CHAPTER 2

Strategic Management and Project Selection

More and more, the accomplishment of important tasks and goals in organizations today is being achieved through the use of projects. The phrases we hear and read about daily at our work and in conversations with our colleagues, such as "management by projects" and "project management maturity," reflect this increasing trend in our society. The explosively rapid adoption of such a powerful tool as project management to help organizations achieve their goals and objectives is certainly awesome. In addition to project management's great utility when correctly used, however, its utility has also led to many misapplications. As noted by one set of scholars (Cleland and King, 1983, p. 155), the rapid adoption of project management means:

- there are many projects that fall outside the organization's stated mission;
- there are many projects being conducted that are completely unrelated to the strategy and goals of the organization; and
- there are many projects with funding levels that are excessive relative to their expected benefits.

In addition to the growth in the number of organizations adopting project management, there is also an accelerating growth in the number of multiple, simultaneously ongoing, and often interrelated projects in organizations—particularly construction, consulting, auditing, systems development, maintenance, and matrixed organizations. Thus, the issue naturally arises as to how one manages all these projects. Are they all really projects? (It has been suggested that perhaps up to 80 percent of all "projects" are not actually projects at all, since they do not include the three project requirements for objectives, budget, and due date.) Should we be undertaking all of them? Of those we should implement, what should be their priorities?

It is not unusual these days for organizations to be wrestling with hundreds of new projects. With so many ongoing projects it becomes difficult for smaller projects to get adequate support, or even the attention of senior management. Three particularly common problems in organizations trying to manage multiple projects are:

1. Delays in one project delay other projects because of common resource needs or technological dependencies.
2. The inefficient use of corporate resources results in peaks and valleys of resource utilization.
3. Bottlenecks in resource availability or lack of required technological inputs result in project delays that depend on those scarce resources or technology.

As might be expected, the report card on organizational success with management by projects is not stellar. For example, one research study (Thomas, Delisle, Jugdev, and Buckle, 2001) has found that 30 percent of all projects are canceled midstream, and over half of completed projects came in up to 190 percent over budget and 220 percent late. This same study found that the primary motivation of organizations to improve and expand their project management processes was due to major troubled or failed projects, new upcoming mega-projects, or to meet competition or maintain their market share. Those firms that "bought" project management skills from consultants tended to see it as a "commodity." These firms also commonly relied on outsourcing difficult activities, or even entire projects. Those who developed the skills internally, however, saw project management as offering a proprietary competitive advantage. The latter firms also moved toward recognizing project management as a viable career path in their organization, leading to senior management positions.

A major development among those choosing to develop project management expertise in house, particularly those interested in using projects to accomplish organizational goals and strategies, is the initiation of a Project Management Office (PMO), described in detail in Chapter 4. This office strives to develop multi-project management expertise throughout the organization and evaluate the interrelationships both between projects (e.g., such as resource and skill requirements) and between projects and the organization's goals. It is expected that the PMO will promote those projects that capitalize on the organization's strengths, offer a competitive advantage, and mutually support each other, while avoiding those with resource or technology needs in areas where the organization is weaker.

The challenges thus facing the contemporary organization are how to tie their projects more closely to the organization's goals and strategy, how to handle the growing number of ongoing projects, and how to make these projects more successful, topics we discuss more fully in Section 2.7 (see also Christenson and Walker, 2004; Kenny, 2003; Kerzner, 2003; and Norrie and Walker, 2004). The latter two of these objectives concern "project management maturity"—the development of project and multi-project management expertise. Following a discussion of project management maturity, we launch into a major aspect of multi-project management: selecting projects for implementation and handling the uncertainty, or risk, involved.

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. *Project selection* is the process of evaluating individual projects or groups of projects and then choosing to implement some set of them so that the objectives of the parent organization will be achieved. Because one's initial notions of precisely how most projects will be carried out, what resources will be required, and how long it will take to complete the project are uncertain, we will introduce risk analysis into the selection process. Following this, we illustrate the process of strategically selecting the best set of projects, called the Project Portfolio Process, for implementation. Last, the chapter closes with a short discussion of *project proposals.*

Before proceeding, a final comment is pertinent. It is not common to discuss project selection, the construction of a project portfolio, and similar matters in any detail in elementary texts on project management. The project manager typically has little or no say in the project funding decision, nor is he or she usually asked for input concerning the development of organizational strategy. Why then discuss these matters? The answer is simple, yet persuasive. The project manager who does not understand what a given project is expected to contribute to the parent organization lacks the critical information needed to manage the project in order to optimize its contribution.

2.1 PROJECT MANAGEMENT MATURITY

As organizations have employed more and more projects for accomplishing their objectives (often referred to as "managing organizations by projects"), it has become natural for senior managers—as well as scholars—to wonder if the organization's project managers have a mastery of the skills required to manage projects competently. In the last few years, a number of different ways to measure this—referred to as "project management maturity" (Fincher and Levin, 1997; Pennypacker and Grant, 2003)—have been suggested, such as basing the evaluation on PMI's *PMBOK Guide* (Lubianiker, 2000; see also *www.pmi.org/opm3/*) or the ISO 9001 standards (contact the American Society for Quality).

A number of consulting firms, as well as scholars, have devised formal maturity measures, many of which are based on Carnegie Mellon University's "Capability Maturity Model" for software development (*www.sei.cmu.edu/cmm/se-cmm.html*). One of these measures, named PM3®, was described by R. Remy (1997). In this system, the final project management "maturity" of an organization is assessed as being at one of five levels: ad-hoc (disorganized, accidental successes and failures); abbreviated (some processes exist, inconsistent management, unpredictable results); organized (standardized processes, more predictable results); managed (controlled and measured processes, results more in line with plans); and adaptive (continuous improvement in processes, success is normal, performance keeps improving).

Since then, another maturity model, also based on Carnegie-Mellon's capability maturity model, has been devised and applied to 38 organizations in four different industries (Ibbs and Kwak, 2000). This model consists of 148 questions divided into six processes/life-cycle phases (initiating, planning, executing, controlling, closing, and project-driven organization environment), and eight PMBOK knowledge areas (scope, time, cost, quality, human resources, communication, risk, and procurement). The model assesses an organization's project management maturity in terms of essentially the same five stages as just described but called: ad-hoc, planned, managed, integrated, and sustained.

