases performance and cost is liable to be rejected as "risky" *in the context of that business setting.*

Strategic statement. Business makes strategic statements, either formally through written statements of strategy for investors, shareholders, and employees, or informally through the actions they take. It is important to recognize that most businesses operate with informal strategies, which are housed in the heads of its leaders, but nevertheless these strategies are clearly driving key business decisions. The truth is that most strategies are not written.

But a project manager dealing with planning decisions, risk, and cost must understand the business strategy—whether it is written down or not—and fit the project into that strategy because the risks the manager faces in the project are directly linked to the assumptions and conditions behind the strategy.

Strategic objectives. Strategic objectives are, in effect, statements of risk contingency—indications that the business sees key challenges in entering the marketplace and has developed an approach to addressing risk and uncertainty. Thus the whole strategic planning process and sets of statements of objectives is aimed at uncovering and addressing risk and uncertainty, in a sense, that downstream will provide the risk framework for projects designed to implement them. This way of looking at risk broadens the perspective of those who plan and direct project initiatives and also provides a useful way to "alert" project teams as to the risks and uncertainties that they face.

SWOT analysis: risk identification

Project risk identification, assessment, and management starts not with a project, but with business planning. Risks are typically identified in the broad business strategic planning and thinking that goes on to direct a company toward its potential markets and customers and toward appropriate products and services. Demystified, risk planning is a business function that identifies barriers and challenges for the company as it enters a market. The results of broad business planning provide the wherewithal for individual project risk assessment, which narrows down business risk into project risk. This translation is only possible if the business actually has a planning process—not necessarily a formal documented process but a way of thinking about the future of the company and its markets.

Strengths. The company looks at its competencies and its core capabilities and identifies its current performance advantage, its differentiators. These strengths are an important signal to the project manager of its history in overcoming risks and uncertainties in earlier improvement and product development projects.

Weaknesses. The company looks at its weaknesses in terms of its inability to overcome risk and uncertainty in past initiatives and identifies internal improvements that it must make to address them.

Opportunities. Opportunity is the converse of risk; there is no risk if there is not opportunity on the other side. The reason a company is undertaking a project is to "jump out" in the market to generate demand for its products and services and to face the possibility that it will fail because of competition or because demand was not there in the first place. Thus a project is a risk contingency, which, if overcome, becomes an opportunity.

Threats. Threats are risks, simply put. In other words, threats, such as competition, technological change, economic crisis, and financial difficulty, all constitute the risk factors that the business faces and thus the risk factors that individual projects face as well.

Weighted scoring model. We use the weighted scoring model to select projects based on their relative scores against strategic objectives, but what we are really doing in this process is evaluating contingency plans to address risk inherent in various candidate project plans, costs estimates, and cash flow forecasts.

Customer and client risks

Client risk management issues. It stands to reason that the client faces risks and the business and project objective is to remove or reduce the risk faced by the client. For instance, if I am developing an electronic instrument that provides a safety margin in an automobile, I am directly serving the client's interest in reducing risk associated with the automobile. While that is a simple and not very profound finding, it is surprising how easy it is to lose sight of the fact *the project risk management is inherently the process of managing customer risk.*

Project deliverable impacts. A differentiator for any project team is the capacity to anticipate impacts of project deliverables in terms of risk and cost and to offset them. That is what projects do fundamentally.

Partnering in risk management. Partnering in risk management aims at spreading risk and uncertainty out among the stakeholders so that no one will bear an inordinate cost should the risk impact success. Thus partnering proves that risk is shared between project company and client, between supplier and customer.

Project risk management: processes

Selecting the right projects. Projects are selected for a company portfolio of projects based on several factors including risk and cost. The review of risk at the selection process involves "order of magnitude" thinking about a project, for example, at the broadest level what are the factors involved in project success and failure and what are the probabilities of their occurring in this project? How can they be offset?

The analysis of risk in project selection involves three basic issues:

Financial risk. What is the probability (0, 25, 50, 75, or 100 percent) that the project estimates for financial performance are accurate? What is the risk of cost variance at the end of the project?

Schedule risk. What is the probability that the task duration estimates are incorrect and that the project will experience negative schedule variance?

Quality risk. What is the probability that the quality of the product or service, either in terms of the product specification itself or customer satisfaction, will not be delivered?

Managing by projects

Project life cycle. Risk is inherently tied to the timing and life cycle of the project because risk probabilities and impacts change over that life cycle. A minor, low-ranked risk at the beginning of the initiation stage can become a highly ranked and severe impact risk later in the project life cycle if not attended to. On the other hand, risks too early attended to can create needless effort and cost before their real implications for project success are fully known. Thus the effective project manager finds the appropriate "window" for risk response. That window is the decision point, or range, in the project where the risk contingency must be implemented to avoid schedule and cost impacts.

