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The World of Project Management

Once upon a time there was a heroine project manager. Her projects were never late. They never ran over budget. They always met contract specifications and invariably satisfied the expectations of her clients. And you know as well as we do, anything that begins with "Once upon a time . . ." is just a fairy tale.

This book is not about fairy tales. Throughout these pages we will be as realistic as we know how to be. We will explain project management practices that we know will work. We will describe project management tools that we know can help the project manager come as close as Mother Nature and Lady Luck will allow to meeting the expectations of all who have a stake in the outcome of the project.

1.1 WHAT IS A PROJECT?

Why this emphasis on project management? The answer is simple: Daily, organizations are asked to accomplish tasks that do not fit neatly into business-as-usual. A software group may be asked to develop an application program that will access U.S. government data on certain commodity prices and generate records on the value of commodity inventories held by a firm; the software must be available for use on April 1. The Illinois State Bureau for Children's Services may require an annually updated census of all Illinois resident children, aged 17 years or younger, living with an illiterate single parent; the census must begin in 18 months.

Note that each task is *specific* and *unique* with a specific *deliverable* aimed at meeting a *specific need or purpose*. These are *projects*. The routine issuance of reports on the value of commodity inventories, the routine counseling of single parents on nurturing their offspring—these are not projects. The difference between a project and a *nonproject* is not always crystal clear. For almost any precise definition, we can point to exceptions. At base, however, projects are unique, have a specific deliverable, and have a specific due date. Note that our examples have all those characteristics. The Project Management Institute (PMI) defines a project as "A temporary endeavor undertaken to create a unique product or service" (Project Management Institute, 2004).

Projects vary widely in size and type. The writing of this book is a project. The reorganization of Procter & Gamble (P&G) into a global enterprise is a project, or more accurately a program, a large integrated set of projects. The construction of a fly-in fishing lodge in Manitoba, Canada is a project. The organization of "Cat-in-the-Hat Day" so that Mrs. Chaney's third grade class can celebrate Dr. Suess's birthday is also a project.

Both the hypothetical projects we mentioned earlier and the real-world projects listed just above have the same characteristics. They are unique, specific, and have desired completion dates. They all qualify as projects under the PMI's definition. They have an additional characteristic in common—they are multidisciplinary. They require input from people with different kinds of knowledge and expertise. This multidisciplinary nature of projects means that they are complex, that is, composed of many interconnected elements and requiring input from groups outside the project. The various areas of knowledge required for the construction of the fly-in fishing lodge are not difficult to imagine. The knowledge needed for globalization of a large conglomerate like P&G is quite beyond the imagination of any one individual and requires input from a diversified group of specialists. Working as a team, the specialists investigate the problem to discover what information, skills, and knowledge are needed to accomplish the overall task. It may take weeks, months, or even years to find the correct inputs and understand how they fit together.

A secondary effect of using multidisciplinary teams to deal with complex problems is conflict. Projects are characterized by conflict. As we will see in later chapters, the project schedule, budget, and specifications conflict with each other. The needs and desires of the client conflict with those of the project team, the senior management of the organization conducting the project and others who may have a less direct stake in the project. Some of the most intense conflicts are those between members of the project team. Much more will be said about this in later chapters. For the moment, it is sufficient to recognize that projects and conflict are inseparable companions, an environment that is unsuitable and uncomfortable for conflict avoiders.

It is also important to note that projects do not exist in isolation. They are often parts of a larger entity or program, just as projects to develop a new engine and an improved suspension system are parts of the program to develop a new automobile. The overall activity is called a *program*. Projects are subdivisions of programs. Likewise, projects are composed of *tasks*, which can be further divided into *subtasks* that can be broken down further still. The purpose of these subdivisions is to allow the project to be viewed at various levels of detail. The fact that projects are typically parts of larger organizational programs is important for another reason, as is explained in Section 1.5.

Finally, it is appropriate to ask, "Why projects?" The reason is simple. We form projects in order to fix the responsibility and authority for the achievement of an organizational goal on an individual or small group when the job does not clearly fall within the definition of routine work.

Trends in Project Management

Many recent developments in project management are being driven by quickly changing global markets, technology, and education. Global competition is putting pressure on prices, response times, and product/service innovation. Computer and telecommunication technology, along with rapidly expanding higher education across the world allows the use of project management for types of projects and in regions where these sophisticated tools had never been considered before. The most important of these recent developments are covered in this book.

Achieving Strategic Goals There has been a growing use of projects to achieve an organization's strategic goals, and existing major projects are screened to make sure that their objectives support the organization's strategy and mission. Projects that do not have clear ties to the strategy and mission are terminated and their resources are redirected to those that do. A discussion of this is given in Section 1.7, where the Project Portfolio Process is described.

Achieving Routine Goals On the other hand, there has also been a growing use of project management to accomplish routine departmental tasks, normally handled as the usual work of functional departments; e.g., routine machine maintenance. Middle management has become aware that projects are organized to accomplish their performance objectives within their budgets and deadlines. As a result, artificial deadlines and budgets are created to accomplish specific, though routine, departmental tasks—a process called "projectizing."

Improving Project Effectiveness A variety of efforts are being pursued to improve the process and results of project management, whether strategic or routine. One well-known effort is the creation of a formal *Project Management Office* (PMO, see Section 2.5) in many organizations that takes responsibility for many of the administrative and specialized tasks of project management. Another effort is the evaluation of an organization's project management "maturity," or skill and experience in managing projects (discussed in Section 7.5). This is often one of the responsibilities of the PMO. Another responsibility of the PMO is to educate project managers about the *ancillary goals* of the organization (Section 8.1), which automatically become a part of the goals of every project whether the project manager knows it or not. Achieving better control over each project though the use of phase gates, earned value (Section 7.3), critical ratios (Section 7.4), and other such techniques is also a current trend.

Virtual Projects With the rapid increase in globalization of industry, many projects now involve global teams whose members operate in different countries and different time zones, each bringing a unique set of talents to the project. These are known as virtual projects because the team members may never physically meet before the team is disbanded and another team reconstituted. Advanced telecommunications and computer technology allow such virtual projects to be created, do their work, and complete their project successfully (see Section 2.1).

Quasi-Projects Led by the demands of the information technology/systems departments, project management is now being extended into areas where the project's objectives are not well understood, time deadlines unknown, and/or budgets undetermined. This ill-defined type of project is extremely difficult to conduct and to date has often resulted in setting an artificial due date and budget, and then specifying project objectives to meet those limits. However, new tools for these quasi-projects are now being developed—prototyping, phase-gating, and others—to help these projects achieve results that satisfy the customer in spite of the unknowns.

> A project, then, is a temporary endeavor undertaken to create a unique product or service. It is specific, timely, usually multidisciplinary, and always conflict ridden. Projects are parts of overall programs and may be broken down into tasks, subtasks, and further if desired. Current trends in project management are noted.

1.2 PROJECT MANAGEMENT VS. GENERAL MANAGEMENT

Project management differs from general management largely because projects differ from what we have referred to as "nonprojects." The naturally high level of conflict present in projects means that the project manager (PM) must have special skills in conflict resolution. The fact that projects are unique means that the PM must be creative and flexible, and have the ability to adjust rapidly to changes. When managing nonprojects, the general manager tries to "manage by exception." In other words, for nonprojects almost everything is routine and is handled routinely by subordinates. The manager deals only with the exceptions. For the PM, almost everything is an exception.

Major Differences

Certainly, general management's success is dependent on good planning. For projects, however, planning is much more carefully detailed and project success is absolutely dependent on such planning. The project plan is the immediate source of the project's budget, schedule, control, and evaluation. Detailed planning is critically important. One should not, of course, take so much time planning that nothing ever gets done, but careful planning is a major contributor to project success. Project planning is discussed in Chapter 3.

Project budgeting differs from standard budgeting, not in accounting techniques, but in the way budgets are constructed. Budgets for nonprojects are primarily modifications of budgets for the same activity in the previous period. Project budgets are newly created for each project and often cover several periods in the future. The project budget is derived directly from the project plan that calls for specific activities. These activities require resources, and such resources are the heart of the project budget. Similarly, the project schedule is also derived from the project plan.

In a nonproject manufacturing line, the sequence in which various things are done is set when the production line is designed. The sequence of activities often is not altered when new models are produced. On the other hand, each project has a schedule of its own. Previous projects with deliverables similar to the one at hand may provide a rough template for the current project, but its schedule will be set by the project's unique plan and by the date on which the project is due for delivery to the client. As we will see in later chapters, the special requirements associated with projects have led to the creation of special managerial tools for budgeting and scheduling.

The routine work of most organizations takes place within a well-defined structure of divisions, departments, sections, and similar subdivisions of the total unit. The typical project cannot thrive under such restrictions. The need for technical knowledge, information, and special skills almost always requires that departmental lines be crossed. This is simply another way of describing the transdisciplinary character of projects. When projects are conducted side-by-side with routine activities, chaos tends to result—the nonprojects rarely crossing organizational boundaries and the projects crossing them freely. These problems and recommended actions are discussed at greater length in Chapter 2.

Even when large firms establish manufacturing plants or distribution centers in different countries, a management team is established on site. For projects, "globalization" has a different meaning. Individual members of project teams may be spread across countries, continents, and oceans, and speak several different languages. Some project team members may never even have a face-to-face meeting with the project manager.

The discussion of structure leads to consideration of another difference between project and general management. In general management, there is a reasonably well defined managerial hierarchy. Superior-subordinate relationships are known, and lines of authority are clear. In project management this is rarely true. The PM may be relatively low in the hierarchical chain of command. This does not, however, reduce his or her responsibility of completing a project successfully. Responsibility without the authority of rank or position is so common in project management as to be the rule, not the exception.

Negotiation

With little legitimate authority, the PM depends on negotiation skills to gain the cooperation of the many departments in the organization that may be asked to supply technology, information, resources, and personnel to the project. The parent organization's standard departments have their own objectives, priorities, and personnel. The project is not their responsibility, and the project tends to get the leftovers, if any, after the departments have satisfied their own need for resources. Without any real command authority, the PM must negotiate for almost everything the project needs.

It is important to note that there are two different types of negotiation, *win-win* negotiation and *win-lose* negotiation. When you negotiate the purchase of a car or a home, you are usually engaging in win-lose negotiation. The less you pay for home or car, the less profit the seller makes. Your savings are the other party's losses—win-lose negotiation. This type of negotiation is never appropriate when dealing with other members of your organization. If you manage to "defeat" a department head and get resources or commitments that the department head did not wish to give you, imagine what will happen the next time you need something from this individual. The PM simply cannot risk win-lose situations when negotiating with other members of the organization.

Within the organization, win-win negotiation is mandatory. In essence, in win-win negotiation both parties must try to understand what the other party needs. The problem you face as a negotiator is how to help other parties meet their needs in return for their help in meeting the needs of your project. When negotiation takes place repeatedly between the same individuals, win-win negotiation is the only sensible procedure. PMs spend a great deal of their time negotiating. General managers spend relatively little. Skill at win-win negotiating is a requirement for successful project managing. (See Fisher and Ury, 1983; Jandt, 1987; and Raiffa, 1982.)

One final point about negotiating: Successful win-win negotiation often involves taking a synergistic approach by searching for the "third alternative." For example, consider a product development project focusing on the development of a new inkjet printer. A design engineer working on the project suggests adding more memory to the printer. The PM initially opposes this suggestion feeling that the added memory will make the printer too costly. Rather than rejecting the suggestion, however, the PM tries to gain a better understanding of the design engineer's concern.

Based on their discussion, the PM learns that the engineer's purpose in requesting additional memory is to increase the printer's speed. After benchmarking the competition, the design engineer feels the printer will not be competitive as it is currently configured. The PM explains his fear that adding the extra memory will increase the cost of the printer to the point that it also will no longer be cost competitive. Based on this discussion the design engineer and PM agree that they need to search for another (third) alternative that will increase the printer's speed without increasing its costs. A couple of days later, the design engineer identifies a new ink that can simultaneously increase the printer's speed and actually lower its total and operating costs.

Project management differs greatly from general management. Every project is planned, budgeted, scheduled, and controlled as a unique task. Unlike nonprojects, projects are often multidisciplinary and usually have considerable need to cross departmental boundaries for technology, information, resources, and personnel. Crossing these boundaries tends to lead to intergroup conflict.

Unlike their general management counterparts, project managers have responsibility for accomplishing a project, but little or no legitimate authority to command the required resources from the functional departments. The PM must be skilled at win-win negotiation to obtain these resources.

1.3 WHAT IS MANAGED? THE THREE GOALS OF A PROJECT

The performance of a project is measured by three criteria. Is the project on time or early? Is the project on or under budget? Does the project meet the agreed-upon specifications to the satisfaction of the customer? Figure 1-1 shows the three goals for any project. The performance of the project, and the PM, is measured by the degree to which these goals are achieved.

One of these goals, specifications, is set primarily by the client (although the client agrees to all three when contracting for the project). It is the client who must decide what capabilities are required of the project's deliverables—and this is what makes the project unique. Some writers insist that "quality" is a separate and distinct goal of the project along with time, cost, and specifications. We do not agree because we consider quality an inherent part of the project specifications, not separable from them.