Project Management in Practice

Implementing Strategy through Projects at Blue Cross/Blue Shield

Since strategic plans are usually developed at the executive level, implementation by middle level managers is often a problem due to poor understanding of the organization's capabilities and top management's expectations. However, bottom-up development of departmental goals and future plans invariably lacks the vision of the overall market and competitive environment. At Blue Cross/Blue Shield (BC/BS) of Louisiana, this problem was avoided by closely tying project management tools to the organizational strategy. The resulting system provided a set of checks and balances for both BC/BS executives and project managers.

Overseeing the system is a newly created Corporate Project Administration Group (CPAG) that helps senior management translate their strategic goals and objectives into project management performance, budget, and schedule targets. These may include new product development, upgrading information systems, or implementing facility automation systems. CPAG also works with the project teams to develop their plans, monitoring activities, and reports so they dovetail with the strategic intentions.

The primary benefits of the system have been that it allows:

- senior management to select any corporate initiative and determine its status;
- PMs to report progress in a relevant, systematic, timely manner;
- all officers, directors, and managers to view the corporate initiatives in terms of the overall strategic plan; and
- senior management to plan, track, and adjust strategy through use of financial project data captured by the system.

Source: P. Diab, "Strategic Planning + Project Management = Competitive Advantage," *PM Network,* July 1998, pp. 25–28.

Regardless of model form, it appears that most organizations do not score very well in terms of maturity. On one form, about three-quarters are no higher than level 2 (planned) and fewer than 6 percent are above level 3 (managed). On another perspective, the average of the 38 organizations was only slightly over 3, though individual firms ranged between 1.8 and 4.6 on the five-point scale.

Next we detail the project selection process, discussing the various types of selection models commonly used, the database needed for selection, and the management of risk.

2.2 PROJECT SELECTION AND CRITERIA OF CHOICE

Project selection is the process of evaluating individual projects or groups of projects, and then choosing to implement some set of them so that the objectives of the parent organization will be achieved. This same systematic process can be applied to any area of the organization's business in which choices must be made between competing alternatives. For example, a manufacturing firm can use evaluation/selection techniques to choose which machine to adopt in a part-fabrication process; a TV station can select which of several syndicated comedy shows to rerun in its 7:30 P.M. weekday time-slot; a construction firm can select the best subset of a large group of potential projects on which to bid; or a hospital can find the best mix of psychiatric, orthopedic, obstetric, and other beds for a new wing. Each project will have different costs, benefits, and risks. Rarely are these known with certainty. In the face of such differences, the selection of one project out of a set is a difficult task. Choosing a number of different projects, a *portfolio,* is even more complex.

In the following sections, we discuss several techniques that can be used to help senior managers select projects. Project selection is only one of many decisions associated with project management. To deal with all of these problems, we use *decision-aiding models.* We need such models because they abstract the relevant issues about a problem from the plethora of detail in which the problem is embedded. Reality is far too complex to deal with in its entirety. An "idealist" is needed to strip away almost all the reality from a problem, leaving only the aspects of the "real" situation with which he or she wishes to deal. This process of carving away the unwanted reality from the bones of a problem is called *modeling the problem.* The idealized version of the problem that results is called a *model.*

The model represents the problem's *structure,* its form. Every problem has a form, though often we may not understand a problem well enough to describe its structure. We will use many models in this book—graphs, analogies, diagrams, as well as *flow graph and network models* to help solve scheduling problems, and *symbolic* (mathematical) models for a number of purposes.

Models may be quite simple to understand, or they may be extremely complex. In general, introducing more reality into a model tends to make the model more difficult to manipulate. If the input data for a model are not known precisely, we often use probabilistic information; that is, the model is said to be *stochastic* rather than *deterministic.* Again, in general, stochastic models are more difficult to manipulate. [Readers who are not familiar with the fundamentals of decision making might find a book such as *The New Science of Management Decisions* (Simon, 1977) or *Quantitative Business Modeling* (Meredith, Shafer, and Turban, 2002) useful.]

We live in the midst of what has been called the "knowledge explosion." We frequently hear comments such as "90 percent of all we know about physics has been discovered since Albert Einstein published his original work on special relativity"; and "80 percent of what we know about the human body has been discovered in the past 50 years." In addition, evidence is cited to show that knowledge is growing exponentially. Such statements emphasize the importance of the *management of change.* To survive, firms should develop strategies for assessing and reassessing the use of their resources. Every allocation of resources is an investment in the future. Because of the complex nature of most strategies, many of these investments are in projects.

To cite one of many possible examples, special visual effects accomplished through computer animation are common in the movies and television shows we watch daily. A few years ago they were unknown. When the capability was in its idea stage, computer companies as well as the firms producing movies and TV shows faced the decision whether or not to invest in the development of these techniques. Obviously valuable as the idea seems today, the choice was not quite so clear a decade ago when an entertainment company compared investment in computer animation to alternative investments in a new star, a new rock group, or a new theme park.

The proper choice of investment projects is crucial to the long-run survival of every firm. Daily we witness the results of both good and bad investment choices. In our daily newspapers we read of Cisco System's decision to purchase firms that have developed valuable communication network software rather than to develop its own software. We read of Procter and Gamble's decision to invest heavily in marketing its products on the Internet; British Airways' decision to purchase passenger planes from Airbus instead of from its traditional supplier, Boeing; or problems faced by school systems when they update student computer labs—should they invest in Windows®-based systems or stick with their traditional choice, Apple®. But can such important choices be made rationally? Once made, do they ever change, and if so, how? These questions reflect the need for effective selection models.

Within the limits of their capabilities, such models can be used to increase profits, select investments for limited capital resources, or improve the competitive position of the organization. They can be used for ongoing evaluation as well as initial selection, and thus are a key to the allocation and reallocation of the organization's scarce resources.

When a firm chooses a project selection model, the following criteria, based on Souder (1973), are most important.