Initiation. The initiation stage is where the overall project risk is conceived, dimensioned, and described to develop an "order of magnitude" grasp of project risk. The kind of thinking and conversation that ensues in this phase addresses the *potential* of a new product or initiative, the *prospect* of customer and market demand, and the *competitive and risk* issues inherent in an endeavor still in its initial conceptual stage. At this point, the project manager and the planner are dealing with broad, "macro" issues such as described below for a variety of projects:

1. For a software project, whether the software deliverable would be new and untested or simply an enhancement or recurring production of software already in place on a similar platform. This project-level risk assessment improves on any business-wide strategic, marketing, technology, and environmental scanning information already available. In addition, the company's capacity to deliver the product to meet customer requirements is also reviewed to ensure that the risk of overcommitting the company and its resources is avoided. This where the tradeoffs are made between risk and opportunity, between cost and payoff, inherent in a new project, where its conceivers *play with and qualify* their misgivings and excitement about a new

effort. It is here that major business risks are first identified and linked directly to the likely outcomes of a particular project or product development process. Conditions and factors of success are rolled over to their worst case counterparts and potential customer requirements are reviewed to focus in on whether a customer would know what he or she really wants and needs—and act on it in the marketplace.

2. For a construction project, whether the building product is within the capacity and resources of the company, whether the customer knows the requirements, and what kinds of seasonal and other challenges lay ahead. Major risks in any construction project lie in the economic and social setting of the proposed investment and require analysis of a series of indicators around building vacancy rates, prices, and forecasted trends in demand.
3. For a telecommunications project, the broad issues of customer requirements, infrastructure and support, clarity of specifications, material costs, and other related cost issues are reviewed. The telecommunications risks and threats lie in the technology itself and the prospect of life cycle performance before being overtaken by another more effective technology. Cash flows are derived from best and worst case scenarios involving alternative telecommunications system life cycles.
4. For a health services project, the initiation phase brings out health technology and service developments, clarity of customer requirements, nature of the health services clientele, and probabilities of government assistance and regulatory activity. Early views of health services investments are fraught with the risks of technological and regulatory change, thus initiation requires a heavy dose of research and subjective judgment about change. Risk is a function of change since it is dimensioned uncertainty about whether a given effort will change a system or its performance as predicted and planned. The risk is that the intended change will not occur as predicted and further that whatever change occurs as a result of the project will create negative consequences for the client and the client's system, whatever it is.
5. Finally, the concept of order of magnitude costing applies here because it is in this phase that a prospective project cash flow is estimated along with costs. It is here that the initial level of profitability is estimated at a gross level, using whatever parametric indicators are available for the given industry. For instance, for an avionics instrument, the prospect of successfully marketing a new digitized instrument for a business aircraft is based on an industry working standard that it takes about 18 months to develop a new instrument and 5 years to recover costs.

Planning. Planning includes the development of project planning documents, scope of work, customer requirements document, schedule, budget, risk management plan, product development process, and project monitoring plan. The significance of the planning process for risk management is that risk is best addressed in the planning process simply because it allows time for assessment and contingency plans to be integrated into the baseline project schedule and budget.

Execution. Execution is the implementation phase once a baseline schedule is completed. Execution begins when work is authorized to begin and the project schedule is underway.

Control. Control is the project-monitoring phase during which performance indicators are monitored and the project is controlled by corrective action. The significance of control for the risk management process is that risk is built into earned value determinations. Earned value indicates variances from schedule and cost estimates, indications that risk may be at work in a project. Investigation of root causes involves first focusing on risks and risk events that were anticipated in the project planning process.

Closeout. Closeout is the termination phase in which a project is closed along with financial books.

Scope. The scope of work describes the work to be performed to produce the deliverable. Scope addresses customer requirements and deliverables, approach to producing the deliverables, and estimated schedule and cost estimates.

Time. Scheduling determines the project life cycle and delivery date for the deliverables. Time is an outcome of the planning process, not an input (despite the tendency of customers to dictate delivery dates without understanding the project process).

Cost. Cost is capture bottom up and top down. Bottom up estimates fixed and labor costs from individual tasks at the work package or level of effort, and rolled up. Top down applies parametric indicators, such as plan your building around $40/ft^2 as the industry standard for this kind of building.

Risk planning. Project planning and risk planning are related in the sense that project planning documents and deliverables incorporate risk and risk contingencies. But risk planning has taken on another slightly different meaning in the new PMI *PMBOK* document. Risk planning is seen by PMI as *preparing the organization and its support systems for risk management.* This emphasis gives special attention to the need to build the cultural underpinnings and support systems for risk management before top management can expect its project teams to address risk.

Risk planning involves the following outcomes:

1. *Development of a risk management policy and procedure system.* This involves the "institutionalization" of risk management into the policies, manuals, and procedures of the company. While stated policy does not always influence actual work setting behavior, it is important for the company to go public with risk as a priority management ethic.

2. *"Walk the talk" programs—orientation of top management to the integration of risk into day-to-day work and communications.* This involves assuring that top managers actually address risk in their project review meetings, customer communications, and performance reviews.
3. *Training and development programs for risk.* The company must have a risk management training program backed up by manuals and web-based training in risk assessment and response.
4. *Network and web-based information system development for project risk information management.* Since a company will want to address risk consistently throughout its project portfolio, a network should be earmarked for support to project managers, providing risk templates, forms, and data formats.
5. *Project management office support.* A separate staff serves project managers with standard and best practice, project review formats, monitoring data and analysis, and risk management services.
6. *Standard work breakdown structures.* The more the company can move toward a standard work breakdown structure, the easier it is to inculcate risk management practice into the scheduling and execution processes. Standard WBS formats will provide for risk contingencies and risk-based scheduling using MS Project PERT analysis or other software tools.

Quality. Quality is addressed in the project planning system first by assuring a firm grasp of customer requirements. This involves making sure the customer's needs and expectations are documented in the requirements document since in the end the customer actually determines the quality of the project outcome.