If we did not live in an uncertain world in which the best made plans often go awry, managing projects would be relatively simple, requiring only careful planning. Unfortunately, we do not live in a perfectly predictable (*deterministic*) world, but one

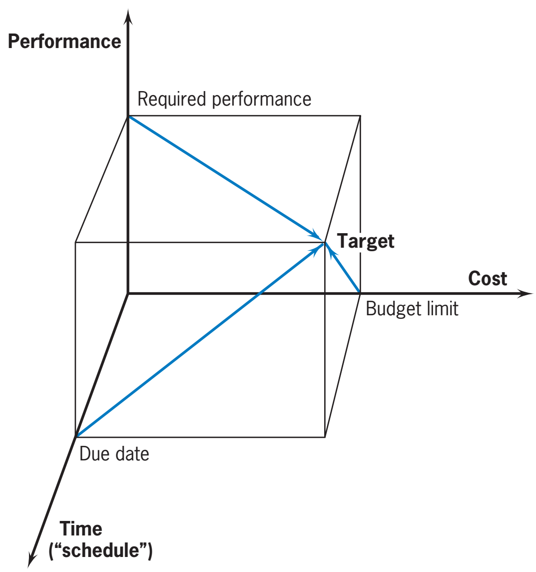


Figure 1-1 Performance, cost, and time project targets.

characterized by chance events (*uncertainty*). This ensures that projects travel a rough road. Murphy's Law seems as universal as death and taxes, and the result is that the most skilled planning is upset by uncertainty. Thus, the PM spends a great deal of time adapting to unpredicted change. The primary method of adapting is to *trade-off* one objective for another. If a construction project falls behind schedule because of bad weather, it may be possible to get back on schedule by adding resources—in this case, probably labor and some equipment. If the budget cannot be raised to cover the additional resources, the PM may have to negotiate with the client for a later delivery date. If neither cost nor schedule can be negotiated, the contractor may have to "swallow" the added costs (or pay a penalty for late delivery), and accept lower profits.

All projects are always carried out under conditions of uncertainty. Well-tested software routines may not perform properly when integrated with other well-tested routines. A chemical compound may destroy cancer cells in a test tube—and even in the bodies of test animals—but may kill the host as well as the cancer. Where one cannot find an acceptable way to deal with a problem, the only alternative may be to stop the project and start afresh to achieve the desired deliverables. In the past, it was popular to label these technical uncertainties "technological risk." This is not very helpful, however, because it is not the technology that is uncertain. We can, in fact, do almost anything we wish, excepting perhaps faster-than-light travel and perpetual motion. What is uncertain is not technological success, but rather how much it will cost and how long it will take to reach success.

Most of the trade-offs PMs make are reasonably straightforward and are discussed during the planning, budgeting, and scheduling phases of the project. Usually they involve trading time and cost, but if we cannot alter either the schedule or the budget, the specifications of the project may be altered. Frills on the finished product may be foregone, capabilities not badly needed may be compromised. From the early stages of the project, it is the PM's duty to know which elements of project performance are sacrosanct and which are not.

One final comment on this subject: Projects must have some flexibility. Again, this is because we do not live in a deterministic world. Occasionally, a senior manager (who does not have to manage the project) presents the PM with a document precisely listing a set of deliverables, a fixed budget, and a firm schedule. This is failure in the making for the PM. Unless the budget is overly generous, the schedule overlong, and the specifications easily accomplished, the system is, as mathematicians say, "overdetermined." If Mother Nature so much as burps, the project will fail to meet its rigid parameters. A PM cannot be successful without flexibility.

Projects have three interrelated objectives: to (1) meet the budget, (2) finish on schedule, and (3) meet specifications that satisfy the client. Because we live in an uncertain world, as work on the project proceeds, unexpected problems are bound to arise. These chance events will threaten the project's schedule or budget or specifications. The PM must now decide how to trade off one project goal against another (e.g., to stay on schedule by assigning extra resources to the project may mean it will run over the predetermined budget.) If the schedule, budget, and specifications are rigidly predetermined, the project is probably doomed to failure unless the preset schedule and budget are overly generous or the difficulty in meeting the specifications has been seriously overestimated.

1.4 THE LIFE CYCLES OF PROJECTS

All organisms have a *life cycle*. They are born, grow, wane, and die. This is true for all living things, for stars and planets, for the products we buy and sell, for our organizations, and for our projects as well. A project's life cycle measures project completion as a function of either time (schedule) or resources (budget). This life cycle must be understood because the PM's managerial focus subtly shifts at different stages of the cycle (Adams and Barndt, 1983; Kloppenborg and Mantel, 1990). During the early stages, the PM must make sure that the project plan really reflects the wishes of the client as well as the abilities of the project team and is designed to be consistent with the goals and objectives of the parent firm.

As the project goes into the implementation stage of its life cycle, the PM's attention turns to the job of keeping the project on budget and schedule—or, when chance interferes with progress, to negotiating the appropriate trade-offs to correct or minimize the damage. At the end of the project, the PM turns into a "fuss-budget" to assure that the specifications of the project are truly met, handling all the details of closing out the books on the project, making sure there are no loose ends, and that every "i" is dotted and "t" crossed.

Many projects are like building a house. A house-building project starts slowly with a lot of discussion and planning. Then construction begins and progress is rapid. When the house is built, but not finished inside, progress appears to slow down and it seemingly takes forever to paint everything, to finish all the trim, and to assemble and install the built-in appliances. Progress is slow-fast-slow, as shown in Figure 1-2.

It used to be thought that the S-shaped curve of Figure 1-2 represented the life cycle for all projects. While this is true of many projects, there are important exceptions. Anyone who has baked a cake has dealt with a project that approaches completion by a very different route than the traditional S-curve, as shown in Figure 1-3.

The process of baking a cake is straightforward. The ingredients are mixed while the oven is preheated, usually to 350°F. The mixture (technically called "goop") is placed in a greased pan, inserted in the oven and the baking process begins. Assume that the entire process from assembling the ingredients to finished cake requires about 45 minutes—15 minutes for assembling the materials and mixing, and 30 minutes for baking. At the end of 15 minutes we have goop. Even after 40 minutes, having baked for 25 minutes, it may look like cake but, as any baker knows, it is still partly goop inside. If a toothpick (our grandmothers used a broom straw) is inserted into the middle of the "cake" and then removed, it does not come out clean. In the last few minutes of the process, the goop in the middle becomes cake. If left a few minutes too long in the oven, the cake will begin to burn on the bottom. Project Cake follows a path to completion much like Figure 1-3.

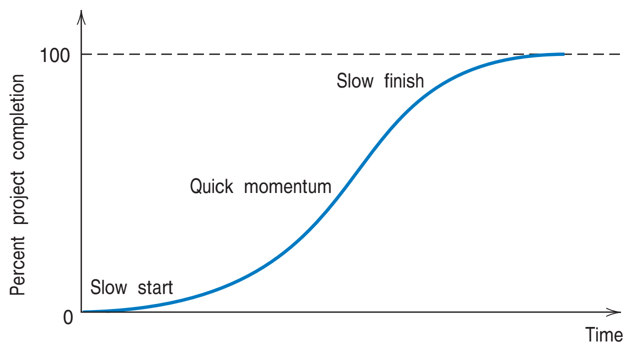


Figure 1-2 The project life cycle.

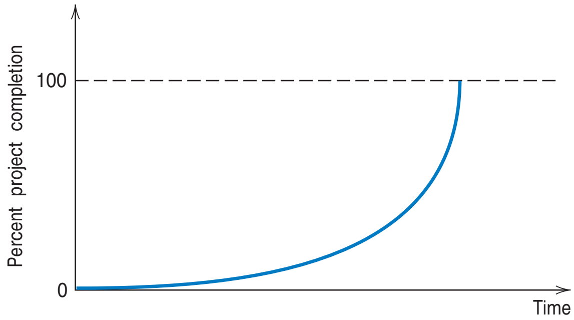


Figure 1-3 An alternate project life cycle.

There are many projects that are similar to cake—the production of computer software, and many chemical engineering projects, for instance. In these cases the PM's job begins with great attention to having all the correct project resources at hand or guaranteed to be available when needed. Once the "baking" process is underway—the integration of various sets of code or chemicals—one can usually not add missing ingredients. As the process continues, the PM must concentrate on determining when the project is complete—"done" in the case of cake, or a fully debugged program in the case of software.

In later chapters, we will also see the importance of the shape of the project's life cycle on how management allocates resources or reacts to potential delays in a project. Management does not need to know the precise shape of the life cycle, but merely whether its completion phase is concave (Figure 1-2) or convex (Figure 1-3) to the baseline.

> There are two different paths (life cycles) along which projects progress from start to completion. One is S-shaped and the other is J-shaped. It is an important distinction because identifying the different life cycles helps the PM to focus attention on appropriate matters to ensure successful project completion.

1.5 SELECTING PROJECTS TO MEET ORGANIZATIONAL OBJECTIVES

The accomplishment of important tasks and goals in organizations today is being achieved increasingly through the use of projects. A new kind of organization has emerged recently to deal with the accelerating growth in the number of multiple, simultaneously ongoing, and often interrelated projects in organizations. This project-oriented organization, often called "enterprise project management" (Levine, 1998), "management by projects" (Boznak, 1996), and similar names, was created to tie projects more closely to the organization's goals and strategy and to handle the growing number of ongoing projects. Given that the organization has an appropriate mission statement and strategy, projects must be selected that are consistent with the strategic goals of the organization. In what follows, we first discuss a variety of common project selection methods. We then describe the process of strategically selecting the best set of projects for implementation, called the Project Portfolio Process.

Project selection is the process of evaluating individual projects or groups of projects and then choosing to implement a set of them so that the objectives of the parent organization are achieved. Before a project begins its life cycle, it must have been *selected* for funding by the parent organization. Whether the project was proposed by someone within the organization or an outside client, it is subject to approval by a more or less formal selection process. Often conducted by a committee of senior managers, the major function of the selection process is to ensure that several conditions are considered before a commitment is made to undertake any project. These conditions vary widely from firm to firm, but several are quite common: (1) Is the project potentially profitable? Does it have a chance of meeting our return-on-investment hurdle rate? (2) Does the firm have, or can it easily acquire, the knowledge and skills to carry out the project successfully? (3) Does the project involve building competencies that are considered consistent with our firm's strategic plan? (4) Does the organization currently have the capacity to carry out the project on its proposed schedule? This list could be greatly extended.

The selection process is usually complete before a PM is appointed to the project. Why, then, should the PM be concerned? Quite simply, the PM should know exactly why the organization selected the specific project because this sheds considerable light on what the project (and hence the PM) is expected to accomplish, from senior management's point of view, with the project. The project may have been selected because it appeared to be profitable, or was a way of entering a new area of business, or a way of building a reputation of competency with a new client or in a new market. This knowledge can be very helpful to the PM by indicating senior management's goals for the project, which will point to the desirability of some trade-offs and the undesirability of others.

There are many different methods for selecting projects, but they may be grouped into two fundamental types, nonnumeric and numeric. The former does not use numbers for evaluation; the latter does.

Nonnumeric Selection Methods

The Sacred Cow At times, the organization's Chief Executive Officer (CEO) or other senior executive casually suggests a potential product or service that the organization might offer to its customers. The suggestion often starts, "You know, I was thinking that we might . . ." and concludes with ". . . Take a look at it and see if it looks sensible. If not, we'll drop the whole thing."

Whatever the selection process, the aforementioned project will be approved. It becomes a "Sacred Cow" and will be shown to be technically, if not economically, feasible. This may seem irrational to new students of project management, but such a judgment ignores senior management's intelligence and valuable years of experience—as well as the subordinate's desire for long-run employment. It also overlooks the value of support from the top of the organization, a condition that is necessary for project success (Green, 1995).

The Operating/Competitive Necessity This method selects any project that is necessary for continued operation of a group or facility. If the answer to the "Is it necessary . . . ?" question is "yes," and if we wish to continue using the facility or system to stay in business, the project is selected. The Investment Committee of a large manufacturing company started to debate the advisability of purchasing and installing pumps to remove 18 inches of flood water from the floor of a small, but critical production facility. The debate stopped immediately when one officer pointed out that without the facility the firm was out of business.

The same questions can be directed toward the maintenance of a competitive position. Some years ago, General Electric almost decided to sell a facility that manufactured the large mercury vapor light bulbs used for streetlights and lighting large parking lots. The lighting industry had considerable excess capacity for this type of bulb and the resulting depressed prices meant they could not be sold profitably. GE, however, felt that if they dropped these bulbs from their line of lighting products, they might lose a significant portion of all lightbulb sales to municipalities. The profits from such sales were far in excess of the losses on the mercury vapor bulbs.

Comparative Benefits Many organizations have to select from a list of projects that are complex, difficult to assess, and often noncomparable, e.g., United Way organizations and R&D organizations. Such institutions often appoint a selection committee made up of knowledgeable individuals. Each person is asked to arrange a set of potential projects into a rank-ordered set. Typically, each individual judge may use whatever criteria he or she wishes to evaluate projects. Some may use carefully determined technical criteria, but others may try to estimate the project's probable impact on the ability of the organization to meet its goals. While the use of various criteria by different judges may trouble some, it results from a purposeful attempt to get as broad a set of evaluations as possible.

Rank-ordering a small number of projects is not inherently difficult, but when the number of projects exceeds 15 or 20, the difficulty of ordering the group rises rapidly. A *Q-sort* is a convenient way to handle the task (Helin and Souder, 1974). First, separate the projects into three subsets, "good," "fair," and "poor," using whatever criteria you have chosen—or been instructed to use. If there are more than seven or eight members in any one classification, divide the group into two subsets, for instance, "good-plus" and "good-minus." Continue subdividing until no set has more than seven or eight members (see Figure 1-4). Now, rank-order the items in each subset. Arrange the subsets in order of rank, and the entire list will be in order.

The committee can make a composite ranking from the individual lists any way it chooses. One way would be to number the items on each individual list in order of rank, and then add the ranks given to each project by each of the judges. Projects may then be approved in the order of their composite ranks, at least until the organization runs out of available funds.

Steps **Results at Each Step**

1. For each participant in the exercise, assemble a deck of cards, with the name and description of one project on each card.
2. Instruct each participant to divide the deck into two piles, one representing a high priority, the other a low-priority level. (The piles need not be equal.)
3. Instruct each participant to select cards from each pile to form a third pile representing the medium-priority level.
4. Instruct each participant to select cards from the high-level pile to yield another pile representing the very high level of priority; select cards from the low-level pile representing the very low level of priority.
5. Finally, instruct each participant to survey the selections and shift any cards that seem out of place until the classifications are satisfactory.