1. *Realism* The model should reflect the reality of the manager's decision situation, including the multiple objectives of both the firm and its managers. Without a common measurement system, direct comparison of different projects is impossible. For example, Project A may strengthen a firm's market share by extending its facilities, and Project B might improve its competitive position by strengthening its technical staff. Other things being equal, which is better? The model should take into account the realities of the firm's limitations on facilities, capital, personnel, and so forth. The model should also include factors that reflect project risks, including the technical risks of performance, cost, and time as well as the market risks of customer rejection and other implementation risks.
2. *Capability* The model should be sophisticated enough to deal with multiple time periods, simulate various situations both internal and external to the project (e.g., strikes, interest rate changes), and optimize the decision. An optimizing model will make the comparisons that management deems important, consider major risks and constraints on the projects, and then select the best overall project or set of projects.
3. *Flexibility* The model should give valid results within the range of conditions that the firm might experience. It should have the ability to be easily modified, or to be self-adjusting in response to changes in the firm's environment; for example, tax laws change, new technological advancements alter risk levels, and, above all, the organization's goals change.
4. *Ease of use* The model should be reasonably convenient, not take a long time to execute, and be easy to use and understand. It should not require special interpretation, data that are difficult to acquire, excessive personnel, or unavailable equip-

ment. The model's variables should also relate one-to-one with those real-world parameters the managers believe significant to the project. Finally, it should be easy to simulate the expected outcomes associated with investments in different project portfolios.

5. *Cost* Data-gathering and modeling costs should be low relative to the cost of the project and must surely be less than the potential benefits of the project. All costs should be considered, including the costs of data management and of running the model.

We would add a sixth criterion:

6. *Easy computerization* It should be easy and convenient to gather and store the information in a computer database, and to manipulate data in the model through use of a widely available, standard computer package such as Excel®, Lotus 1-2-3®, Quattro Pro®, and like programs. The same ease and convenience should apply to transferring the information to any standard decision support system.

In what follows, we first examine fundamental types of project selection models and the characteristics that make any model more or less acceptable. Next we consider the limitations, strengths, and weaknesses of project selection models, including some suggestions of factors to consider when making a decision about which, if any, of the project selection models to use. We then discuss the problem of selecting projects when high levels of uncertainty about outcomes, costs, schedules, or technology are present, as well as some ways of managing the risks associated with the uncertainties. Finally, we comment on some special aspects of the information base required for project selection. Then we turn our attention to the selection of a set of projects to help the organization achieve its goals and illustrate this with a technique called the *Project Portfolio Process.* We finish the chapter with a discussion of project proposals.

2.3 THE NATURE OF PROJECT SELECTION MODELS

There are two basic types of project selection models, *numeric* and *nonnumeric.* Both are widely used. Many organizations use both at the same time, or they use models that are combinations of the two. Nonnumeric models, as the name implies, do not use numbers as inputs. Numeric models do, but the criteria being measured may be either objective or subjective. It is important to remember that the *qualities* of a project may be represented by numbers, and that *subjective* measures are not necessarily less useful or reliable than *objective* measures. (We will discuss these matters in more detail in Section 2.6.)

Before examining specific kinds of models within the two basic types, let us consider just what we wish the model to do for us, never forgetting two critically important, but often overlooked, facts.

- Models do not make decisions—people do. The manager, not the model, bears responsibility for the decision. The manager may "delegate" the task of making the decision to a model, but the responsibility cannot be abdicated.
- All models, however sophisticated, are only partial representations of the real-

> ity they are meant to reflect. Reality is far too complex for us to capture more than a small fraction of it in any model. Therefore, no model can yield an optimal decision except within its own, possibly inadequate, framework.

We seek a model to assist us in making project selection decisions. This model should possess the characteristics discussed previously and, above all, it should evaluate potential projects by the degree to which they will meet the firm's objectives. To construct a selection/evaluation model, therefore, it is necessary to develop a list of the firm's objectives.

A list of objectives should be generated by the organization's top management. It is a direct expression of organizational philosophy and policy. The list should go beyond the typical clichés about "survival" and "maximizing profits," which are certainly real goals but are just as certainly not the only goals of the firm. Other objectives might include maintenance of share of specific markets, development of an improved image with specific clients or competitors, expansion into a new line of business, decrease in sensitivity to business cycles, maintenance of employment for specific categories of workers, and maintenance of system loading at or above some percent of capacity, just to mention a few.

A model of some sort is implied by any conscious decision. The choice between two or more alternative courses of action requires reference to some objective(s), and the choice is thus made in accord with some, possibly subjective, "model."

Since the development of computers and the establishment of operations research as an academic subject in the mid-1950s, the use of formal, numeric models to assist in decision making has expanded. Many of these models use financial metrics such as profits and/or cash flow to measure the "correctness" of a managerial decision. Project selection decisions are no exception, being based primarily on the degree to which the financial goals of the organization are met. As we will see later, this stress on financial goals, largely to the exclusion of other criteria, raises some serious problems for the firm, irrespective of whether the firm is for-profit or not-for-profit.

When the list of objectives has been developed, an additional refinement is recommended. The elements in the list should be *weighted.* Each item is added to the list because it represents a contribution to the success of the organization, but each item does not make an equal contribution. The weights reflect different degrees of contribution each element makes in accomplishing a set of goals.

Once the list of goals has been developed, one more task remains. The probable contribution of each project to each of the goals should be estimated. A project is selected or rejected because it is predicted to have certain outcomes if implemented. These outcomes are expected to contribute to goal achievement. If the estimated level of goal achievement is sufficiently large, the project is selected. If not, it is rejected. The relationship between the project's expected results and the organization's goals must be understood. In general, the kinds of information required to evaluate a project can be listed under production, marketing, financial, personnel, administrative, and other such categories.

Table 2-1 is a list of factors that contribute, positively or negatively, to these categories. In order to give focus to this list, we assume that the projects in question involve the possible substitution of a new production process for an existing one. The list is meant to be illustrative. It certainly is not exhaustive.