Second, quality is addressed in the application of quality assurance and quality control processes, ISO standards, and process improvement initiatives. Quality can be defined as the response to risk in the sense that quality issues stem from high-risk projects and project tasks. Therefore, it is important to address quality through the risk management process to produce a project system that protects against quality defects, variances, and high appraisal and inspection costs.

Human resources. The human resources element of project management involves the development of proficient workers and high-performance teams, focusing on strong support of the human resources staff. This means that employees who are comfortable with their work settings and employee support systems are more likely to seriously address good planning practice and protect the company from risk. As employees become more disengaged from the human resources function, they are liable to be increasingly alienated from the company and therefore be less interested in protecting it.

Communications. Risk is communicated in the project planning process through regular exchanges on risk in project reviews and task assignments. But the essence of risk communication is the ability to keep all stakeholders informed on risks so that they are not surprised by shifts to contingency plans, which push out schedules and increase costs and budgets.

Procurement. In any contracting system the contract is designed and managed with the purpose of minimizing risk and maximizing risk-sharing arrangements. This means that fixed price contracts are favored over cost reimbursable contracts in most cases because fixed prices shift the risk to the contractor.

Integration. Integration involves the mixing and matching of project components and parts to create the whole. Technically, integration is a systems function, but in terms of risk management the integration function means that risk is *embedded* in the process. For instance, in producing a product the company incorporates technical checks and balances in the system to offset the likelihood that product quality has been compromised.

Triple constraints

In a way, the so-called *triple constraints* of quality, schedule, and cost are not really constraints, they are outcomes of constraints. Constraints are resources, technology, risk, and project processes. People make it possible to produce project deliverables by managing these constraints to optimize schedule and costs while meeting quality and performance requirements.

Project Manager's Roles and Responsibilities in Risk Management

Leadership. The leadership function in risk management includes all the core leadership skills, e.g., vision, team development, giving purpose and direction, along with a strong sensitivity to risk. Leaders ask questions, but do not necessarily provide answers. The role of the leader in a risk management process is to ask the right questions, pose the right issues, and inspire the project team to come up with solutions and opportunities. Risk provides the leader with a conceptual framework for posing project issues in terms that can be incorporated into risk planning, matrices, and assessments.

Motivation. The classic role of motivating is actually a process of integrating individual leadership with a project work setting in which motivation is self generated. In other words organizational leadership cannot be very effective in motivating a project team unless the leader has designed the work itself to be challenging to the team. It is the work that motivates teams, not leaders alone. So it is the work that needs to be designed to be challenging. And since opportunity and challenge come from *risking yourself together to overcome a risk,* project teams typically are motivated by risk that is manageable.

Keeping risk manageable. Leaders keep risk manageable by framing a project that is feasible but that stretches the project team enough to represent a meaningful barrier. Overcoming that barrier then becomes the source of recognition and achievement and more motivation to go on to other challenges.

Facilitator/Manager. The facilitating gift is the capacity to guide a team to high performance by orchestrating the dialogue without dominating it. This means that facilitators must stay engaged with the team and keep the team moving by raising issues and challenges, but keep disengaged from the solutions and outcomes as much as possible. Solutions and outcomes are to be addressed by the customer in the context of customer requirements; the facilitator is interested in spurring the team to a high level of achievement, but not necessarily interested in guiding the resultant solution.

Work Breakdown Structure, Again!

Description, purpose, and use in decomposing a project. The reason a WBS is a necessary part of risk management is that the WBS defines the risks in a project at a level that the risk can be identified, described, and assessed. Thus you can look at the WBS as the structural support for risk management in the sense that it "rolls out" the work so that everyone can see the work in small enough chunks to ascertain the risks inherent in completing it. If a WBS misses a major chunk of work, it may also miss a major chunk of risk, so it is important for the WBS to define all the work.

Activity definition. Activities are project tasks that create outcomes, consume resources, and must be scheduled. Activities are differentiated from milestones, which are points in time, which mark significant endpoints or intermediate products of activities. Defining the activity—not just identifying it in a one-liner—thus is a critical step in risk management. The more detailed the activity the more clear the risks inherent in the work will be.

Resource planning. Resources are constraints and thus are the generators of risk. According to the theory of constraints, resources are the major sources of project failure or success. Using the "article chain" concept, the project manager is advised to trim estimates down to "bare bones" so that *buffer* time can be doled out when necessary, and to concentrate only on the key constraints in the project. Inherent in the theory is a major criticism of micromanaging all tasks as if they were all of the same importance. Isolating the few high-risk tasks gives the project manager focus.

Cost estimating. Cost estimating is a bottom-up and top-down process, but it begins with the WBS and builds labor and fixed costs as part of the scheduling process. At the heart of the cost estimating process is the definition of the work, with work equaling resources multiplied by time. In other words, a task might be defined as a "five person week job," that is, given the nature of the defined work it is estimated that it will take five people 1 week to do the task—a 200 h job—*if they are all working full time.* If less than five people are working on the task, or some are not full time, it will take longer, thus the duration and resource levels are traded off with each other. The work itself and its definition stay constant unless changed by a new estimate of the work. Costing out a job that has been defined to this detail is relatively easy since it includes the cost of full time staff working for 40 h.