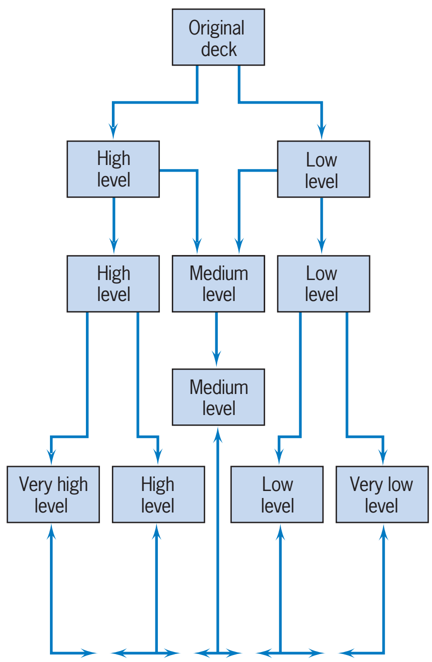


Figure 1-4 The Q-sort method (Helin and Souder, 1974).

Numeric Selection Methods

Financial Assessment Methods Most firms select projects on the basis of their expected economic value to the firm. Although there are many economic assessment methods available—payback period, average annual rate of return, internal rate of return, and so on—we will describe here two of the most widely used methods: *payback period* and *discounted cash flow*.*

The payback period for a project is the initial fixed investment in the project divided by the estimated annual net cash inflows from the project (which include the cash inflows from depreciation of the investment). The ratio of these quantities is the number of years required for the project to return its initial investment. Because of this perspective, the payback period is often considered a surrogate measure of risk to the firm: the longer the payback period, the greater the risk to the firm. To illustrate, if a project requires an investment of $100,000 and is expected to return a net cash inflow of $25,000 each year, then the payback period is simply 100,000/25,000 = 4 years, assuming the $25,000 annual inflow continues at least 4 years. Although this is a popular financial assessment method, it ignores the time value of money as well as any returns beyond the payback period. For these reasons, it is not usually recommended as a project selection method, though it is valuable for cash budgeting. Of the financial assessment methods, the discounted cash flow method discussed next is recommended instead.

The discounted cash flow method considers the time value of money, the inflation rate, and the firm's return-on-investment hurdle rate for projects. The annual cash inflows and outflows are collected and discounted to their *net present value* (NPV) using the organization's *required rate of return* (a.k.a. the *hurdle rate* or *cutoff rate*).

$$\text{NPV (project)} = -I_0 + \sum_{t=1}^{n} F_t/(1+k)^t$$

where

I_0 = the initial investment, which will be negative because it is an outflow

F_t = the net cash flow in period t

k = the required rate of return or hurdle rate

If one wishes to include the potential effects of inflation or deflation in the calculation, it is quite easily done. The discounting term, $(1 + k)^t$, simply becomes, $(1 + k + p_t)^t$, where p_t is the estimated rate of inflation or deflation for period t. If the required rate of return is 10 percent and we expect the rate of inflation will be 3 percent, then the discount factor becomes $(1 + .10 + .03)^t = (1.13)^t$ for that period.

In the early years of a project when outflows usually exceed inflows, the NPV of the project for those years will be negative. If the project becomes profitable, inflows become larger than outflows and the NPV for those later years will be positive. If we add up the present value of the net cash flows for all years, we have the NPV of the project. If this sum is positive, the project may be accepted because it earns more than the required rate of return. The following boxed example illustrates these calculations. Although the example employs a spreadsheet for clarity and convenience in the analysis, we have chosen to illustrate the calculations using the NPV formula directly rather than using a spreadsheet function such as NPV (in Excel®) so the reader can better see what is happening. Once the reader understands how this works, we suggest using the simpler spreadsheet functions to speed up the process.

* Explanations of the theory and methods of calculating the net present value of cash inflows are beyond the scope of this book. We recommend that the reader who could benefit from an explanation turn to any standard college textbook on finance (Moyer, McGuigan, and Kretlow, 1998, for instance).

PsychoCeramic Sciences, Inc.*

PsychoCeramic Sciences, Inc. (PSI) is a large producer of cracked pots and other cracked items. The firm is considering the installation of a new manufacturing line that will, it is hoped, allow more precise quality control on the size, shape, and location of the cracks in its pots as well as in vases designed to hold artificial flowers.

The plant engineering department has submitted a project proposal that estimates the following investment requirements: an initial investment of $125,000 to be paid up-front to the Pocketa-Pocketa Machine Corporation, an additional investment of $100,000 to install the machines, and another $90,000 to add new material handling systems and integrate the new equipment into the overall production system. Delivery and installation is estimated to take one year, and integrating the entire system should require an additional year. Thereafter, the engineers predict that scheduled machine overhauls will require further expenditures of about $15,000 every second year, beginning in the fourth year. They will not, however, overhaul the machinery in the last year of its life.

The project schedule calls for the line to begin production in the third year, and to be up-to-speed by the end of that year. Projected manufacturing cost savings and added profits resulting from higher quality are estimated to be $50,000 in the first year of operation and are expected to peak at $120,000 in the second year of operation, and then to follow the gradually declining pattern shown in Table A.

Project life is expected to be 10 years from project inception, at which time the proposed system will be obsolete and will have to be replaced. It is estimated that the machinery will have a salvage value of $35,000. PSI has a 13 percent hurdle rate for capital investments and expects the rate of inflation to be about 2 percent per year over the life of the project. Assuming that the initial expenditure occurs at the beginning of the year and that all other receipts and expenditures occur as lump sums at the end of the year, we can prepare the Net Present Value analysis for the project as shown in Table A.

Because the first cash flow of −$125,000 occurs at the beginning of the first period, there is no need to discount it as it is already in present value terms. The remaining cash flows are assumed to occur at the end of their respective periods. For example, the $115,000 cash flow associated with 2012 is assumed to occur at the end of the fifth period. According to the results, the Net Present Value of the project is positive and, thus, the project can be accepted. (The project would have been rejected if the hurdle rate had been 15 percent or if the inflation rate was 4 percent, either one resulting in a discount rate of 17 percent.)

* The authors thank John Wiley & Sons for permission to adapt material from Meredith, J. R. and Mantel, S. J., *Project Management: A Managerial Approach*, 6th ed. New York, John Wiley & Sons, 2006 for use in this section and in Section 1.6.

Perhaps the most difficult aspect related to the proper use of discounted cash flow is determining the appropriate discount rate to use. While this determination is made by senior management, it has a major impact on project selection, and therefore, on the life of the PM. For most projects the hurdle rate selected is the organization's cost of capital though it is often arbitrarily set too high as a general allowance for risk. In the case of

Table A

	A	B	C	D	E	F	G
1					Discount	Net Present	
2	Year	Inflow	Outflow	Net Flow	Factor	Value	
3	A	B	C	D = (B − C)	$1/(1+k+p)^t$	D × (Disc. Factor)	
4	2008*	$0.00	$125,000.00	−$125,000.00	1.00	−$125,000.00	
5	2008	0.00	100,000.00	−100,000.00	0.87	−86,957.00	
6	2009	0.00	90,000.00	−90,000.00	0.76	−68,053.00	
7	2010	50,000.00	0.00	50,000.00	0.66	32,876.00	
8	2011	120,000.00	15,000.00	105,000.00	0.57	60,034.00	
9	2012	115,000.00	0.00	115,000.00	0.50	57,175.00	
10	2013	105,000.00	15,000.00	90,000.00	0.43	38,909.00	
11	2014	97,000.00	0.00	97,000.00	0.38	36,466.00	
12	2015	90,000.00	15,000.00	75,000.00	0.33	24,518.00	
13	2016	82,000.00	0.00	82,000.00	0.28	23,310.00	
14	2017	65,000.00	0.00	65,000.00	0.25	16,067.00	
15	2017	35,000.00		35,000.00	0.25	8,651.00	
16							
17	Total	$759,000.00	$360,000.00	$399,000.00		$17,997.00	
18							
19		*t = 0 at the beginning of 2008					
20							
21	**Formulae**						
22	**Cell D4**		=(B4−C4) copy to D5:D15				
23	**Cell E4**		=1/(1 + 0.13 + 0.002)^0				
24	**Cell E5**		=1/(1 + 0.13 + 0.02)^1				
25	**Cell E6**		=1/(1 + .12 + .02)^(A6−2007) copy to E7:E15				
26	**Cell F4**		=D4*E4 copy to F5:F15				
27	**Cell B17**		Sum(B4:B15) copy to C17, D17, F17				
28							

particularly risky projects, a higher hurdle rate may be justified, but it is not a good general practice. If a project is competing for funds with alternative investments, the hurdle rate may be the *opportunity cost of capital*, that is, the rate of return the firm must forego if it invests in the project instead of making an alternative investment. Another common, but misguided practice is to set the hurdle rate high as an allowance for resource costs increases. Neither risk nor inflation should be treated so casually. Specific corrections for each should be made if the firm's management feels it is required. We recommend strongly a careful risk analysis, which we will discuss in further detail throughout this book.

Because the present value of future returns decreases as the discount rate rises, a high hurdle rate biases the analysis strongly in favor of short-run projects. For example, given a rate of 20 percent, a dollar ten years from now has a present value of only $.16, $(1/1.20)^{10} = .16$. The critical feature of long-run projects is that costs associated with them are spent early in the project and have high present values while revenues are delayed for several years and have low present values.

This effect may have far-reaching implications. The high interest rates during the 1970s and 1980s, and again in the 2000s, forced many firms to focus on short-run projects. The resulting disregard for long-term technological advancement led to a deterioration in the ability of some United States firms to compete in world markets (Hayes and Abernathy, 1980).

The discounted cash flow methods of calculation are simple and straightforward. Like the other financial assessment methods, it has a serious defect. First, it ignores all nonmonetary factors except risk. Second, because of the nature of discounting, all the discounted methods bias the selection system by favoring short-run projects. Let us now examine a selection method that goes beyond assessing only financial profitability.

Real Options A more recent approach to project selection employs a financial model that recognizes the value of positioning the organization to capitalize on future opportunities. It is based on the financial options approach to valuing prospective capital investment opportunities. A real option derives its value beyond the net present value of a project through two means. The first is simply the additional value from spending money for the opportunity later rather than now. The second is the option to make a more profitable decision later, once natural events have transpired to either increase or decrease the value of the investment opportunity. If the value decreases, you may choose to not invest after all, and thus save a large sum that would have been wasted. If the value increases, you still can reap the rewards which you would not have been able to do if you had declined the investment at the beginning based on the project's rate of return or riskiness.

Occasionally, organizations will approve projects that are forecast to lose money when fully costed and sometimes even when only direct costed. Such decisions by upper management are not necessarily foolish because there may be other, more important reasons for proceeding with a project, such as to:

- Acquire knowledge concerning a specific or new technology
- Get the organization's "foot in the door"
- Obtain the parts, service, or maintenance portion of the work
- Allow them to bid on a lucrative, follow-on contract
- Improve their competitive position
- Broaden a product line or line of business

Of course, such decisions are expected to lose money in the short term only. Over the longer term they are expected to bring extra profits to the organization. It should be understood that "lowball" or "buy-in" bids (bidding low with the intent of cutting corners on work and material, or forcing subsequent contract changes) are unethical practices, violate the PMI Code of Ethics for Project Managers, and are clearly dishonest.

The details of evaluating projects in terms of real options are too extensive to present here. The interested reader is referred to Luehrman (1998a and b).

Scoring Methods Scoring methods were developed to overcome some of the disadvantages of the simple financial profitability methods, especially their focus on a single criterion. The simplest scoring approach, the *unweighted 0–1 factor method*, lists multiple criteria of significant interest to management. Given a list of the organization's goals, a

Project ______________________________

Rater ______________ Date ______________

	Qualifies	Does Not Qualify
No increase in energy requirements	x	
Potential market size, dollars	x	
Potential market share, percent	x	
No new facility required	x	
No new technical expertise required		x
No decrease in quality of final product	x	
Ability to manage project with current personnel		x
No requirement for reorganization	x	
Impact on work force safety	x	
Impact on environmental standards	x	
Profitability		
Rate of return more than 15% after tax	x	
Estimated annual profits more than $250,000	x	
Time to break-even less than 3 years	x	
No need for external consultants		x
Consistency with current line of business		x
Impact on company image		
With customers	x	
With our industry		x
Totals	12	5

Figure 1-5 A sample project selection form, an unweighted 0–1 scoring model.

selection committee, usually senior managers, familiar with both the organization's criteria and potential project portfolio check off, for each project, which of the criteria would be satisfied; for example, see Figure 1-5. Those projects that exceed a certain number of check-marks may be selected for funding.

All the criteria, however, may not be equally important and the various projects may satisfy each criterion to different degrees. To correct for these drawbacks, the *weighted factor scoring method* was developed. In this method, a number of criteria, n, are considered for evaluating each project and their relative importance weights, w_j, are estimated. The sum of the weights over all the j criteria is usually set arbitrarily at 1.00, though this is not mandatory. It is helpful to limit the criteria to just the major factors and not include criteria that are only marginal to the decision such as representing only 2 or 3% importance. A rule of thumb might be to keep n less than eight factors because the higher weights, say 20 percent or more, tend to force the smaller weights to be insignificant. The importance weights, w_j, can be determined in any of a number of ways: a particular individual's subjective belief, available objective factors such as surveys or reports, group composite beliefs such as simple averaging among the group members, and so on.