Table 2–1. Project Evaluation Factors

Production Factors

1. Time until ready to install
2. Length of disruption during installation
3. Learning curve—time until operating as desired
4. Effects on waste and rejects
5. Energy requirements
6. Facility and other equipment requirements
7. Safety of process
8. Other applications of technology
9. Change in cost to produce a unit output
10. Change in raw material usage
11. Availability of raw materials
12. Required development time and cost
13. Impact on current suppliers
14. Change in quality of output

Marketing Factors

1. Size of potential market for output
2. Probable market share of output
3. Time until market share is acquired
4. Impact on current product line
5. Consumer acceptance
6. Impact on consumer safety
7. Estimated life of output
8. Spin-off project possibilities

Financial Factors

1. Profitability, net present value of the investment
2. Impact on cash flows
3. Payout period
4. Cash requirements
5. Time until break-even
6. Size of investment required
7. Impact on seasonal and cyclical fluctuations

Personnel Factors

1. Training requirements
2. Labor skill requirements
3. Availability of required labor skills
4. Level of resistance from current work force
5. Change in size of labor force
6. Inter- and intra-group communication requirements
7. Impact on working conditions

Administrative and Miscellaneous Factors

1. Meet government safety standards
2. Meet government environmental standards
3. Impact on information system
4. Reaction of stockholders and securities markets
5. Patent and trade secret protection
6. Impact on image with customers, suppliers, and competitors
7. Degree to which we understand new technology
8. Managerial capacity to direct and control new process

Some factors in this list have a one-time impact and some recur. Some are difficult to estimate and may be subject to considerable error. For these, it is helpful to identify a *range of uncertainty.* In addition, the factors may occur at different times. And some factors may have *thresholds,* critical values above or below which we might wish to reject the project. We will deal in more detail with these issues later in this chapter.

Clearly, no single project decision need include all these factors. Moreover, not only is the list incomplete, it also contains redundant items. Perhaps more important, the factors are not at the same level of generality: *profitability* and *impact on organizational image* both affect the overall organization, but *impact on working conditions* is more oriented to the production system. Nor are all elements of equal importance. *Change in production cost* is usually considered more important than *impact on current suppliers.* Shortly, we will consider the problem of generating an acceptable list of factors and measuring their relative importance. At that time we will discuss the creation of a Decision Support System (DSS) for project evaluation and selection. The same subject will arise once more in Chapters 12 and 13 when we consider project auditing, evaluation, and termination.

Although the process of evaluating a potential project is time-consuming and difficult, its importance cannot be overstated. A major consulting firm has argued (Booz, Allen, and Hamilton, 1966) that the primary cause for the failure of R & D projects is insufficient care in evaluating the proposal before the expenditure of funds. What is true for R & D projects also appears to be true for other kinds of projects, and it is clear that product development projects are more successful if they incorporate user needs and satisfaction in the design process (Matzler and Hinterhuber, 1998). Careful analysis of a potential project is a *sine qua non* for profitability in the construction business. There are many horror stories (Meredith, 1981) about firms that undertook projects for the installation of a computer information system without sufficient analysis of the time, cost, and disruption involved.

Later in this chapter we will consider the problem of conducting an evaluation under conditions of uncertainty about the outcomes associated with a project. Before dealing with this problem, however, it helps to examine several different evaluation/selection models and consider their strengths and weaknesses. Recall that the problem of choosing the project selection model itself will also be discussed later.

2.4 TYPES OF PROJECT SELECTION MODELS

Of the two basic types of selection models (numeric and nonnumeric), nonnumeric models are older and simpler and have only a few subtypes to consider. We examine them first.

Nonnumeric Models

The Sacred Cow In this case the project is suggested by a senior and powerful official in the organization. Often the project is initiated with a simple comment such as, "If you have a chance, why don't you look into . . .," and there follows an undeveloped idea for a new product, for the development of a new market, for the design and adoption of a global data base and information system, or for some other project requiring an investment of the firm's resources. The immediate result of this bland statement is the creation of a "project" to investigate whatever the boss has suggested. The project is "sacred" in the sense that it will be maintained until successfully concluded, or until the boss, personally, recognizes the idea as a failure and terminates it.

The Operating Necessity If a flood is threatening the plant, a project to build a protective dike does not require much formal evaluation, which is an example of this scenario. XYZ Steel Corporation has used this criterion (and the following criterion also) in evaluating potential projects. If the project is required in order to keep the system operating, the primary question becomes: Is the system worth saving at the estimated cost of the project? If the answer is yes, project costs will be examined to make sure they are kept as low as is consistent with project success, but the project will be funded.

The Competitive Necessity Using this criterion, XYZ Steel undertook a major plant rebuilding project in the late 1960s in its steel-bar-manufacturing facilities near Chicago. It had become apparent to XYZ's management that the company's bar mill needed modernization if the firm was to maintain its competitive position in the Chicago market area. Although the planning process for the project was quite sophisticated, the decision to undertake the project was based on a desire to maintain the company's competitive position in that market.

In a similar manner, many business schools are restructuring their undergraduate and MBA programs to stay competitive with the more forward-looking schools. In large part, this action is driven by declining numbers of tuition-paying students and the need to develop stronger programs to attract them.

Investment in an *operating necessity* project takes precedence over a *competitive necessity* project, but both types of projects may bypass the more careful numeric analysis used for projects deemed to be less urgent or less important to the survival of the firm.

The Product Line Extension In this case, a project to develop and distribute new products would be judged on the degree to which it fits the firm's existing product line, fills a gap, strengthens a weak link, or extends the line in a new, desirable direction. Sometimes careful calculations of profitability are not required. Decision makers can act on their beliefs about what will be the likely impact on the total system performance if the new product is added to the line.

Comparative Benefit Model For this situation, assume that an organization has many projects to consider, perhaps several dozen. Senior management would like to select a subset of the projects that would most benefit the firm, but the projects do not seem to be easily comparable. For example, some projects concern potential new products, some concern changes in production methods, others concern computerization of certain records, and still others cover a variety of subjects not easily categorized (e.g., a proposal to create a daycare center for employees with small children). The organization has no formal method of selecting projects, but members of the Selection Committee think that some projects will benefit the firm more than others, even if they have no precise way to define or measure "benefit."

The concept of comparative benefits, if not a formal model, is widely adopted for selection decisions on all sorts of projects. Most United Way organizations use the concept to make decisions about which of several social programs to fund. Senior management of the funding organization then examines all projects with positive recommendations and attempts to construct a portfolio that best fits the organization's aims and its budget.

Of the several techniques for ordering projects, the Q-Sort (Helin and Souder, 1974) is one of the most straightforward. First, the projects are divided into three groups—*good, fair*, and *poor*—according to their relative merits. If any group has more than eight members, it is subdivided into two categories, such as *fair-plus* and *fair-minus*. When all categories have eight or fewer members, the projects within each category are ordered from best to worst. Again, the order is determined on the basis of relative merit. The rater may use specific criteria to rank each project, or may simply use general overall judgment. (See Figure 2-1 for an example of a Q-Sort.)