How does risk figure into cost estimating? Risk is a driver of cost since its impact is to extend the work beyond the expected duration to a more pessimistic duration based on the potential occurrence of a risk and the time and cost of implementing a contingency action. Thus cost and risk are associated with each other; various levels of risk create different costs.

Budgeting. Budgeting is the allocation of available resources to projects based on priorities. While cost estimates are useful inputs to budgeting, the company decides where to put its money based on its *portfolio* analysis, using cost estimates.

Progress reporting. Progress reporting is accomplished through earned value, e.g., schedule and cost variance, as well as by risk assessment.

Coding of work breakdown structure (WBS) elements. The estimation of cost from the WBS includes the cost of all tasks and risk contingencies built up from the bottom of the WBS.

Relationship to cost accounting. Risk impacts on project cost are captured in the budget and since the WBS is coded to the task level, the cost of all risk contingencies should be documented in the cost accounting system.

Activity-based costing. The purpose of activity-based costing is to measure costs and therefore profitability based on the cost of time. This leads to accuracy in cost tracking as well as measuring resource capacity excesses and constraints. It also helps decide what costs contribute to profitability. The costs of risk mitigation are attributed to appropriate project tasks and subtract from project margins.

Relationship to responsibility matrix and organizational structure. The responsibility for risk is shared in a matrix between functional and project managers. The responsibility for process and technical risk is with the functional department and that for deliverable schedule and cost risk is with the project manager. The organizational structure should be clear on roles and responsibilities so that risk accountability can be assured.

Estimating

Estimating is the process of estimating schedules and costs based on a proposed deliverable specification. There are different types of estimates:

Order of magnitude/conceptual. Order of magnitude is "ballpark" estimating, getting a handle on the general cost based on all task work and expected risk mitigation costs. This estimate is general and helps to *scale* the project initially as complex and big, mid-sized, or small—in the context of the company's capacity and past work.

Budget/parametric. Parametric costing depends on the availability of parameters for scaling costs, e.g., the cost/square foot of building a health clinic building.

Definitive/detailed. Definitive is a detailed costing based on individual work packages and levels of effort at the individual and team level. This is the final budget against which cost variance is measured, including overhead and general and administrative costs.

Project type/industry. The estimating process differs depending on the industry. Estimating a construction project is typically at the definitive and detailed level while estimating an information technology project is often at the budget and parametric level because of uncertainties and risks.

Time

Activity duration. Activity duration estimates are based on information from the assigned team member, parametric data, and can be in three dimensions—expected, optimistic, and pessimistic—for PERT analysis.

Expert judgment. Expert judgment is used in providing order of magnitude and parametric budget estimates.

Analogy. If there is an analogous project to the target project, then analogous cost data are used, as in parametric costing.

Productivity rate. Productivity rates are useful in estimating the impacts of risks on costs and schedule because of the rate at which deliverable components and pieces of work can be produced. For instance, if a given report typically takes 1 week to design, prepare, and publish, then two reports can be done in 2 weeks or less.

Contingency time. Contingency plans take time and financing, so estimating the cost and schedule impact of contingencies should be part of the regular project planning and scheduling process.

Risk-based scheduling

Calculating a risk-based schedule: PERT analysis. We deal with MS Project in more detail in Chapter 7, but here is a summary of risk-based scheduling.

MS Project has the capability of calculating a risk-based schedule and task durations using the PERT tool. This is based on estimated expected, optimistic, and pessimistic task durations.

The purpose is to use risk assessment and analysis information to calculate a *risk-based* project schedule in Microsoft Project. The risk-based schedule is calculated from your original project schedule, but uses your weighted estimates of three possible task durations (expected, pessimistic, and optimistic) to come up with a new project schedule. The new schedule is calculated for individual tasks and "rolled up" to the whole project.

The risk-based schedule is usually a better schedule estimate than your original one because it reflects your best estimates of what could go wrong (risk) and what could go right (controlling risk).

Procedure

1. Prepare your regular project schedule using Microsoft Project using your best estimates of task durations and linkages. This project schedule does not reflect any risk assessment.
2. Prepare a risk matrix using the work breakdown structure (WBS) and the project schedule and rank *all* project tasks in terms of risk, designating them "high, medium, or low."
   a. A high-risk ranking shows a high probability (>50 percent) of the risk actually occurring, *and* that the risk will have a relatively severe impact on schedule, cost, and/or quality.
   b. A medium-risk ranking implies less probability (<50 percent) of happening and less schedule impact
   c. A low-risk ranking implies very low probability (<10 percent) that the task will occur and low impact.
3. Select the five highest-risk tasks (or more if you have more tasks that present risks that you want to reflect in your risk-based schedule).
4. Calculate the risk-based schedule: Your objective now is to calculate a risk-based schedule by taking each of the five highest-risk tasks and calculating a risk-based duration for each. Using Microsoft Project, here are the steps:
   a. Pull the PERT Analysis Toolbar up from "View."
   b. Highlight one of the high-risk tasks on the Gantt chart.
   c. Go to the PERT Entry Form and enter your duration estimates for that task for three scenarios—expected (use the duration in your original schedule), pessimistic (worst case impact if risk occurs), and optimistic (best case, all risk controlled with no impacts).
   d. Then use the PERT Weight button to set the weights for each scenario (weights reflect the probability that a given risk and impact will happen). Microsoft Project uses a total weight scale of six points; your job is to divide the six points up among three scenarios—expected, pessimistic, and optimistic. Note that the Microsoft Project "default" is 4 for expected (based on the high probability that the actual duration will fall somewhere between the two extremes) and 1 each for pessimistic and optimistic. But you may want to change those weights based on your estimate of the relative probability that a given scenario is going to happen.
   e. Once you have entered weights, go to the PERT Calculation button and calculate the risk-based duration for that task, based on your inputs.

f. Now click the PERT Entry Sheet and you will see the newly calculated, risk-based duration for the task compared to the three scenario durations (expected, pessimistic, and optimistic).
g. Now repeat this procedure for the remaining high-risk tasks.
h. The resulting "rolled up" schedule is now a risk-based schedule, reflecting a new project duration.