In addition, a score, s_{ij}, must be determined for how well each project i satisfies each criterion j. Each score is multiplied by its category weight, and the set of scores is summed to give the total weighted score, $S_i = \Sigma_j\, s_{ij}\, w_j$ for each project, i, from which the best project is then selected. Typically, a 5-point scale is used to ascertain these scores, though 3-, 7-, and even 9-point scales are sometimes used. The top score, such as 5, is reserved for excellent performance on that criterion such as a return on investment (ROI) of 50% or more, or a reliability rating of "superior." The bottom score of 1 is for "poor performance," such as an ROI of 5 percent or less, or a reliability rating of "poor." The middle score of 3 is usually for average or nominal performance (e.g., 15–20% ROI), and 4 is "above average" (21–49% ROI) while 2 is "below average" (6–14% ROI). Notice that the bottom score, 1, on one category may be offset by very high scores on other categories. Any condition that is so bad that it makes a project unacceptable, irrespective of how good it may be on other criteria, is a *constraint*. If a project violates a constraint, it is removed from the set and not scored.

Note two characteristics in these descriptions. First, the categories for each scale need not be in equal intervals—though they should correspond to the subjective beliefs about what constitutes excellent, below average, and so on. Second, the five-point scales can be based on either quantitative or qualitative data, thus allowing the inclusion of financial and other "hard" data (cash flows, net present value, market share growth, costs) as well as "soft" subjective data (fit with the organization's goals, personal preferences, attractiveness, comfort). And again, the soft data also need not be of equal intervals. For example, "superior" may rate a 5 but "OK" may rate only a 2.

The general mathematical form of the weighted factor scoring method is

$$S_i = \sum_{j=1}^{n} s_{ij} w_j$$

where

S_i = the total score of the *i*th project
s_{ij} = the score of the *i*th project on the *j*th criterion
w_j = the weight or importance of the *j*th criterion

Using a Weighted Scoring Model to Select Wheels

As a junior in college, you now find that you need to purchase a car in order to get to your new part-time job and around town more quickly. This is not going to be your "forever" car, and your income is limited; basically, you need reliable wheels. You have two primary criteria of equal importance, cost and reliability. You have a limited budget and would like to spend no more than $3,500 on the car. In terms of reliability, you can't afford to have the car break down on your way to work, or for that matter, cost a lot to repair. Beyond these two major criteria, you consider everything else a "nicety" such as comfort, heat and air, appearance, handling, and so on. Such niceties you consider only half as important as either cost or reliability. Table A shows a set of scales you created for your three criteria, converted into quantitative scores.

Table A: Criteria Scales and Equivalent Scores

			Scores		
Criterion	**1**	**2**	**3**	**4**	**5**
Cost	>$3,500	$3,000–3,499	$2,500–2,999	2,000–2,499	<$2,000
Reliability	poor	mediocre	ok	good	great
Niceties	none	few	some	many	lots

You have identified three possible cars to purchase. Your sorority sister is graduating this semester and is looking to replace "Betsy," her nice subcompact. She was going to trade it in but would let you have it for $2,800, a fair deal, except the auto magazines rate its reliability as below average. You have also seen an ad in the paper for a more reliable Minicar for $3,400 but the ad indicates it needs some body work. Last, you tore off a phone number from a campus poster for an old Japanese Import for only $2,200.

In Table B, you have scored each of the cars on each of the criteria, calculated their weighted scores, and summed them to get a total. The weights for the criteria were obtained from the following logic: If Y is the importance weight for Cost, then Y is also the importance for Reliability and $\frac{1}{2}$Y is the importance for Niceties. This results in the formula

$$Y + Y + \tfrac{1}{2}Y = 1.00 \text{ or } Y = 0.4$$

Thus, Cost has 0.4 importance weight, as does Reliability, and Niceties has 0.2 importance.

Table B: Weighted Total Scores for Each Car

	Criteria (and Weights)			
Alternative Car	***Cost (0.4)***	***Reliability (0.4)***	***Niceties (0.2)***	***Total***
Betsy	3 × 0.4 = 1.2	2 × 0.4 = 0.8	4 × 0.2 = 0.8	2.8
Minicar	2 × 0.4 = 0.8	4 × 0.4 = 1.6	1 × 0.2 = 0.2	2.6
Import	4 × 0.4 = 1.6	3 × 0.4 = 1.2	1 × 0.2 = 0.2	3.0

Based on this assessment, it appears that the Import with a total weighted score of 3.0 may best satisfy your need for basic transportation. As shown in Table C, spreadsheets are a particularly useful tool for comparing options using a weighted scoring model.

Table C: Creating a Weighted Scoring Model in a Spreadsheet

	A	B	C	D	E
1	**Criteria**	Cost	Reliability	Niceties	
2	**Weights**	0.4	0.4	0.2	
3					
4	**Alternative Car**	Cost	Reliability	Niceties	Total
5	Betsy	3	2	4	**2.8**
6	Minicar	2	4	1	**2.6**
7	Import	4	3	1	**3.0**
8					
9	**Formula**				
10	Cell E5	= SUMPRODUCT(B$2:D$2,B5:D5)			
11		(copy to cells E6:E7)			

Project selection is an inherently risky process. Throughout this section we have treated risk by "making allowance" for it. Managing and analyzing risk can be handled in a more straightforward manner. By estimating the highest, lowest, and most likely values that costs, revenues, and other relevant variables may have, and by making some other assumptions about the world, we can estimate outcomes for the projects among which we are trying to make selections. This is accomplished by simulating project outcomes. The next section demonstrates how to do this using Crystal Ball® 7.2.2 on a sample selection problem.

The PM should understand why a project is selected for funding so that the project can be managed to optimize its advantages and achieve its objectives. There are two types of project selection methods: numeric and nonnumeric. Both have their advantages. Of the numeric methods, there are two subtypes—methods that assess the profits associated with a project and more general methods that measure nonmonetary advantages in addition to the monetary pluses. Of the financial methods, the discounted cash flow is best. In our judgment, however, the weighted scoring method is the most useful.

1.6 CONFRONTING UNCERTAINTY—THE MANAGEMENT OF RISK

As we argue throughout this book, effective project management requires an ability to deal with uncertainty. The time required to complete a project, the availability and costs of key resources, the timing of solutions to technological problems, a wide variety of macroeconomic variables, the whims of a client, the actions taken by competitors, even the likelihood that the output of a project will perform as expected, all these exemplify the uncertainties encountered when managing projects. While there are actions that may be taken to reduce the uncertainty, no actions of a PM can ever eliminate it. Therefore, in today's turbulent business environment, effective decision making is predicated on an ability to manage the ambiguity that arises while we operate in a world characterized by uncertain information.

One approach that is particularly useful in helping us understand the implications of uncertain information is *risk analysis*. The essence of risk analysis is to make estimates or assumptions about the probability distributions associated with key parameters and variables and to use analytic decision models or Monte Carlo simulation models based on these distributions to evaluate the desirability of certain managerial decisions. Real-world problems are usually large enough that the use of analytic models is very difficult and time consuming. With modern computer software, simulation is not difficult.

A mathematical model of the situation is constructed and a simulation is run to determine the model's outcomes under various scenarios. The model is run (or replicated) repeatedly, starting from a different point each time based on random choices of values from the probability distributions of the input variables. Outputs of the model are used to construct statistical distributions of items of interest to decision makers, such as costs, profits, completion dates, or return on investment. These distributions are the *risk profiles* of the outcomes associated with a decision. Risk profiles can be considered by the manager when considering a decision, along with many other factors such as strategic concerns, behavioral issues, fit with the organization, and so on.

In the following section, using an example we have examined earlier, we illustrate how Crystal Ball® 7.2.2 (CB), a widely used Excel® Add-In that is bundled with this book, can be used to improve the PM's understanding of the risks associated with managing projects.

Considering Uncertainty in Project Selection Decisions

Reconsider the PsychoCeramic Sciences example we solved in the section devoted to finding the discounted cash flows associated with a project. Setting this problem up on Excel® is straightforward, and the earlier solution is shown here for convenience as Table 1-1. We found that the project cleared the barrier of a 13 percent hurdle rate for acceptance. The net cash flow over the project's life is just under $400,000, and discounted at the hurdle rate plus 2 percent annual inflation, the net present value of the

Table 1-1 Single-Point Estimates of the Cash Flows for PsychoCeramic Sciences, Inc.

	A	B	C	D	E	F	G
1					Discount	Net Present	Inflation
2	Year	Inflow	Outflow	Net Flow	Factor	Value	Rate
3	A	B	C	D = (B − C)	$1/(1 + k + p)^t$	D × (Disc. Factor)	
4	2008*	$0.00	$125,000.00	−$125,000.00	1.00	−$125,000.00	0.02
5	2008	0.00	100,000.00	−100,000.00	0.87	−86,957.00	0.02
6	2009	0.00	90,000.00	−90,000.00	0.76	−68,053.00	0.02
7	2010	50,000.00	0.00	50,000.00	0.66	32,876.00	0.02
8	2011	120,000.00	15,000.00	105,000.00	0.57	60,034.00	0.02
9	2012	115,000.00	0.00	115,000.00	0.50	57,175.00	0.02
10	2013	105,000.00	15,000.00	90,000.00	0.43	38,909.00	0.02
11	2014	97,000.00	0.00	97,000.00	0.38	36,466.00	0.02
12	2015	90,000.00	15,000.00	75,000.00	0.33	24,518.00	0.02
13	2016	82,000.00	0.00	82,000.00	0.28	23,310.00	0.02
14	2017	65,000.00	0.00	65,000.00	0.25	16,067.00	0.02
15	2017	35,000.00		35,000.00	0.25	8,651.00	0.02
16							
17	**Total**	$759,000.00	$360,000.00	$399,000.00		$17,997.00	
18							
19		* t = 0 at the beginning of 2008					
20							
21	**Formulae**						
22	**Cell D4**		=(B4–C4) copy to D5:D15				
23	**Cell E4**		=1/(1 + 0.13 + 0.02)^0				
24	**Cell E5**		=1/(1 + 0.13 + 0.02)^1				
25	**Cell E6**		=1/(1 + .12 + .02)^(A6 − 2007) copy to E7:E15				
26	**Cell F4**		=D4*E4 copy to F5:F15				
27	**Cell B17**		Sum(B4:B15) copy to C17, D17, F17				
28							
29							

cash flow is about $18,000. The rate of inflation is shown in a separate column because it is another uncertain variable that should be included in the risk analysis.

Assume that the expenditures in this example are fixed by contract with an outside vendor so that there is no uncertainty about the outflows; there is, of course, uncertainty about the inflows. Suppose that the estimated inflows are as shown in Table 1-2 and include a minimum (pessimistic) estimate, a most likely estimate, and a maximum (optimistic) estimate. (In Chapter 5, "Scheduling the Project," we will deal in more detail with the methods and meaning of making such estimates. Shortly, we will deal with the importance of ensuring the honesty of such estimates.) Both the beta and the triangular statistical distributions

Table 1-2 Pessimistic, Most Likely, and Optimistic Estimates for Cash Inflows for PsychoCeramic Sciences, Inc.

	A	B	C	D
1		**Minimum**	**Most Likely**	**Maximum**
2	**Year**	**Inflow**	**Inflow**	**Inflow**
3	2010	$35,000	$50,000	$60,000
4	2011	95,000	120,000	136,000
5	2012	100,000	115,000	125,000
6	2013	88,000	105,000	116,000
7	2014	80,000	97,000	108,000
8	2015	75,000	90,000	100,000
9	2016	67,000	82,000	91,000
10	2017	51,000	65,000	73,000
11	2017	30,000	35,000	38,000
12				
13	**Total**	$621,000	$759,000	$847,000

are well suited for modeling variables with these three parameters, but fitting a beta distribution is complicated and not particularly intuitive. Therefore, we will assume that the triangular distribution will give us a reasonably good fit for the inflow variables.

The hurdle rate of return is typically fixed by the firm, so the only remaining variable is the rate of inflation that is included in finding the discount factor. We have assumed a 2 percent rate of inflation with a normal distribution, plus or minus 1 percent (i.e., ±1 percent represents ±3 standard deviations).

It is important to point out that approaches in which only the most likely estimate of each variable is used are equivalent to assuming that the input data are known with certainty. The major benefit of simulation is that it allows all possible values for each variable to be considered. Just as the distribution of possible values for a variable is a better reflection of reality than the single "most likely" value, the distribution of outcomes developed by simulation is a better forecast of an uncertain future reality than is a forecast of a single outcome. In general, precise forecasts will be "precisely wrong."

Using CB to run a Monte Carlo simulation requires us to define two types of cells in the Excel® spreadsheet. The cells that contain variables or parameters that we make assumptions about are defined as *assumption cells*. For the PsychoCeramic Sciences case, these are the cells in Table 1-1, columns B and G, the inflows and the rate of inflation, respectively. As noted above, we assume that the rate of inflation is normally distributed with a mean of 2 percent and a standard deviation of .33 percent. Likewise, we assume that yearly inflows can be modeled with a triangular distribution.

The cells that contain the outcomes (or results) we are interested in forecasting are called *forecast cells*. In PsychoCeramic's case we want to predict the NPV of the project. Hence, cell F17 in Table 1-1 is defined as a forecast cell. Each forecast cell typically contains a formula that is dependent on one or more of the assumption cells. Simulations may have many assumption and forecast cells, but they must have at least one of each. Before proceeding, open Crystal Ball® and make an Excel® spreadsheet copy of Table 1-1.