The process described may be carried out by one person who is responsible for evaluation and selection, or it may be performed by a committee charged with the re-

Steps

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.

Results at Each Step

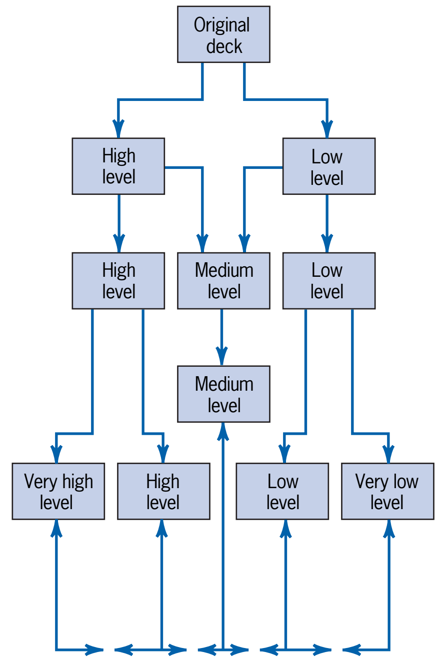


Figure 2-1 The Q-sort method. *Source: Souder 1983.*

sponsibility. If a committee handles the task, the individual rankings can be developed anonymously, and the set of anonymous rankings can be examined by the committee itself for consensus. It is common for such rankings to differ somewhat from rater to rater, but they do not often vary strikingly because the individuals chosen for such committees rarely differ widely on what they feel to be appropriate for the parent organization. Projects can then be selected in the order of preference, though they are usually evaluated financially before final selection.

There are other, similar nonnumeric models for accepting or rejecting projects. Although it is easy to dismiss such models as unscientific, they should not be discounted casually. These models are clearly goal-oriented and directly reflect the primary concerns of the organization. The sacred cow model, in particular, has an added feature; sacred cow projects are visibly supported by "the powers that be." Full support by top management is certainly an important contributor to project success (Meredith, 1981). Without such support, the probability of project success is sharply lowered.

Numeric Models: Profit/Profitability

As noted earlier, a large majority of all firms using project evaluation and selection models use profitability as the sole measure of acceptability. We will consider these models first, and then discuss models that surpass the profit test for acceptance.

Payback Period 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. The ratio of these quantities is the number of years required for the project to repay its initial fixed investment. For example, assume a project costs $100,000 to implement and has annual net cash inflows of $25,000. Then

$$\text{Payback period} = \$100{,}000/\$25{,}000 = 4 \text{ years}$$

This method assumes that the cash inflows will persist at least long enough to pay back the investment, and it ignores any cash inflows beyond the payback period. The method also serves as an (inadequate) proxy for risk. The faster the investment is recovered, the less the risk to which the firm is exposed.

Average Rate of Return Often mistaken as the reciprocal of the payback period, the average rate of return is the ratio of the average annual profit (either before or after taxes) to the initial or average investment in the project. Because average annual profits are usually not equivalent to net cash inflows, the average rate of return does not usually equal the reciprocal of the payback period. Assume, in the example just given, that the average annual profits are $15,000:

$$\text{Average rate of return} = \$15{,}000/\$100{,}000 = 0.15$$

Neither of these evaluation methods is recommended for project selection, though payback period is widely used and does have a legitimate value for cash budgeting decisions. The major advantage of these models is their simplicity, but neither takes into account the time-value of money. Unless interest rates are extremely low and the rate of inflation is nil, the failure to reduce future cash flows or profits to their present value will result in serious evaluation errors.

Discounted Cash Flow Also referred to as the net present value method, the discounted cash flow method determines the net present value of all cash flows by discounting them by the required rate of return (also known as the *hurdle rate, cutoff rate*, and similar terms) as follows:

$$\text{NPV (project)} = A_0 + \sum_{t=1}^{n} \frac{F_t}{(1 + k)^t}$$

where

F_t = the net cash flow in period t,
k = the required rate of return, and
A_0 = initial cash investment (because this is an outflow, it will be negative).

To include the impact of inflation (or deflation) where p_t is the predicted rate of inflation during period t, we have

$$\text{NPV (project)} = A_0 + \sum_{t=1}^{n} \frac{F_t}{(1 + k + p_t)^t}$$

Early in the life of a project, net cash flow is likely to be negative, the major outflow being the initial investment in the project, A_0. If the project is successful, however, cash flows will become positive. The project is *acceptable* if the sum of the net present values of all estimated cash flows over the life of the project is positive. A simple example will suffice. Using our $100,000 investment with a net cash inflow of $25,000 per year for a period of eight years, a required rate of return of 15 percent, and an inflation rate of 3 percent per year, we have

$$\text{NPV (project)} = \$100{,}000 + \sum_{t=1}^{8} \frac{\$25{,}000}{(1 + 0.15 + 0.03)^t}$$
$$= \$1939$$

Because the present value of the inflows is greater than the present value of the outflow—that is, the net present value is positive—the project is deemed acceptable.

PsychoCeramic Sciences, Inc.

PsychoCeramic Sciences, Inc. (PSI), a large producer of cracked pots and other cracked items, is considering the installation of a new marketing software package that will, it is hoped, allow more accurate sales information concerning the inventory, sales, and deliveries of its pots as well as its vases designed to hold artificial flowers.

The information systems (IS) department has submitted a project proposal that estimates the investment requirements as follows: an initial investment of $125,000 to be paid up-front to the Pottery Software Corporation; an additional investment of $100,000 to modify and install the software; and another $90,000 to integrate the new software into the overall information system. Delivery and installation is estimated to take one year; integrating the entire system should require an additional year. Thereafter, the IS department predicts that scheduled software updates will require further expenditures of about $15,000 every second year, beginning in the fourth year. They will not, however, update the software in the last year of its expected useful life.

The project schedule calls for benefits to begin in the third year, and to be up-to-speed by the end of that year. Projected additional profits resulting from better and more timely sales information 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 the table at the end of this box.

Project life is expected to be 10 years from project inception, at which time the proposed system will be obsolete for this division and will have to be replaced. It is estimated, however, that the software can be sold to a smaller division of PSI and will thus have a salvage value of $35,000.