Dependencies

Risk and activity sequencing. It is important that the project schedule reflect the correct linkages. There is considerable risk inherent in these linkages since in a complex project these linkages change. Dependencies identified at the beginning of the project sometimes disappear as team members consult and collaborate before the tasks begin. And, conversely, some tasks not initially linked develop dependencies because of unanticipated developments in the project.

For instance, one design and one integration task might be initially linked because of the obvious need to design before a system is integrated. But as the team collaborates, it is probable that integration starts before design is completed and may go on in parallel. The risk is that because of Murphy's law (work expands according to the amount of time available to do it) the original task durations may be too long but are never changed. On the other hand, two project tasks, such as design and reporting progress, are not originally linked but later become interdependent because of an unanticipated request for a special report to a stakeholder on design review results.

Cost

Direct and indirect costs. Direct costs are costs of labor and other costs applied to the project by those who add value to the deliverable. Indirect costs are support costs—overhead and general and administrative costs. The risk inherent in costing is that the overhead and G&A costs are underestimated and the customer is surprised with invoices that exceed the expected costs.

Fixed and variable costs. Simply put, fixed costs are costs of capital, equipment, and space, and are entered as fixed costs into MS Project in building the project cost estimate. Variable costs are direct costs of labor, those that vary over time. The risk in fixed cost is the probability of misestimating fixed costs and the possibility that while fixed costs can be prorated over the life cycle of the project, cash flow is drained when the costs are actually incurred.

Basis for estimates

Internal accounting records. There are inherent risks in using internal accounting records as the basis for estimates. Each project is different and unless the project was exactly like the one under review, there is a high probability that past records will not be a good guidepost. On the other hand, internal accounting records are useful on the actual cost of labor and capital equipment.

Project team knowledge. There is risk in assuming project team knowledge about costs that may not be relevant to the new project. The best approach is to seek team insights, but to temper them with the perspective of a project manager.

Estimating manuals and databases. For deliverable components, estimating manuals can be useful as parametric guides, but again the risk is that manuals will not have accurate data.

Construction. In the construction industry, there are many sources of risk and cost data, from such organizations as The National Association of Home Builders. Parametric data are available on construction unit costs ($/sq ft) and supply and contractor risks and contract types.

Software development. Software development creates a unique set of risks and costs associated with this business. Since software development involves creative work in design and coding and faces major challenges in integration and platform options, the business does not have reliable cost and risk data and experiences major project delays.

The Software Engineering Institute is the major source of practical methodologies and risk and cost data. SEI defines a successful risk management practice as "one in which risks are continuously identified and analyzed for relative importance. Risks are mitigated, tracked, and controlled to effectively use program resources. Problems are prevented before they occur and personnel consciously focus on what could affect product quality and schedules."

The lack of focus on risk in software development has created major delays and cost overruns because of the lack of top management support, failure to gain user commitment, misunderstanding requirements, lack of adequate user involvement, failure to manage end-user expectations, changing scope, lack of technical skills, new technology, and staffing inadequacies and conflict.

Typical risk and cost issues are grounded in technology issues, e.g., two computers having different architectures that interpret a designated protocol differently.

Learning curves. As an organization gains competence in a given project arena, project life cycles are shortened. Performance time and experience can be represented by a learning curve relating the direct labor required to experience gained in past work.

Parametric estimating. Parametric estimating, that is estimating based on unit measures, such as $/sq ft, creates risk in the sense that these are median measures from a wide variety of similar projects and are not reliable for unique projects.

Issues

Poorly defined project scope. Since there is no industry standard on what is involved in a scope of work, the quality of the scope is typically measured against the number of changes or scope creep the project experiences. Risks and cost/schedule impacts are widespread in most project areas, particularly in software development and system developments. *PMBOK* states that the scope of work should include all the work necessary to complete the product to meet specifications, e.g., the WBS is a core element in the *PMBOK* framework. To the extent that the WBS covers all the work and by reference all the components of the product, and risks and costs are estimated from that WBS, the scope of work is the major anchor and stability factor in project planning and control. The potential for scope creep is a major generic risk in any project, and the best contingency is to assure that a WBS is prepared that is thorough from the perspective of the project team, stakeholders, top management, and the customer.

Major omissions in tasks/activities. If tasks are left out of the WBS and scope, then adding them requires a change order and rescheduling and rebudgeting of the project. Project managers cannot accept major additions or changes based on new work unless the project team is clearly at fault in missing an important piece of work.