To illustrate the process of defining an assumption cell, consider cell B7, the cash inflow estimate for 2010. We can see from Table 1-2 that the minimum expected cash

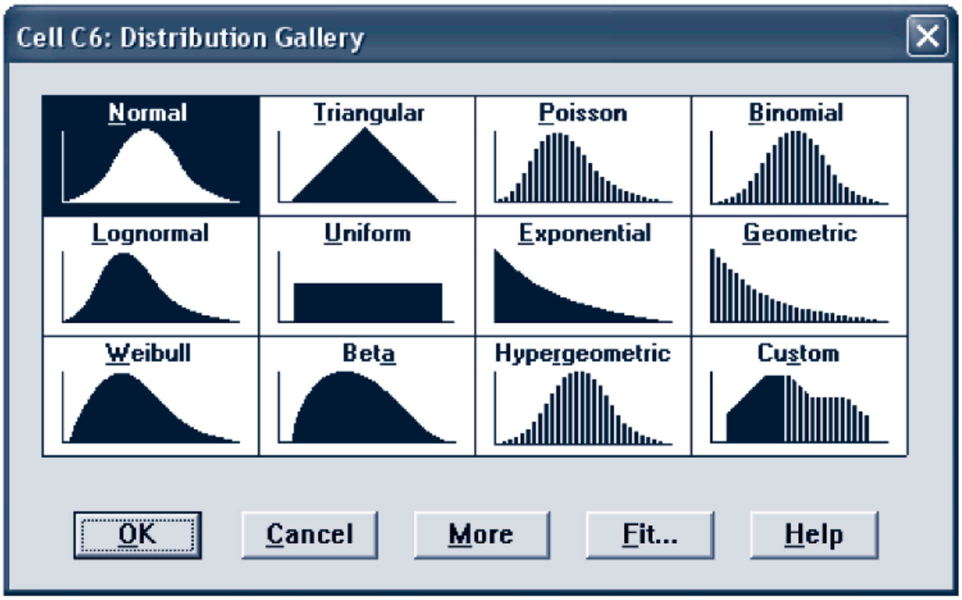


Figure 1-6 Crystal Ball® Distribution Gallery.

inflow is $35,000, the most likely cash flow is $50,000, and the maximum is $60,000. Also remember that we decided to model all these flows with a triangular distribution.

Given the information in Table 1-2, the process of defining the assumption cells and entering the pessimistic and optimistic data is straightforward and involves six steps:*

1. Click on cell **B7** to identify it as the relevant assumption cell.
2. Select the menu option **Cell** at the top of the screen.
3. From the dropdown menu that appears, select **Define Assumption**. CB's **Distribution Gallery** is now displayed as shown in Figure 1-6. (Note: it is important that the cell being defined as an assumption cell contain a numeric value. If the cell is empty or contains a label, an error message will be displayed during this step.)
4. CB allows you to choose from a wide variety of probability distributions. Double-click on the **Triangular** box to select it.
5. CB's Triangular Distribution dialog box is displayed as in Figure 1-7. In the **Assumption Name:** textbox at the top of the dialog box enter a descriptive label, for example, *Cash Inflow 2010*. Then, enter the pessimistic, most likely, and optimistic costs of $35,000, $50,000, and $60,000 in the **Min**, **Likeliest**, and **Max** boxes, respectively.
6. Click on the **OK** button. (When you do this step, note that the inflow in cell B7 automatically changes from the most likely entry, or other number you might have entered, to the *mean* of the triangular distribution which is (Min + Likeliest + Max)/3.

Now repeat steps 1–6 for the remaining cash inflow assumption cells (cells B8:B15). Remember that the proper information to be entered is found in Table 1-2.

* It is generally helpful for the reader to work the problem as we explain it. If Crystal Ball® has been installed on your computer but is not running, select **Tools**, and then **Add-ins** from Excel®'s menu. Next, click on the **CB** checkbox and select **OK**. If the CB Add-In has not been installed on your computer, consult your Excel® manual and the CD-ROM that accompanies this book to install it.

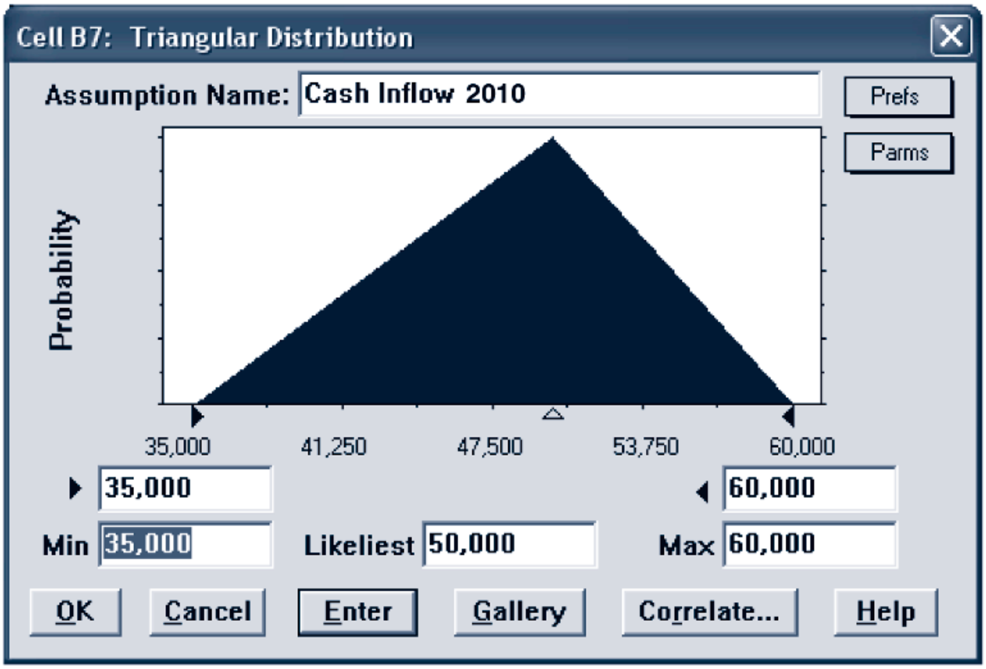


Figure 1-7 Crystal Ball® dialog box for model inputs assuming the triangular distribution.

When finished with the cash inflow cells, assumption cells for the inflation values in column G need to be defined. For these cells select the **Normal** distribution. We decided earlier to use a 2 percent inflation rate, plus or minus 1 percent. Recall that the normal distribution is bell-shaped and that the mean of the distribution is its center point. Also recall that the mean, plus or minus three standard deviations includes 99+ percent of the data. The normal distribution dialog box, Figure 1-8, calls for the distribution's mean and its standard deviation. The mean will be 0.02 (2 percent) for all cells. The standard deviation will be .0033 (one-third of 1 percent). (Note that Figure 1-8 displays only the first two decimal places of the standard deviation. The actual standard deviation of .0033 is used by the program.) As you enter this data you will note that the distribution will show a mean of 2 percent and a range from 1 percent to 3 percent.

Notice that there are two cash inflows for the year 2008, but one of those occurs at the beginning of the year and the other at the end of the year. The entry at the beginning of the year is not discounted so there is no need for an entry in G4. (Some versions of CB insist on an entry, however, so go ahead and enter 2 percent with zero standard deviation.) Move on to cell G5, in the **Assumption Name:** textbox for the cell G5 enter *Inflation Rate*. Then enter .02 in the **Mean** textbox and .0033 in the **Std Dev** textbox. While the rate of inflation could be entered in a similar fashion for the following years, a more efficient approach is to copy the assumption cell G5 to G6:G14. Since CB is an add-in to Excel®, simply using Excel®'s copy and paste commands will not work. Rather, CB's own copy and paste commands must be used to copy the information contained in both assumption and forecast cells. The following steps are required:

1. Place the cursor on cell **G5**.
2. Enter the command **Cell**, then click on **Copy Data**.
3. Highlight the range **G6:G14**.
4. Enter the command **Cell**, then **Paste Data**.

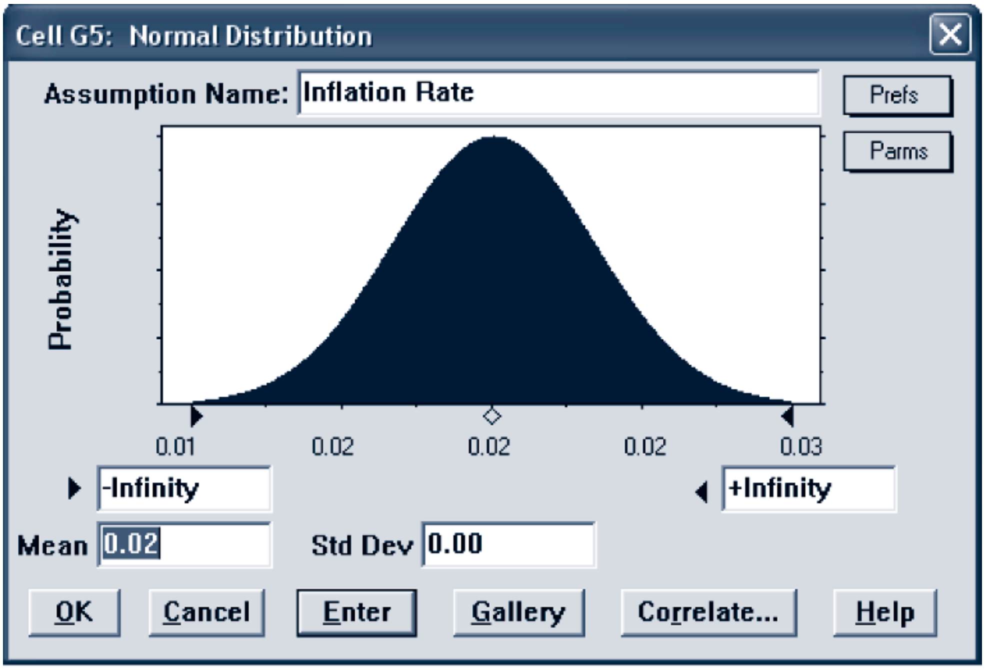


Figure 1-8 Crystal Ball® dialog box for model inputs assuming the normal distribution.

Note that the year 2017 has two cash inflows, both occurring at the end of the year.

Because we don't want to generate two different rates of inflation for 2017, the value generated in cell G14 will be used for both 2017 entries. In cell G15 simply enter **=G14**.*

Now we consider the forecast or outcome cell. In this example we wish to find the net present value of the cash flows we have estimated. The process of defining a forecast cell involves five steps.

1. Click on the cell **F17** to identify it as containing an outcome that interests us.
2. Select the menu option **Cell** at the top of the screen.
3. From the dropdown menu that appears, select **Define Forecast** . . .
4. CB's Define Forecast dialog box is now displayed. In the **Forecast Name**: textbox, enter a descriptive name such as *Net Present Value of Project*. Then enter a descriptive label such as *Dollars* in the **Units**: textbox.
5. Click **OK**. There is only one Forecast cell in this example, but in other situations there may be several. Use the same five steps to define each of them.

When you have completed all entries, what was Table 1-1 is now changed and appears as Table 1-3.

We are ready to simulate. CB randomly selects a value for each assumption cell based on the probability distributions which we specified and then calculates the net present value of the cell values selected. By repeating this process many times, we can get a sense of the distribution of possible outcomes.

To simulate the model you have constructed 1000 times, select the **Run** menu item from the toolbar at the top of the page. In the dropdown box that appears, select **Run**

* You may wonder why we spend time with this kind of detail. The reason is simple. Once you have dealt with this kind of problem, and it is common in such analyses, you won't make this mistake in the real world where having such errors called to your attention may be quite painful.

Table 1-3 Three-Point Estimate of Cash Flows and Inflation Rate for PsychoCeramic Sciences, Inc. All Assumption and Forecast Cells Defined

	A	B	C	D	E	F	G
1					Discount	Net Present	Inflation
2	Year	Inflow	Outflow	Net Flow	Factor	Value	Rate
3	A	B	C	D = (B − C)	$1/(1 + k + p)^t$	D × (Disc. Factor)	
4	2008*	$0	$125,000	($125,000)	1	($125,000)	0.02
5	2008	0	100,000	(100,000)	0.8696	(86,957)	0.02
6	2009	0	90,000	(90,000)	0.7561	(68,053)	0.02
7	2010	48,333	0	48,333	0.6575	31,780	0.02
8	2011	117,000	15,000	102,000	0.5718	58,319	0.02
9	2012	113,333	0	113,333	0.4972	56,347	0.02
10	2013	103,000	15,000	88,000	0.4323	38,045	0.02
11	2014	95,000	0	95,000	0.3759	35,714	0.02
12	2015	88,333	15,000	73,333	0.3269	23,973	0.02
13	2016	80,000	0	80,000	0.2843	22,741	0.02
14	2017	63,000	0	63,000	0.2472	15,573	0.02
15	2017	34,333		34,333	0.2472	8,487	
16							
17	**Total**	$742,333	$360,000	$382,333		$10,968	
18							
19		*t = 0 at the beginning of 2008					
20							
21	**Formulae**						
22	**Cell D4**		=(B4–C4) copy to D5:D15				
23	**Cell E4**		=1/(1 + .13 + G4)^0				
24	**Cell E5**		=1/(1 + .13 + G5)^1				
25	**Cell E6**		=1(1 + .13 + G6)^(A6 − 2008) copy to E7:E15				
26	**Cell F4**		=D4*E4 copy to F5:F15				
27	**Cell B17**		Sum(B4:B15) copy to C17, D17, F17				
28							

Preferences. In the Run Preferences dialog box that appears, enter **1,000** in the **Maximum Number of Trials** textbox and then click **OK**. To perform the simulation, select the **Run** menu item again and then **Run** from the dropdown menu. CB summarizes the results of the simulation in the form of a frequency chart that changes as the simulations are executed. See the results of one such run in Figure 1-9.