PSI has a 12 percent hurdle rate for capital investments and expects the rate of inflation to be about 3 percent 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 the table below.

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 were 14 percent.)

Just for the intellectual exercise, note that the total inflow for the project is $759,000, or $75,900 per year on average for the 10 year project. The required investment is $315,000 (ignoring the biennial overhaul charges). Assuming 10 year, straight line depreciation, or $31,500 per year, the payback period would be:

$$\text{PB} = \frac{\$315{,}000}{\$75{,}900 + 31{,}500} = 2.9 \text{ years}$$

A project with this payback period would probably be considered quite desirable.

Year **A**	*Inflow* **B**	*Outflow* **C**	*Net Flow* **D = (B − C)**	*Discount Factor* **1/(1 + k + p)^t**	*Net Present Value* **D (Disc. Fact.)**
2006*	$ 0	$125,000	$−125,000	1.0000	$−125,000
2006	0	100,000	−100,000	0.8696	−86,957
2007	0	90,000	-90,000	0.7561	−68,053
2008	50,000	0	50,000	0.6575	32,876
2009	120,000	15,000	105,000	0.5718	60,034
2010	115,000	0	115,000	0.4972	57,175
2011	105,000	15,000	90,000	0.4323	38,909
2012	97,000	0	97,000	0.3759	36,466
2013	90,000	15,000	75,000	0.3269	24,518
2014	82,000	0	82,000	0.2843	23,310
2015	65,000	0	65,000	0.2472	16,067
2015	35,000		35,000	0.2472	8,651
Total	$759,000	$360,000	$ 399,000		$ 17,997

* t = 0 at the beginning of 2006.

Internal Rate of Return If we have a set of expected cash inflows and cash outflows, the internal rate of return is the discount rate that equates the present values of the two sets of flows. If A_t is an expected cash outflow in the period t and R_t is the expected inflow for the period t, the internal rate of return is the value of k that satisfies the following equation (note that the A_0 will be positive in this formulation of the problem):

$$A_0 + A_1/(1 + k) + A_2/(1 + k)^2 + \ldots + A_n/(1 + k)^n = R_1/(1 + k) + R_2/(1 + k)^2 + \ldots + R_n/(1 + k)^n$$

The value of k is found by trial and error.

Profitability Index Also known as the benefit–cost ratio, the profitability index is the net present value of all future expected cash flows divided by the initial cash investment. (Some firms do not discount the cash flows in making this calculation.) If this ratio is greater than 1.0, the project may be accepted.

Other Profitability Models There are a great many variations of the models just described. These variations fall into three general categories: (1) those that subdivide net cash flow into the elements that comprise the net flow; (2) those that include specific terms to introduce risk (or uncertainty, which is treated as risk) into the evaluation; and (3) those that extend the analysis to consider effects that the project might have on other projects or activities in the organization.

Several comments are in order about all the profit-profitability numeric models. First, let us consider their advantages:

1. The undiscounted models are simple to use and understand.
2. All use readily available accounting data to determine the cash flows.
3. Model output is in terms familiar to business decision makers.

4. With a few exceptions, model output is on an "absolute" profit/profitability scale and allows "absolute" go/no-go decisions.
5. Some profit models account for project risk.

The disadvantages of these models are the following:

1. These models ignore all nonmonetary factors except risk.
2. Models that do not include discounting ignore the timing of the cash flows and the time–value of money.
3. Models that reduce cash flows to their present value are strongly biased toward the short run.
4. Payback-type models ignore cash flows beyond the payback period.
5. The internal rate of return model can result in multiple solutions.
6. All are sensitive to errors in the input data for the early years of the project.
7. All discounting models are nonlinear, and the effects of changes (or errors) in the variables or parameters are generally not obvious to most decision makers.
8. All these models depend for input on a determination of cash flows, but it is not clear exactly how the concept of cash flow is properly defined for the purpose of evaluating projects.

A complete discussion of profit/profitability models can be found in any standard work on financial management—see Ross, Westerfield, and Jordan (1995), for example. In general, the net present value models are preferred to the internal rate of return models. Despite wide use, financial models rarely include non-financial outcomes in their benefits and costs. In a discussion of the financial value of adopting project management (that is, selecting as a project the use of project management) in a firm, Githens (1998) notes that traditional financial models "simply cannot capture the complexity and value-added of today's process-oriented firm."

The commonly seen phrase "return on investment," or ROI, does not denote any *specific* method of calculation. It usually involves NPV or internal rate of return (IRR) calculations, but we have seen it used in reference to undiscounted average rate of return models and (incorrectly) payback period models.

In our experience, the payback period model, occasionally using discounted cash flows, is one of the most commonly used models for evaluating projects and other investment opportunities. Managers generally feel that insistence on short payout periods tends to minimize the *risks* associated with outstanding monies over the passage of time. While this is certainly logical, we prefer evaluation methods that discount cash flows and deal with uncertainty more directly by considering specific risks. Using the payout period as a cash-budgeting tool aside, *its primary virtue is its simplicity.*

Real Options Recently, a project selection model was developed based on a notion well known in financial markets. When one invests, one foregoes the value of alternative future investments. Economists refer to the value of an opportunity foregone as the "opportunity cost" of the investment made.