Optimistic time/cost estimates. The natural tendency is to be optimistic in estimating schedule durations and costs, thus the risk is that the schedule is not risk-based. To offset that tendency, the project manager should use the outputs of the risk analysis process and risk matrix content to estimate a "pessimistic" duration option in the MS Project PERT analysis and then to calculate a risk-based schedule on that basis. The difference between the expected and pessimistic durations is a "buffer" in the sense that the term is used in the theory of constraints that should be controlled by the project manager.

Project Financial Perspectives

There is risk in the misuse or inaccuracy of financial analysis tools, and more importantly of the inputs or assumptions used in the application of those tools.

Concepts associated with interest rate; time value of money; simple interest; compound interest; discount rate; minimum acceptable rate of return (MARR); present, annual, and future worth (PW); and various rate of return and tax methods should be peer reviewed by an internal or external accounting consultant before being applied to projects. The risk is that rules of thumb and industry practice may be ignored.

Evaluation tools and techniques. Projects can be evaluated by several tools, including break-even analysis, payback period, replacement analysis, economic life, and feasibility studies. But the real issue in project evaluation is the longer term viability and value of the deliverable in meeting business and financial objectives, and the risk is that short-term, internal corrective actions during project delivery will be short sighted and focused on narrow schedule and cost issues, and not on long-term success.

Project budgeting

Budget inputs. Budget inputs include the risk management plan as well as the traditional project tools such as WBS and schedule. The risk in budgeting is the same as the risk experienced in scheduling—the tendency to be too optimistic. One way to address this issue is to perform a PERT analysis on a task using dollars instead of time units and to calculate a risk-based budget using that tool.

Preparation approaches

Top-down (strategic, tactical). Risk and cost are approached in a similar way, first from the top-down approach to develop "chunks" of risk and cost associated with various large packages of work, then to proceed to bottom up to refine the estimates.

Bottom-up (WBS-based). "Bottom-up" means taking the lowest level of the WBS (at least four levels down), estimating cost and risk, then rolling the budget up and preparing a risk matrix to rank risks with direct impacts on cost.

Iterative (combination of both). The iterative approach simply assumes that both approaches are helpful in developing a project budget and risk plan.

Estimates plus contingency

Refine estimates. Estimates are refined at the definitive level (from the budgetary level) by relating costs to specific measures and task durations, and to arrive at an estimate that can be used to propose a budget to a sponsor or investor.

Risk considerations. Risk is integrated into the refining of estimates by calculating a risk-based budget and schedule and comparing it to the original estimates, and making sure that all contingency plans have been estimated and integrated into the baseline schedule.

Issues

How much contingency. Contingency can be seen in the framework of critical chain theory so that the costs of the pessimistic option, both time and money, are earmarked as contingency funds and tapped by the project manager for allocation according to need.

Who controls contingency. The project manager controls contingency to avoid a multitude of contingencies being built into every task estimate, thus suboptimizing the project.

Management reserve

Project financing. There is substantial risk in the financing of a project, and more importantly in the financing of the parent company. Issues such as internal resources, commercial credit, equity issues, venture capital, government grants/subsidies, and capital rationing govern the viability of the company itself and its capacity to finance a project up front. To share risk, many companies are going to earmarked venture funds for new product development so that sponsors' funds are bounded by a project to avoid cross subsidy.

Insurable risk. Insurable risk is risk that is determined to be insurable on the open market and which is not self funded. Insurance is a vehicle to share risk and to outsource risk that has a high probability and impact severity.

Identification of project risks. Project risks will surface in a number of ways.

Internal. Internal risk is risk that is organizational and system-related, and that poses challenges to the company itself to support successful project management.

Technical. Technical and technology risk can be managed using reliability and testing methods, which must be built into the project itself. Technical risk is handled by embedding testing in the design and development of the product.

Nontechnical. Nontechnical risks are personnel, organizational, and process risks which are faced by the project manager. Some would say nontechnical risks are the most endemic since they stem from individual and workforce performance.

External. External risk is risk generated by the environment and the market, and can be anticipated through environmental scanning and strategic planning.

Predictable. Predictable uncertainty becomes risk because it can be anticipated, dimensioned, and mitigated.

Unpredictable. Unpredictable risk is uncertainty that cannot be anticipated or managed.

Legal. Legal risk is the probability that a project will generate legal action focused on the deliverable or proprietary information.

Risk event. A risk event is the triggering action, milestone, or task output that generates the risk and evidences that an anticipated risk is occurring.

Probability of occurrence. The probability of occurrence is estimated by the project manager, or rank ordered in terms of ranges of probability, such as 25, 50, and 75 percent.

Potential consequences. Consequences of risk are captured in the risk matrix not only in terms of impacts on schedule, cost, and quality, but also in terms of external consequences, such as change in company competency or market share.

Impact assessment techniques. Impacts are estimated by tools, which develop scenarios of future impacts through use of expert judgment and sometimes simulations.

Sensitivity analysis. This analysis looks at how project outcome is sensitive to various changes in schedule, cost, and quality, usually by trial and error.

Expected value. Expected value is the value of one path of decisions versus another, and is calculated by estimating the probabilities of various decisions and the profit margins outcomes of those decisions, then multiplying them and comparing various decision paths.

Decision tree. A *decision tree* is a tree diagram that outlines the various alternative paths at key points when the project manager must decide between contrasting decisions.