The frequency chart in Figure 1-9 is sometimes referred to as a risk profile. While in this particular case our best guess of the NPV for this project would be perhaps $11,000, we see that there is considerable uncertainty associated with the project. For example, the frequency diagram shows the project could yield a NPV below −$9,000. At the same time, we see that this same project could yield a NPV in excess of $30,000. As you can

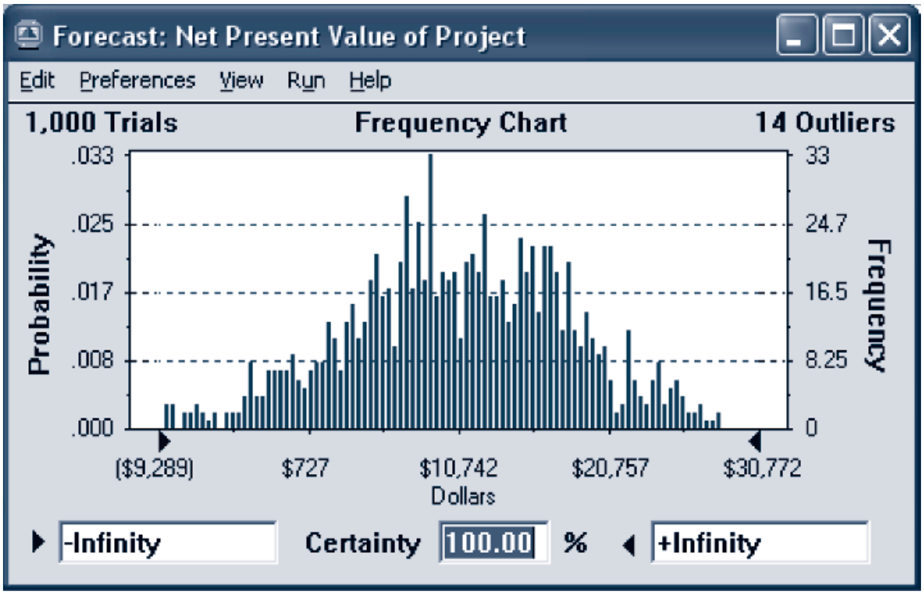
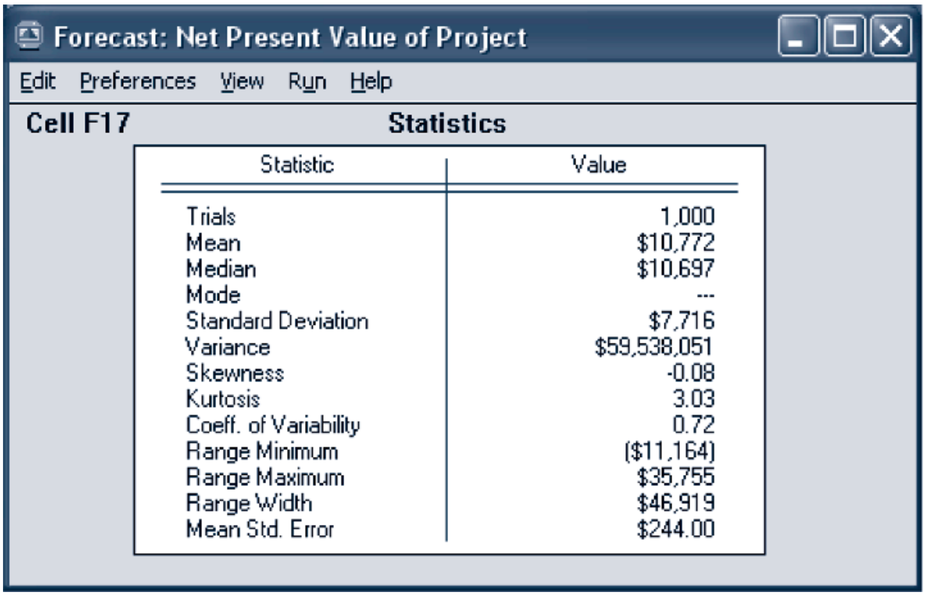


Figure 1-9 Frequency chart of the simulation output for net present value of Psycho-Ceramic Sciences, Inc. Project.

see, the amount of uncertainty increases as the width or range of the values in the frequency diagram increases. In other words, there would be less uncertainty in the NPV of this project if the range of outcomes had been $2,000–$15,000 as opposed to the range shown in the chart that goes from −9,289 to $30,772. And as we have stated before, as the level of uncertainty increases, so does the risk.

CB provides considerable information about the forecast cell in addition to the frequency chart including percentile information, summary statistics, a cumulative chart, and a reverse cumulative chart. For example, to see the summary statistics for a forecast cell, select **View** from the Forecast dialogue box toolbar and then select **Statistics** from the dropdown menu that appears. The Statistics view for the frequency chart (Figure 1-9) is illustrated in Figure 1-10.



Statistic	Value
Trials	1,000
Mean	$10,772
Median	$10,697
Mode	---
Standard Deviation	$7,716
Variance	$59,538,051
Skewness	-0.08
Kurtosis	3.03
Coeff. of Variability	0.72
Range Minimum	($11,164)
Range Maximum	$35,755
Range Width	$46,919
Mean Std. Error	$244.00

Figure 1-10 Summary statistics of the PsychoCeramic Sciences, Inc. simulation.

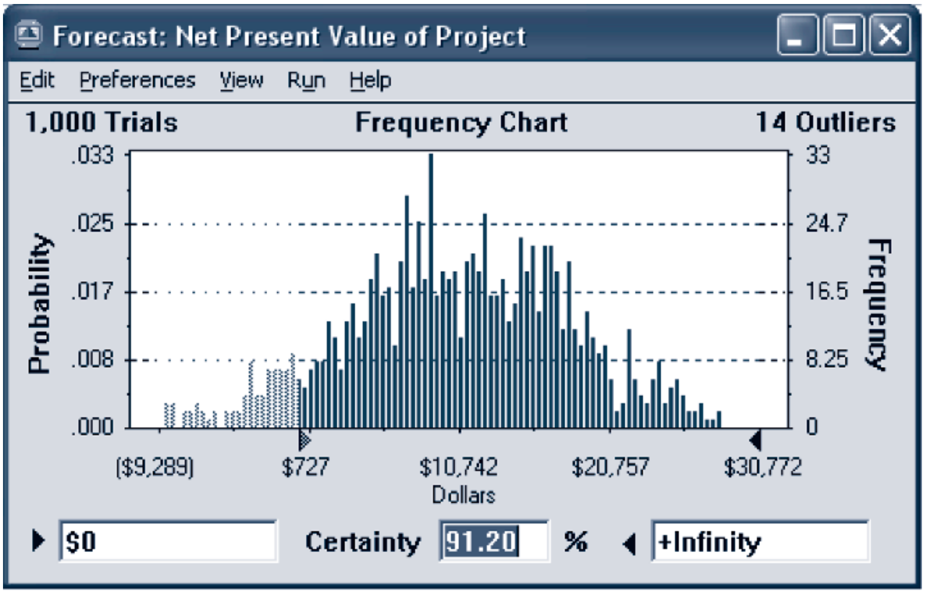


Figure 1-11 Calculating the probability that the net present value of the PsychoCeramic Sciences, Inc. project is equal to or greater than the firm's hurdle rate.

Figure 1-10 contains some interesting information. Both the mean and median NPV resulting from the simulation are nicely positive and thus indicate a return above the hurdle rate of 13 percent (15 percent including inflation). There are, however, several negative outcomes, those showing a return below the hurdle rate. What is the likelihood that this project will achieve a positive NPV, and therefore produce a rate of return at or above the hurdle rate? With CB, the answer is easy. Using the display shown in Figure 1-9, erase –*Infinity* from the box in the lower left corner. Type **0** (or *1*) in that box and press **Enter**. Figure 1-9 now changes as shown in Figure 1-11. The boxes at the bottom of Figure 1-11 show that given our estimates and assumptions of the cash flows and the rate of inflation, there is a .90+ probability that the project will have an NPV between zero and infinity, that is, a rate of return at or above the 13 percent hurdle rate.

Even in this simple example the power of including uncertainty in project selection should be obvious. Because a manager is always uncertain about the amount of uncertainty, it is also possible to examine various levels of uncertainty quite easily using CB. We could, for instance, alter the degree to which the inflow estimates are uncertain by expanding or contracting the degree to which optimistic and pessimistic estimates vary around the most likely estimate. We could increase or decrease the level of inflation. Simulation runs made with these changes provide us with the ability to examine just how sensitive the outcomes (forecasts) are to possible errors in the input data. This allows us to focus on the important risks and to ignore those that have little effect on our decisions. We strongly recommend the User Manual for users of CB (*Crystal Ball*® 2007 User Manual, 2005).

Considering Disaster

In our consideration of risk management in the PsychoCeramic Sciences example, we based our analysis on an "expected value" approach to risk. The expected cost of a risk is the estimated cost of the risk if it does occur times the probability that it will occur (see Section 4.4, for another example). How should we consider an event that may have an extraordinarily high cost if it occurs, but has a very low probability of occurring? Examples come readily to mind: the World Trade Center destruction of 9/11, Hurricane Katrina, the New England floods of 2007, deadly poison in pet food. The probability of such events occurring is so low that their expected value may be much less than some comparatively minor misfortunes with a far higher probability of happening.

If you are operating a business that uses a "just in time" input inventory system, how do you feel about a major fire at the plant of your sole supplier of a critical input to your product? The supplier reports that his (or her) plant has never had a major fire, and has the latest in fire prevention equipment. Does that mean that a major plant fire is impossible? Might some other disaster close the plant—a strike, an al Qaida bomb. Insurance comes immediately to mind, but getting a monetary payback is of little use when you are concerned with the loss of your customer base or the death of your firm.

In an excellent book, *The Resilient Enterprise*, Yossi Sheffi (Sheffi, 2005) deals with the risk management of many different types of disasters. It details the methods that creative businesses have used to cope with disasters that struck their facilities, supply chains, customers, and threatened the future of their firms. The subject is more complex that we can deal with in these pages, but we strongly recommend the book, a "good read" to use a reviewer's cliché.

1.7 THE PROJECT PORTFOLIO PROCESS

The Project Portfolio Process (PPP) attempts to link the organization's projects directly to the goals and strategy of the organization. This occurs not only in the project's initiation and planning phases, but also throughout the life cycle of the projects as they are managed and eventually brought to completion. Thus, the PPP is also a means for monitoring and controlling the organization's strategic projects as will be reiterated in Chapter 7: monitoring and controlling the project. On occasion this will mean shutting down projects prior to their completion because their risks have become excessive, their costs have escalated beyond their expected benefits, another (or a new) project does a better job of supporting the goals, or any of a variety of similar reasons. The steps in this process generally follow those described in Longman, Sandahl, and Speir (1999) and Englund and Graham (2000).

Step 1: Establish a Project Council

The main purpose of the project council is to establish and articulate a strategic direction for projects. The council will also be responsible for allocating funds to those projects that support the organization's goals and controlling the allocation of resources and skills to the projects. In addition to senior management, other appropriate members of the project council include: project managers of major projects; the head of the Project Management Office (if one exists); particularly relevant general managers, that is, those who can identify key opportunities and risks facing the organization; and finally, those who can derail the progress of the PPP later in the process.

Step 2: Identify Project Categories and Criteria

In this step, various project categories are identified so the mix of projects funded by the organization will be spread appropriately across those areas making major contributions to the organization's goals. In addition, within each category criteria are established to

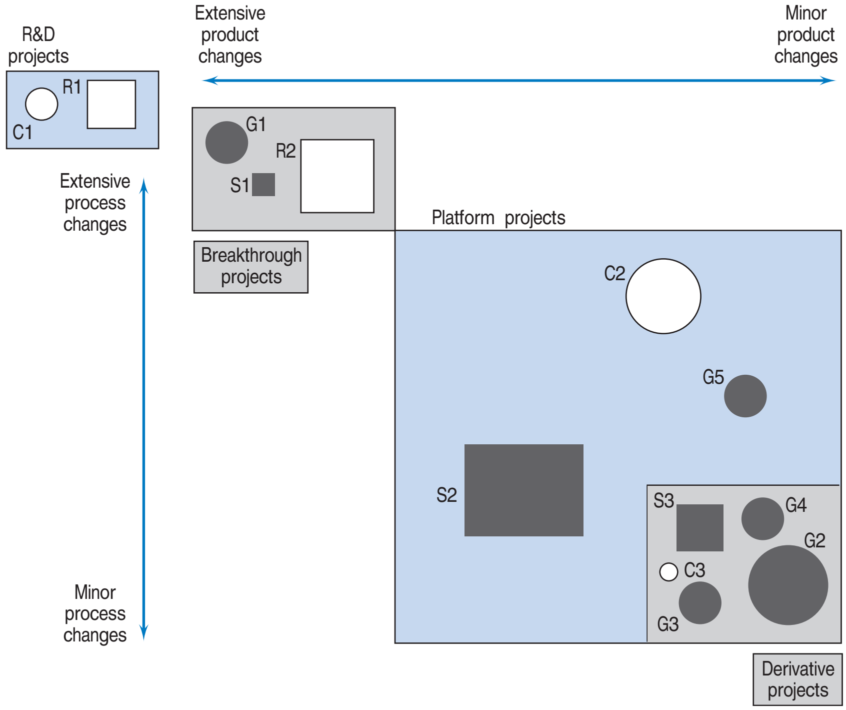


Figure 1-12 An example aggregate project plan.

discriminate between very good and even better projects. The criteria are also weighted to reflect their relative importance.