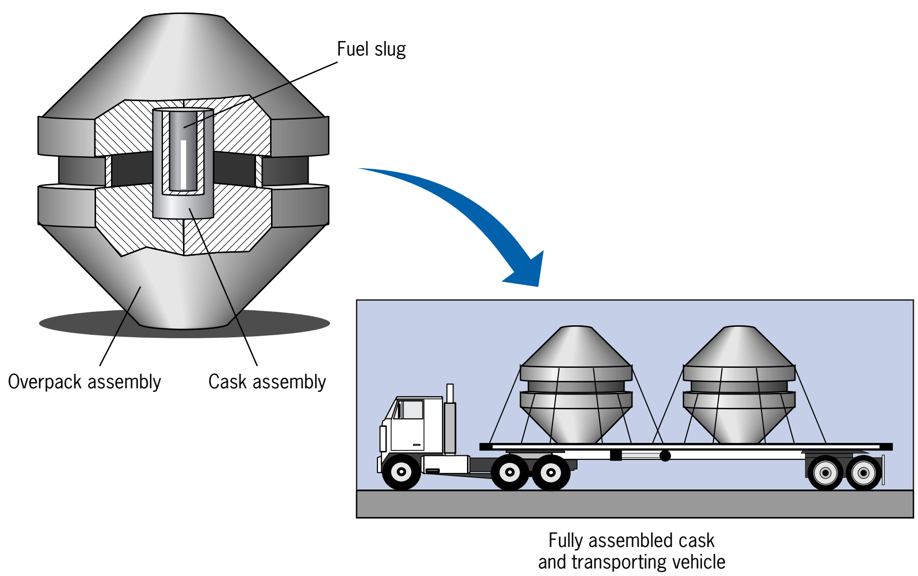
Project Management in Practice

Project Selection for Spent Nuclear Fuel Cleanup

In 1994, Westinghouse Hanford Co., on contract to the Department of Energy's Hanford Nuclear Fuel Site, reorganized for "projectization" to help Hanford with facility shutdown, decommissioning, and site cleanup. The major project in this overall task was the site cleanup of 2,100 metric tons of degraded spent nuclear fuel slugs submerged beneath 16 feet of water (as a radiation shield) in two rectangular, 25-foot-deep, half-football field–sized basins. Of the over 105,000 slugs, about 6,000 were severely damaged or corroded and leaking radiation into the basin water. The 40-year old basins, located only 400 yards from Washington State's pristine Columbia River, had an original 20-year design life and were in very poor condition, experiencing major leaks in the late 1970s and again in 1993. Operating and attempting to maintain these "accidents waiting to happen" cost $100,000 a day.

To address this problem, Westinghouse Hanford went to the site's stakeholders—the media, activists, regulators, oversight groups, three Indian tribes, government leaders, Congress, and Hanford employees—to determine acceptable options for dealing with this immense problem. It required five months of public discussion for the stakeholders to understand the issues and regain their trust in Hanford. Another two months were required to develop four project options as follows:

1. Better encapsulate the fuel and leave it in the basins.
2. Place the fuel in wet storage elsewhere at Hanford.
3. Place the fuel in dry storage at Hanford.
4. Ship the fuel overseas for reprocessing.



Fuel slug packaging system developed to transport and store fuel capsules.

Following three months of evaluation, the third option was selected and an environmental impact statement (EIS) begun, which required eleven more months to complete (yet half the normal EIS completion time). The project is now underway and is expected to be complete by December 1999, three years ahead of the original schedule and thereby saving taxpayers $350 million. Also, the cost of maintaining the fuel is expected to drop to only $3,000 per day.

Source: J.C. Fulton, "Complex Problem . . . Simple Concepts . . . Transformed Organization," *PM Network,* July 1996, pp. 15–21.

The argument is that a project may have greater net present value if delayed to the future. If the investment can be delayed, its cost is discounted compared to a present investment of the same amount. Further, if the investment in a project is delayed, its value may increase (or decrease) with the passage of time because some of the uncertainties will be reduced. If the value of the project drops, it may fail the selection process. If the value increases, the investor gets a higher payoff. The real options approach acts to reduce both technological and commercial risk. For a full explanation of the method and its use as a strategic selection tool, see Luehrman (1998a and 1998b). An interesting application of real options as a project selection tool for pharmaceutical R & D projects is described by Jacob and Kwak (2003). Real options combined with Monte Carlo simulation is compared with alternative selection/assessment methods by Doctor, Newton, and Pearson (2001).

Numeric Models: Scoring

In an attempt to overcome some of the disadvantages of profitability models, particularly their focus on a single decision criterion, a number of evaluation/selection models that use multiple criteria to evaluate a project have been developed. Such models vary widely in their complexity and information requirements. The examples discussed illustrate some of the different types of numeric scoring models.

Unweighted 0–1 Factor Model A set of relevant factors is selected by management and then usually listed in a preprinted form. One or more raters score the project on each factor, depending on whether or not it qualifies for an individual criterion. The raters are chosen by senior managers, for the most part from the rolls of senior management. The criteria for choice are (1) a clear understanding of organizational goals and (2) a good knowledge of the firm's potential project *portfolio*. Figure 2-2 shows an example of the rating sheet for an unweighted, 0–1 factor model.

The columns of Figure 2-2 are summed and those projects with a sufficient number of qualifying factors may be selected. The main advantage of such a model is that it uses several criteria in the decision process. The major disadvantages are that it assumes all criteria are of equal importance and it allows for no gradation of the degree to which a specific project meets the various criteria.

Unweighted Factor Scoring Model The second disadvantage of the 0–1 factor model can be dealt with by constructing a simple linear measure of the degree to which the project being evaluated meets each of the criteria contained in the list. The x marks

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	
Need for external consultants		x
Consistency with current line of business		x
Inpact on company image		
With customers	x	
With our industry		x
Totals	12	5

Figure 2-2 Sample project evaluation form.

in Figure 2-2 would be replaced by numbers. Often a five-point scale is used, where 5 is very good, 4 is good, 3 is fair, 2 is poor, 1 is very poor. (Three-, seven-, and 10-point scales are also common.) The second column of Figure 2-2 would not be needed. The column of scores is summed, and those projects with a total score exceeding some critical value are selected. A variant of this selection process might choose the highest-scoring projects (still assuming they are all above some critical score) until the estimated costs of the set of projects equaled the resource limit. However, the criticism that the criteria are all assumed to be of equal importance still holds.

The use of a discrete numeric scale to represent the degree to which a criterion is satisfied is widely accepted. To construct such measures for project evaluation, we proceed in the following manner. Select a criterion, say, "estimated annual profits in dollars." For this criterion, determine five ranges of performance so that a typical project, chosen at random, would have a roughly equal chance of being in any one of the five performance ranges. (Another way of describing this condition is: Take a large number of projects that were selected for support in the past, regardless of whether they were actually successful or not, and create five levels of predicted performance so that about one-fifth of the projects fall into each level.) This procedure will usually create unequal ranges, which may offend our sense of symmetry but need not concern us otherwise. It ensures that each criterion performance measure utilizes the full scale of possible values, a desirable characteristic for performance measures.