More Background

It is traditional to address project management in terms of time, schedule, and cost, and to focus on the Gantt chart as the key planning and control tool. Yet this emphasis on managing and sequencing tasks does not do justice to project management as a decision process. Project decisions are made (or not made) regularly on the basis of cost, risk, procurement and contracting, and other issues that can have major impacts on project success but which are not addressed in the traditional Gantt chart. The critical success factor for a project can often be the timing and nature of decisions made on the basis of risk and uncertainty and cost. These decision points in a project can figure importantly in the success of the project because they determine how risks and costs are handled and they narrow options.

Further, the timing of key decisions sets the conditions for what tasks are critical and what tasks become redundant as a project unfolds. But traditional project tools do not serve project managers well in this area, especially in flagging key decisions in terms of the project schedule and showing impacts as they are made. The risk process as described in the PMI *PMBOK* stresses risk planning, identification, assessment, and response. But this model does not help project managers anticipate key decisions and assess the costs and benefits (or expected value) of making one decision or another when key tradeoffs have to be made.

Project Tools

The combination of three analytic tools helps to illustrate the point: (1) decision tree analysis, (2) expected value, and (3) the traditional Gantt chart.

Decision tree theory

The decision tree helps to identify key decisions and evaluate expected value of key decisions based on the analysis of risk and costs associated with each branch.

There are two components to the decision tree—a decision and a risk or uncertainty. The decision is shown as a box with one arrow for each option available in the decision. The risk or uncertainty is represented by a circle and an arrow for each state of risk. The arrows for risk must contain the outcome in dollars if that state occurs, along with the probability of it occurring.

Note that the sum of all probabilities around the risk circle must add to 1.0. Therefore, the states must represent all possible conditions. These conditions are strung together to give a picture of the decision to be made. With the addition of a method for making a decision using the decision tree called the *expected value*, we can make our decision and have a method for presenting the results in a consistent manner.

An illustration of a decision tree analysis of risk

Pat is a project manager with a local contractor who has submitted a proposal to install a telephone trunk line between Macon central station and Kathlyne, GA. Pat has just received an option on 1000 acres of right-or-way property at \$100/acre. If Pat purchases the option and the project is not selected, there is a 60 percent chance that she can sell the property at what it was brought for; otherwise she believes that there is a 60 percent chance she can sell it at \$90/acre. Pat has another option to wait until the project is awarded to purchase the property. However, there is a 20 percent chance that the property will increase to \$120/acre. Pat feels that there is a 60 percent chance that the company will be awarded the project. The original proposal, based on \$100/acre, netted the company a profit of \$100,000.

In building the decision tree for this problem we need to establish what decisions need to be made. In this case, the decision is to either "buy now" or "buy later." Then we need to establish what the uncertainties are in the problem. In this problem, there are two uncertainties; the first is the same no matter which option we choose. That is, whether we win the contract. There is a 60 percent chance that we will win the contract. Therefore, there is a 40 percent chance we will not. The second uncertainty is different depending on the option being