The first task in this step is to list the goals of each existing and proposed project—that is, the mission, or purpose, of each project. Relating these to the organization's goals and strategies should allow the council to identify a variety of categories that are important to achieving the organization's goals. One way to position many of the projects (particularly product/service development projects) is in terms of the extent of product and process changes. Wheelwright and Clark (1992) have developed a matrix called the *aggregate project plan* illustrating these changes, as shown in Figure 1-12. Based on the extent of product change and process change, they identified four separate categories of projects:

1. ***Derivative projects*** These are projects with objectives or deliverables that are only incrementally different in both product and process from existing offerings. They are often meant to replace current offerings or add an extension to current offerings (lower priced version, upscale version).
2. ***Platform projects*** The planned outputs of these projects represent major departures from existing offerings in terms of either the product/service itself or the process used to make and deliver it, or both. As such, they become "platforms" for the next generation of organizational offerings, such as a new model of automobile or a new type of insurance plan. They form the basis for follow-on derivative projects that attempt to extend the platform in various dimensions.
3. ***Breakthrough projects*** Breakthrough projects typically involve a newer technology than platform projects. It may be a "disruptive" technology that is known to the industry or something proprietary that the organization has been developing over time. Examples here include the use of fiber-optic cables for data transmission, cash-balance pension plans, and hybrid gasoline-electric automobiles.

4. ***R&D projects*** These projects are "blue-sky," visionary endeavors, oriented toward using newly developed technologies, or existing technologies in a new manner. They may also be for acquiring new knowledge, or developing new technologies themselves.

The size of the projects plotted on the array indicates the size/resource needs of the project, and the shape may indicate another aspect of the project (for example, internal/external, long/medium/short term, or whatever aspect needs to be shown). The numbers indicate the order, or time frame, in which the projects are to be (or were) implemented, separated by category, if desired.

The aggregate project plan can be used to:

- View the mix of projects within each illustrated aspect (shape)
- Analyze and adjust the mix of projects within each category or aspect
- Assess the resource demands on the organization, indicated by the size, timing, and number of projects shown
- Identify and adjust the gaps in the categories, aspects, sizes, and timing of the projects
- Identify potential career paths for developing project managers, such as team members of a derivative project, then team member of a platform project, manager of a derivative project, member of a breakthrough project, and so on

Step 3: Collect Project Data

For each existing and proposed project, assemble the data appropriate to that category's criteria. Include the timing, both date and duration, for expected benefits and resource needs. Use the project plan, a schedule of project activities, past experience, expert opinion, whatever is available to get a good estimate of these data. If the project is new, you may want to fund only enough work on the project to verify the assumptions.

Next, use the criteria score limits, or constraints as described in our discussions of scoring models, to screen out the weaker projects. For example, have costs on existing projects escalated beyond the project's expected benefits? Has the benefit of a project lessened because the organization's goals have changed? Also, screen *in* any projects that do not require deliberation, such as projects mandated by regulations or laws, projects that are competitive or operating necessities (described above), projects required for environmental or personnel reasons, and so on. The fewer projects that need to be compared and analyzed, the easier the work of the council.

Step 4: Assess Resource Availability

Next, assess the availability of both internal and external resources, by type, department, and timing. Note that labor availability should be estimated conservatively. Timing is particularly important, since project resource needs by type typically vary up to 100 percent over the life cycle of projects. Needing a normally plentiful resource at the same moment it is fully utilized elsewhere may doom an otherwise promising project. Eventually, the council will be trying to balance aggregate project resource needs over future periods with resource availabilities so timing is as important as the amount of maximum demand and availability. Many managers insist on trying to schedule resource usage as closely as possible to system capacity. This is almost certain to produce catastrophe (see Chapter 6, Section 6.3, subsection on Resource Loading/Leveling and Uncertainty).

Step 5: Reduce the Project and Criteria Set

In this step, multiple screens are employed to reduce the number of competing projects. As noted earlier, the first screen is each project's support of the organization's goals. Other possible screens might be criteria such as:

- Whether the required competence exists in the organization
- Whether there is a market for the offering
- The likely profitability of the offering
- How risky the project is
- If there is a potential partner to help with the project
- If the right resources are available at the right times
- If the project is a good technological/knowledge fit with the organization
- If the project uses the organizations strengths, or depends on its weaknesses
- If the project is synergistic with other important projects
- If the project is dominated by another existing or proposed project
- If the project has slipped in its desirability since the last evaluation.

Step 6: Prioritize the Projects within Categories

Apply the scores and criterion weights to rank the projects within each category. It is acceptable to hold some hard-to-measure criteria out for subjective evaluation, such as riskiness, or development of new knowledge. Subjective evaluations can be translated from verbal to numeric terms easily by the Delphi (Dalkey, 1969), pairwise comparisons, or other methods.

It is also possible at this time for the council to summarize the "returns" from the projects to the organization. This, however, should be done by category, not for each project individually since different projects are offering different packages of benefits that are not comparable. For example, R&D projects will not have the expected monetary return of derivative projects; yet it would be foolish to eliminate them simply because they do not measure up on this (irrelevant, for this category) criterion.

Step 7: Select the Projects to be Funded and Held in Reserve

The first task in this step is to determine the mix of projects across the various categories (and aspects, if used) and time periods. Next, be sure to leave some percent (the common 10–15 percent is often insufficient) of the organization's resource capacity free for new opportunities, crises in existing projects, errors in estimates, and so on. Then allocate the categorized projects in rank order to the categories according to the mix desired. It is usually good practice to include some speculative projects in each category to allow future options, knowledge improvement, additional experience in new areas, and so on. The focus should be on committing to fewer projects but with sufficient funding to allow project completion. Document why late projects were delayed and why any were defunded.

Step 8: Implement the Process

The first task in this final step is to make the results of the PPP widely known, including the documented reasons for project cancellations, deferrals, and nonselection as was mentioned earlier. Top management must now make their commitment to this project portfolio process totally clear by supporting the process and its results. This may require a

PPP champion near the top of the organization. As project proposers come to understand and appreciate the workings and importance of the PPP, their proposals will more closely fit the profile of the kinds of projects the organization wishes to fund. As this happens, it is important to note that the council will have to concern itself with the reliability and accuracy of proposals competing for limited funds. Senior management must fully fund the selected projects. It is unethical and inappropriate for senior management to undermine PPP and the council as well as strategically important projects by playing a game of arbitrarily cutting *X* percent from project budgets. It is equally unethical and inappropriate to pad potential project budgets on the expectation that they will be arbitrarily cut.

Finally, the process must be repeated on a regular basis. The council should determine the frequency, which to some extent will depend on the speed of change within the organization's industry. For some industries, quarterly analysis may be best, while in slow-moving industries yearly may be fine.

> Projects are often subdivisions of major programs. Long-run success is determined by the organization's portfolio of projects. Classified by the extent of innovation in product and process, there are four types of projects: derivative, breakthrough, platform, and R&D projects. The actual mix of projects is a direct expression of the organization's competitive strategy. A proper mix of project categories can help ensure its long-run competitive position.

1.8 THE MATERIALS IN THIS TEXT

When reading a text, it is helpful to understand how the book is organized and where it will take the reader. Following this introductory chapter, our attention goes to the various roles the PM must play and the ways projects are organized. Chapter 2 focuses on the behavioral and structural aspects of projects and their management. It describes the PM's roles as communicator, negotiator, and manager. It also includes a discussion of project management as a profession and reports briefly on the Project Management Institute (PMI), the PM's professional organization. Then attention turns to the ways in which projects can be organized within the parent establishment. *Matrix organization* is discussed at length as are the conflicts and managerial problems that matrix organizations tend to foster. Finally, the chapter moves to the *project team*: its purposes and the widespread use of transdisciplinary teams. Using transdisciplinary teams to plan and carry out the project is a source of both creativity and conflict. The process of building effective teams is briefly covered.

The remainder of the book is designed to conform to the life cycle of any project, whatever the shape of the life cycle curve. Chapter 3 covers the process of *planning and launching the project*, construction of the *work breakdown structure* (WBS), and *responsibility charts*. These activities require the project team to estimate resource and time requirements for accomplishing what the project plan has described. Chapter 4 not only discusses the construction of a *project budget*, it also presents a method of improving one's estimating skills. Because any estimate is a forecast, the allied subject of risk management is introduced.

Chapter 5 covers scheduling, the Program Evaluation Review Technique (PERT), the Critical Path Method (CPM), and Gantt charts, the most common ways of illustrating the *project schedule*. Schedules will be calculated under conditions of uncertainty in two ways: (1) using standard probability theory, and (2) using simulation. In Chapter 6, *resource allocation* is discussed. To begin, we consider the problem of *crashing* a project, i.e., using additional resources in order to shorten project duration. Then we deal with two fundamental problems of resource management. First, a schedule of resource usage must be prepared (a.k.a., *resource loading*). Second, we adjust the resource loads to avoid gluts and shortages of valuable resources, (a.k.a., *resource leveling*). The problems of resource usage when there are multiple projects competing for a limited resource pool are then covered, as are ways of dealing with these problems. The chapter ends with a discussion of Goldratt's *Critical Chain* (1997).

The subjects of Chapter 7 are monitoring and controlling projects. The nature of project data collection is explained and various types of project reports, including *earned value reports*, are illustrated and discussed. Following this, we cover the general purposes and mechanisms for project control. The chapter ends with a section devoted to the *control of change* on a project. It is here that we discuss "*scope creep*" and how to control it.

Chapter 8 deals with *evaluating*, *auditing*, and *terminating* projects. The project team often fears evaluation and auditing. Team members usually equate these activities with fault finding, but when correctly used they are valuable aids for the PM and team. Project termination is usually ignored or treated as a trivial problem in practice—and in most works on project management. We feel it is an important and complex process that may cause serious problems if not handled properly.

Throughout this book there are illustrations of the tools and reports used by project managers. Many of these were produced using Microsoft Project® (MSP), Crystal Ball® (CB), and Excel® (All illustrations and applications generated by MSP, CB, and Excel®, or any other application software will be clearly identified.) There are a large number of spreadsheets and literally hundreds of project management software packages on the market. Most of them perform with reasonable competence in the tasks for which they were designed. Of the packages intended for overall project management, MSP is by far the favorite with roughly half the total market. There are also a large number of specialized software packages, for example, report generators, and special risk management packages. Most are compatible with MSP or Excel®, often seamlessly so, and we mention some of them when relevant. In the past decade or two, spreadsheet software has become highly sophisticated. Excel®, for example, can perform simulations and statistical analysis as well as handle the usual arithmetic, accounting, and financial calculations.

When one reads the literature of project management, one sees much about *risk management*. Too often, it may seem to the reader that risk management is a highly specific task. It isn't. Risk management is a reference to a class of ideas, methods, and techniques that aids the management of projects being carried out in an uncertain world. Outside factors can affect projects in a wide variety of ways and so our discussions of risk management cannot be restricted to a chapter on the subject. They appear throughout the book. Tools and techniques are introduced as they are needed to deal with specific problems. The reader should note that these tools have wide application beyond project management and most are valuable for the general manager as well as the PM.

With this introduction, let us begin our study of project management.

REVIEW QUESTIONS

1. Use the characteristics of a project to differentiate it from a nonproject.
2. Contrast win-lose negotiation with win-win negotiation and explain why the latter is so important in project management.
3. Identify the three goals of a project and describe how the project manager achieves them. What does it mean for a project to be "overdetermined?"
4. Contrast the two types of project life cycles and discuss why it is important to know which type the current project is following.
5. How does the weighted scoring approach avoid the drawbacks of the NPV approach? Can the two approaches be combined? How? What weights would be appropriate if they were combined?

6. What advantages are lost if the sum of the weights in a weighted scoring approach does not add to 1.0? Why is it suggested that factors with less than 2 percent or 3 percent impact not be considered in this approach?
7. Draw a distinction between a project and a program. Why is the distinction important?
8. Why is it important for a project to have "flexibility"?
9. Why are R&D projects in a company's Aggregate Project Plan significantly different in type from the firm's Derivative, Breakthrough, and Platform projects?

DISCUSSION QUESTIONS

10. Contrast the three types of nonnumeric project selection methods. Could any specific case combine two of them, such as the sacred cow and the operating necessity, or the comparative benefits and the competitive necessity?
11. What errors in a firm's project portfolio might the Wheelwright and Clark aggregate project plan graphically identify?
12. You are the project manager of a team of software specialists working on a project to produce a piece of application software in the field of project management. Give some examples of things that might go wrong on such a project and the sorts of trade-offs you might have to make.
13. In Figure 1-12, what distribution of large and small circles and squares across the four boxes would characterize a strong, well-positioned product development business? A weak business?
14. Give several examples of projects found in your city, region, or country—avoiding those used as examples in the chapter.
15. For each of the projects identified in the answer to Question 14, is the life cycle for the project S-shaped or J-shaped?
16. Construct a list of factors, conditions, and circumstances you think might be important for a manufacturing firm to evaluate during the project selection process. Do the same for a computer repair shop.
17. How might you use project management for doing a major school work assignment?

PROBLEMS

18. A four-year financial project is forecast to have net cash inflows of $20,000; $25,000; $30,000; and $50,000 in the next four years. It will cost $75,000 to implement the project payable at the beginning of the project. If the required rate of return is 0.2, conduct a discounted cash flow calculation to determine the NPV.
19. In the project described in Problem 18, assume that the net cash inflows are probabilistic variables. Further assume that each forecast net cash inflow is normally distributed with standard deviations of $1,000, $1,500, $2,000, and $3,500, respectively. Given a required rate of return of 0.2, find the mean forecast NPV using Crystal Ball®. What is the probability that the actual NPV will be positive?
20. What would happen to the NPV of the above project if the inflation rate was expected to be 4 percent in each of the next four years? You may use either Excel® or CB to determine your answer.
21. Use a weighted scoring model to choose between three locations (A, B, C) for setting up a factory. The relative weights for each criterion are shown in the following table. A score of 1 represents unfavorable, 2 satisfactory, and 3 favorable.