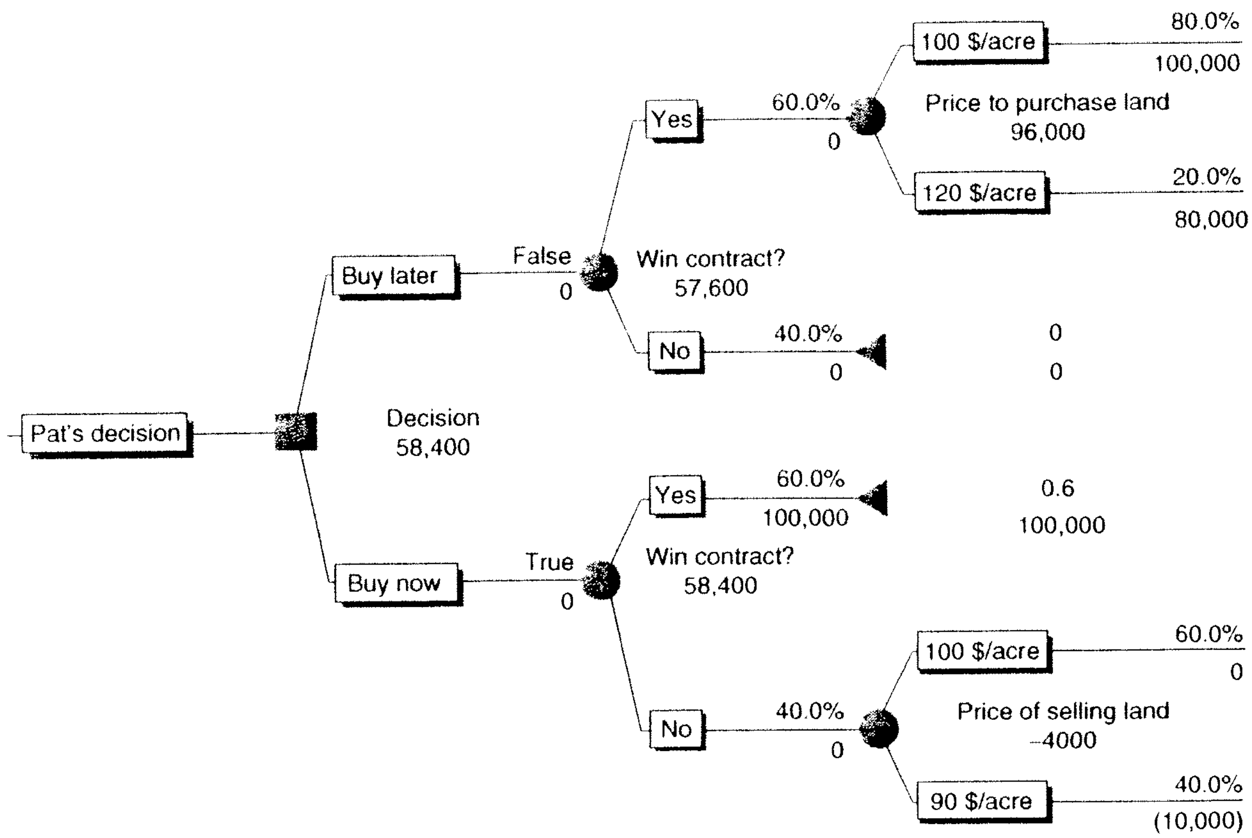

Figure 3.5 Pat's decision tree.

evaluated. That is, if we buy now and lose the contract, there is an uncertainty as to the price we can sell the land for to recoup our expenses. If we do not buy the land and win the contract, then we have to purchase the land. There is an uncertainty as to the price we can buy the land for at this point. The answer is calculated in the same manner above using expected value. When you have uncertainties that are chained together the expected value starts at the right-hand side and works left. You calculate the expected value around each uncertainty. The resulting expected value replaces the entire uncertainty in the next uncertainty. The resulting decision tree of Pat's decision process is shown in Fig. 3.5.

Using the decision tree, we start with the upper decision alternative of "buy later." At the left-hand side we see that the expected value of *purchase price* of land is 100,000(0.8) + 80,000(0.2) or $96,000. The entire uncertainty can be replaced by $96,000. Then the next uncertainty expected value can be determined as 96,000 (0.60) + 0(.4) or $57,600.

Following the same procedure, we can calculate the lower alternative of "buy now" with a result of $58,400. The tree can now be collapsed to the following decision:

We choose between an average profit of $57,600 for "buy later" or $58,400 for "buy now." Based on this, we would like to get as much profit as possible, so we would choose "buy now."

Issues

Simulation. Simulations create mathematical models using key factors in a future scenario and calculate outcomes based on various assumptions and input values. For the estimation of risk and impacts, simulations are useful when the project complexity is such that the interaction and impact of many factors cannot be handled manually.

Expert judgment. Expert judgment is gathered through Delphi techniques and focus groups who brainstorm to express their insights on a given risk problem.

Response planning

Prioritization. In prioritizing risks, the project manager develops a sense of where response planning is most needed. Risks are ranked in the risk matrix and assessed, and then the level of response planning and contingency is aligned with the relative importance of the risk.

Amount at stake. The amount at stake is actually a calculation of the expected value of a given risk decision; it is the dollar loss should a risk not be controlled, or should an opportunity not be exploited.

Response strategies

Avoidance. Avoidance is a viable approach, neglecting the risk, which sometimes "goes away."

Transference. Transference moves the risk to another party, as in insurance or contracting.

Mitigation. Mitigation planning takes the risk on squarely and provides the project manager with a direct corrective action.

Acceptance. Acceptance is the approach that essentially plans for the risk to occur and plans for covering the cost and schedule impacts.

Monitoring and control

Risk response audits. Risk response audits are used to look back at how a given project or project risk has been handled. A project audit looks more broadly at how the project was managed across the board.

Periodic project risk reviews. Risk reviews are incorporated into project reviews, not in separate sessions. The project review agenda includes risk analysis and planning data and poses risk decisions to be made.

Earned value analysis. Earned value monitors schedule and cost variance as indicators of risk impacts.

Communicating risks. Risks are addressed in business and project reports, which anticipate risks, explain contingencies, and pose decisions to be made which may shape the risk impact.

Project Control Systems

Cost/schedule integration

Information flow and ties to WBS. Baseline schedules are developed from the WBS and schedule and cost data are related to particular tasks. Since costs are directly associated with tasks, each task can be assessed in terms of cost and schedule impacts.

Network planning and schedule development. Scheduling is the most important function of project managers and risk determines the amount of "buffer" that is withheld by the project manager based on the probabilities of risk occurrence and contingency action.

Project cash flows and commitments. Cash flows committed out beyond customer agreements or contracts represent separate risks, thus cash flows are aligned with work performed and scope boundaries.

Reporting responsibilities. Project managers report risk and cost information to top management, stakeholders and customers; functional managers report technical and technology risks and costs to top management.

Issues

Cost, schedule, performance/quality tradeoffs. Decisions which trade off schedule, cost, and quality/performance factors can be guided by the risk impacts of each option. In other words, when a project manager decides to delay a task outcome because of quality considerations, the determining factor might be the risk that the quality outcome cannot be achieved even with more time provided by a task delay.

Integrated change management. Change management is the process of accommodating to a change request by reviewing all internal and external impacts, reviewing the risks of change, and integrating the change across all appropriate interfaces.

Corrective action

Crashing. Sometimes the project manager must direct new resources to a project to make up for unanticipated impacts of risk events, thus crashing the project. The risk of quality impacts of crashing can be found in the tendency for "haste to make waste."

Phasing of deliverables. Phasing deliverables in a different way may help to relieve the tensions of a project task delay or failure.

Modification of scope, schedule, budget. Sometimes a scope or schedule must be altered because of schedule or cost variance, but there are inherent risks in doing so.