		Location		
Category	**Weight**	**A**	**B**	**C**
Labor costs	20	1	2	3
Labor productivity	20	2	3	1
Labor supply	10	2	1	3
Union relations	10	3	3	2
Material supply	10	2	1	1
Transport costs	25	1	2	3
Infrastructure	5	2	2	2

22. Using a spreadsheet for Problem 21, find the following:
    (a) What would be your recommendation if the weight for the transportation cost went down to 10 and the weight for union relations went up to 25?
    (b) Suppose location A received a score of 3 for transport cost and location C received a score of 2

for transport cost. Would your recommendation change under these circumstances?

(c) The VP of Finance has looked at your scoring model and feels that tax considerations should be included in the model with a weight of 15. In addition, the VP has scored the locations on tax considerations as follows: A-3, B-2, and C-1. How does this affect your recommendation?

23. Nina is trying to decide in which of four shopping centers to locate her new boutique. Some cater to a higher class of clientele than others, some are in an indoor mall, some have a much greater volume than others, and, of course, rent varies considerably. Because of the nature of her store, she has decided that the class of clientele is the most important consideration. Following this, however, she must pay attention to her expenses, and rent is a major item—probably 90 percent as important as clientele. An indoor, temperature-controlled mall is a big help for stores such as hers where 70 percent of sales are from passersby slowly strolling and window shopping. Thus, she rates this as about 95 percent as important as rent. Last, a higher volume of shoppers means more potential sales; she thus rates this factor as 80 percent as important as rent.

As an aid in visualizing her location alternatives, she has constructed the following table. A "good" is scored as 3, "fair" as 2, and "poor" as 1. Use a weighted score model to help Nina come to a decision.

	Location			
	1	**2**	**3**	**4**
Class of clientele	fair	good	poor	good
Rent	good	fair	poor	good
Indoor mall	good	poor	good	poor
Volume	good	fair	good	poor

24. Using a spreadsheet for Problem 23, determine how Nina's ability to negotiate a lower rent at location 3, thereby raising its ranking to "good," will affect the overall rankings of the four locations.

25. Information about the cash flows for a four-year financial project are listed in the following table. The cash flows are assumed to follow a triangular distribution. The cost of implementing the project is expected to be between $60,000 and $70,000, with all values in this range being equally likely. Analysis of changes in the Consumer Price Index suggests that the annual rate of inflation can be approximated with a normal distribution with a mean of 4 percent and standard deviation of 1.5 percent. The organization's required rate of return is 20 percent. Develop a model in CB to analyze this situation and answer the following questions.

Year	Minimum Inflow	Most Likely Inflow	Maximum Inflow
1	$15,000	$20,000	$30,000
2	$20,000	$25,000	$35,000
3	$20,000	$30,000	$35,000
4	$40,000	$50,000	$60,000

(a) What is the expected NPV of this project?
(b) What is the range of NPVs?
(c) How would you characterize the level of risk associated with this project?
(d) Would you recommend undertaking the project? Why or why not?

26. Server Farm Inc. (SFI) needs to upgrade its server computers. Company management has identified the following two options: (1) shift to a Windows-based platform from its current Unix-based platform, or (2) stick with a Unix-based platform. It is standard practice at SFI to use a triangular distribution to model uncertain costs.

Along these lines, the company estimates that if it migrates to Windows, the new server hardware could cost as little as $100,000 or as much as $200,000. The technical group's best estimate is that the hardware costs will be $125,000 if the Window's option is pursued. Likewise, the company's best guess regarding the cost to upgrade and convert its software to Windows is $300,000 with a range of $275,000 to $500,000. Finally, if the company converts to Windows, employee training costs are estimated to range between $9,000 and $15,000, with the best guess being $10,000. If the company sticks with Unix, the new server hardware will most likely cost $100,000, but could cost as little as $80,000 or as much as $210,000. Software conversion and upgrade costs are expected to be $300,000 but could be as low as $250,000 and as high as $525,000. Employee training costs should fall between $8,000 and $17,500 with a best guess of $10,000. Develop a model to simulate this situation using CB and answer the following questions.

(a) What is the expected cost of each project?
(b) What is the probability that each project's cost will exceed $575,000?
(c) Which project would you consider to be the most risky?
(d) Which project would you recommend SFI undertake? Why?

INCIDENT FOR DISCUSSION

Broken Welds

A manufacturer of mountain bicycles designed an automated system for welding bike frames. For three years, the system worked nicely, handling about 1000 frames per shift. Production was scheduled for two shifts per day. The system was designed to weld the frame and then to check the quality of each weld. The welded frames were then transported to another plant for assembly.

Recently, a few of the frames had failed. Careful testing showed that a foreign substance in the welding rod purchased from an outside vendor possibly contributed to the failure. When checked, however, the rods conformed to the specifications given to the Purchasing Department and guaranteed by the vendor. The Chief Engineer ordered the Production Department's Project Leader, Alison Passette, to create a project immediately to find out precisely what was causing the failures and to find a way to solve the problem. This project was to take priority over all other projects in the department.

Alison was familiar with the Chief Engineer's tendency to overreact to any glitches in the production process, so she decided to determine the impact of the proposed project on all the other projects in the department. She also discussed the problem with Ken Kelsey, one of her welding experts, who felt sure he could solve the welding problems by determining what foreign substance, if any, caused the problem. He could then set up a system to detect the presence of the substance and reweld the affected frames. Of course, he added, they would also have to change their specifications for the welding rod to eliminate the chemical responsible for the failures.

Questions: What information does Alison need to determine the probable impact of Kelsey's proposed project on the other projects in the department? Should her findings affect her decision about Kelsey's project? How?

C A S E

United Screen Printers

United Screen Printers (USP) produces a wide range of decals for displaying promotional messages on fleet vehicles (including delivery vans, eighteen-wheelers and aircraft). Its decals range from flat-color designs to full-color photographic reproductions.

Although it is one of the oldest forms of printing, screen printing is superior to most of the more modern approaches because it permits making heavier deposits of ink onto a surface resulting in more vibrant and longer lasting finishes. Screen printing works by blocking out areas on a silk screen so that ink passes through only the unblocked areas to make an impression on the vinyl decal.

Many in the industry believe that the economics of fleet graphics makes them an extremely attractive form of advertising and should lead to their continued penetration of a largely untapped market. One industry source estimated that the cost of fleet graphics works out to be $2.84 per 1,000,000 visual impressions. Given the highly cost effective nature of using fleet graphics as a form of advertising, it is speculated that organizations will increasingly exploit this form of advertising. In addition, as organizations become better aware of this advertising medium, it is likely they will want to change their message more frequently. According to managers at USP, this may be one of the major factors that is apparently driving the competition to focus more on short leadtimes and prices, and less on decal durability.

USP is about to begin its annual evaluation of proposed projects. Six projects have been proposed as described below.

1. *Purchase new large press.* There is currently a three-and-half to four-week backlog in the screen printing department. The result of this is that USP's total leadtime is 4 to 6 weeks in comparison to an industry average leadtime of 3.5 to 4 weeks. In a typical month, USP ships 13 percent of its orders early, 38 percent on-time, and 49 percent late. It has been estimated that 75 percent of the backlog is waiting for press 6, the largest press in the shop. Furthermore, press 6 is in dire need of replacement parts but USP has been unable thus far to locate a source for these parts. Given the problem of finding replacement parts and the fact that the press is somewhat outdated, this proposal calls for purchasing a new large press for $160,000. Based on estimates that a new large press could process jobs 50 percent to 100 percent faster than press 6, it is calculated that the payback period for a new large press would be one year.
2. *Build new headquarters.* USP's CEO fervently believes that the company needs to have a strong corporate identity. He therefore purchased land and had

plans drawn up for the construction of a new corporate headquarters. Analysis of the new headquarters indicated that although it would improve operating efficiencies, the savings generated would not pay for the new building (estimated to cost $4 million). Many of the board members viewed the project as too risky since it would increase the company's debt as a percent of capital from almost zero to 50 percent.

3. *Pursue ISO 9000 certification*. This proposal also comes from USP's CEO. ISO 9000 is a set of standards that provides customers with some assurance that a supplier follows accepted business practices. In some industries obtaining ISO 9000 certification is essential, such as in industries that export to Europe and the domestic automobile industry. It was less clear what competitive advantage pursuing ISO 9000 would provide USP at this time. On the other hand, the process alone would help it document and perhaps improve its processes. The cost of this initiative was estimated to be $250,000 to $300,000 and would take one year to complete.
4. *Develop formal procedure for mixing inks*. This proposal comes from USP's plant manager. At present, mixing inks is a highly specialized skill that consumes 2–3 hours of the team leader's time each day. This project would focus on developing ink formulas to make the task of mixing inks more routine, and less specialized and subjective. The team leader is paid $25,000 annually. The cost of pursuing this project is estimated to be $10,000.
5. *Purchase and install equipment to produce four-color positives in-house*. The lead time to have positives made by an outside supplier is typically one week and costs $1,500 to $6,000. According to this proposal, the cost of purchasing the equipment to produce four-color positives in-house would be approximately $150,000 plus $25,000 for installation and training. The variable costs of producing positives in house are estimated to be $375 per job. If produced in-house, the leadtime for the four-color positives would be approximately an hour-and-a-half.
6. *Purchase inkjet printers*. An alternative to purchasing a new screen printing press is to add capacity based on newer technology. Given the inkjet's production rate, six inkjet printers at a cost of $140,000 would be needed to provide the equivalent capacity of a new large screen printing press. The major disadvantage of the inkjet printers is that compared to the screen printing process, the outdoor durability is more limited. In general, inkjet printers are more economical for small orders, while screen printing presses are more economical for large orders.

USP currently has annual sales of approximately $7 million. It typically allocates up to 10 percent of sales to these types of projects.

QUESTIONS

1. Construct an aggregate project plan for USP.
2. What criteria would you recommend USP use in selecting its projects this year?
3. Based on your recommended criteria and the aggregate project plan, what projects would you recommend USP fund this year? Are there any types of projects you would recommend USP pursue that were not proposed?
4. What, if any, additional information would you want in making your recommendations? How would you go about obtaining this information?

C A S E

Handstar Inc.

Handstar Inc. was created a little over four years ago by two college roommates to develop software applications for handheld computing devices. It has since grown to ten employees with annual sales approaching $1.5 million. Handstar's original product was an expense report application that allowed users to record expenses on their handheld computer and then import these expenses into a spreadsheet that then created an expense report in one of five standard formats. Based on the success of its first product, Handstar subsequently developed three additional software products: a program for tracking and measuring the performance of investment portfolios, a calendar program, and a program that allowed users to download their email messages from their PC and read them on their handheld computer.

The two founders of Handstar have recently become concerned about the competitiveness of the firm's offerings, particularly since none of them has been updated since their initial launch. Therefore, they asked the directors of product development and marketing to work together and prepare a list of potential projects for updating Handstar's current offerings as well as to develop ideas for additional offerings. The directors were also asked to estimate the development costs of the various projects, product revenues, and the likelihood that Handstar could retain or obtain a leadership position for the given product. Also, with the increasing popularity of the Internet, the founders asked the directors to evaluate the extent to which the products made use of the Internet.

The product development and marketing directors identified three projects related to updating Handstar's existing products. The first project would integrate Handstar's current calendar program with its email program. Integrating these two applications into a single program would provide a number of benefits to users such as allowing them to automatically enter the dates of meetings into the calendar based on the content of an email message. The directors estimated that this project would require 1250 hours of software development time. Revenues in the first year of the product's launch were estimated to be $750,000. However, because the directors expected that a large percentage of the users would likely upgrade to this new product soon after its introduction, they projected that annual sales would decline by 10 percent annually in subsequent years. The directors speculated that Handstar was moderately likely to obtain a leadership position in email/calendar programs if this project were undertaken and felt this program made moderate use of the Internet.

The second project related to updating the expense report program. The directors estimated that this project would require 400 hours of development time. Sales were estimated to be $250,000 in the first year and to increase 5 percent annually in subsequent years. The directors speculated that completing this project would almost certainly maintain Handstar's leadership position in the expense report category, although it made little use of the Internet.

The last product enhancement project related to enhancing the existing portfolio tracking program. This project would require 750 hours of development time and would generate first-year sales of $500,000. Sales were projected to increase 5 percent annually in subsequent years. The directors felt this project would have a high probability of maintaining Handstar's leadership position in this category and the product would make moderate use of the Internet.

The directors also identified three opportunities for new products. One project was the development of a spreadsheet program that could share files with spreadsheet programs written for PCs. Developing this product would require 2500 hours of development time. First-year sales were estimated to be $1,000,000 with an annual growth rate of 10 percent. While this product did not make use of the Internet, the directors felt that Handstar had a moderate chance of obtaining a leadership position in this product category.

The second new product opportunity identified was a Web browser. Developing this product would require 1875 development hours. First-year sales were estimated to be $2,500,000 with an annual growth rate of 15 percent. Although this application made extensive use of the Internet, the directors felt that there was a very low probability that Handstar could obtain a leadership position in this product category.

The final product opportunity identified was a trip planner program that would work in conjunction with a PC connected to the Web and download travel instructions to the user's handheld computer. This product would require 6250 hours of development time. First-year sales were projected to be $1,300,000 with an annual growth rate of 5 percent. Like the Web browser program, the directors felt that there was a low probability that Handstar could obtain a leadership position in this category, although the program would make extensive use of the Internet.

In evaluating the projects, the founders believed it was reasonable to assume each product had a three-year life. They also felt that a discount rate of 12 percent fairly reflected the company's cost of capital. An analysis of payroll records indicated that the cost of software developers is $52 per hour including salary and fringe benefits. Currently there are four software developers on staff, and each works 2500 hours per year.

QUESTIONS

1. Which projects would you recommend Handstar pursue based on the NPV approach?
2. Assume the founders weigh a project's NPV twice as much as both obtaining/retaining a leadership position and making use of the Internet. Use the weighted factor scoring method to rank these projects. Which projects would you recommend Handstar pursue?
3. In your opinion is hiring an additional software development engineer justified?

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