Consider the following two simple examples. Using the criterion just mentioned, "estimated annual profits in dollars," we might construct the following scale:

Score	**Performance Level**
5	Above $1,100,000
4	$750,001 to $1,100,000
3	$500,001 to $750,000
2	$200,000 to $500,000
1	Less than $200,000

As suggested, these ranges might have been chosen so that about 20 percent of the projects considered for funding would fall into each of the five ranges.

The criterion "no decrease in quality of the final product" would have to be restated to be scored on a five-point scale, perhaps as follows:

Score	**Performance Level**
	The quality of the final product is:
5	significantly and visibly improved
4	significantly improved, but not visible to buyer
3	not significantly changed
2	significantly lowered, but not visible to buyer
1	significantly and visibly lowered

This scale is an example of scoring cells that represent opinion rather than objective (even if "estimated") fact, as was the case in the profit scale.

Weighted Factor Scoring Model When numeric weights reflecting the relative importance of each individual factor are added, we have a weighted factor scoring model. In general, it takes the form

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

where

S_i = the total score of the ith project,

s_{ij} = the score of the ith project on the jth criterion, and

w_j = the weight of the jth criterion.

The weights, w_j, may be generated by any technique that is acceptable to the organization's policy makers. There are several techniques available to generate such numbers, but the most effective and most widely used is the Delphi technique. The Delphi technique was developed by Brown and Dalkey of the Rand Corporation during the 1950s and 1960s (Dalkey, 1969). It is a technique for developing numeric values that are equivalent to subjective, verbal measures of relative value. The method of successive comparisons (or pairwise comparisons) may also be used for the same purpose (Khorramshahgol, Azani, and Gousty, 1988).

Another popular and quite similar approach is the Analytic Hierarchy Process, developed by Saaty (1990). For an extensive example involving finance, sales, and purchasing, see pages 306–316 of Turban and Meredith (1994). This example also illustrates the use of Expert Choice®, a software package to facilitate the application of the Analytic Hierarchy Process. Meade and Presley (2002) developed a more general form of Saaty's AHP. They call it the Analytic Network Process, and their paper includes an example of its application to evaluation of multiple R & D projects. (Which reminds us, once more, to caution those who include "technological risk" when evaluating projects. The probability of technical success for any project is 1.0 if there is no limit on time and/or budget. Any estimate of technical success should be accompanied by time and cost constraints, or it is meaningless.)

Finally, the use of experts to develop weightings is nicely demonstrated by Jolly (2003) who applies the technique to the development of weights to a technology portfolio.

When numeric weights have been generated, it is helpful (but not necessary) to scale the weights so that

$$0 \le w_j \le 1 \qquad j = 1, 2, 3, \ldots, n$$

$$\sum_{j=1}^{n} w_j = 1$$

The weight of each criterion can be interpreted as the "percent of the total weight accorded to that particular criterion."

A special caveat is in order. It is quite possible with this type of model to include a large number of criteria. It is not particularly difficult to develop scoring scales and weights, and the ease of gathering and processing the required information makes it tempting to include marginally relevant criteria along with the obviously important items. Resist this temptation! After the important factors have been weighted, there usually is little residual weight to be distributed among the remaining elements. The result is that the evaluation is simply insensitive to major differences in the scores on trivial criteria. A good rule of thumb is to discard elements with weights less than 0.02 or 0.03. (If elements are discarded, and if you wish $\Sigma w_j = 1$, the weights must be rescaled to 1.0.) As with any linear model, the user should be aware that the elements in the model are assumed to be independent. This presents no particular problems for these scoring models because they are used to make estimates in a "steady–state" system, and we are not concerned with transitions between states.

It is useful to note that if one uses a weighted scoring model to aid in project selection, the model can also serve as an aid to project *improvement.* For any given criterion, the difference between the criterion's score and the highest possible score on that criterion, multiplied by the weight of the criterion, is a measure of the potential improvement in the project score that would result were the project's performance on that criterion sufficiently improved. It may be that such improvement is not feasible or is more costly than the improvement warrants. On the other hand, such an analysis of each project yields a valuable statement of the comparative benefits of project improvements. Viewing a project in this way is a type of sensitivity analysis. We examine the degree to which a project's score is sensitive to attempts to improve it—usually by adding resources. We will use sensitivity analysis several times in this book. It is a powerful managerial technique.

It is not particularly difficult to computerize a weighted scoring model by creating a template on Excel® or one of the other standard computer spreadsheets. In Chapter 13 we discuss an example of a computerized scoring model used for the project termination decision. The model is, in fact, a project selection model. The logic of using a "selection" model for the termination decision is straightforward: Given the time and resources required to take a project from its current state to completion, should we make the investment? A "Yes" answer to that question "selects" for funding the partially completed project from the set of all partially finished and not-yet-started projects.

Gettin' Wheels

Rather than using an example in which actual projects are selected for funding with a weighted factor scoring model (hereafter "scoring model") that would require tediously long descriptions of the projects, we can demonstrate the use of the model in a simple, common problem that many readers will have faced—the choice of an automobile for purchase. This problem is nicely suited to use of the scoring model because the purchaser is trying to satisfy multiple objectives in making the purchase and is typically faced with several different cars from which to choose.

Our model must have the following elements:

1. A set of criteria on which to judge the value of any alternative;
2. A numeric estimate of the relative importance (i.e., the "weight") of each criterion in the set; and
3. Scales by which to measure or score the performance or contribution–to–value of each alternative on each criterion.

The criteria weights and measures of performance must be numeric in form, but this does not mean that they must be either "objective" or "quantitative." (If you find this confusing, look ahead in this chapter and read the subsection entitled "Measurements" in Section 2.6.) Criteria weights, obviously, are subjective by their nature, being an expression of what the decision maker thinks is important. The development of performance scales is more easily dealt with in the context of our example, and we will develop them shortly.

Assume that we have chosen the criteria and weights shown in Table A to be used in our evaluations.* The weights represent the relative importance of the criteria measured on a 10-point scale. The numbers in parentheses show the proportion of the total weight carried by each criterion. (They add to only .99 due to rounding.) Raw weights work just as well for decision making as their percentage counterparts, but the latter are usually preferred because they are a constant reminder to the decision maker of the impact of each of the criteria.

Table A. Criteria and Weights for Automobile Purchase

Appearance	4	(.10)
Braking	3	(.07)
Comfort	7	(.17)
Cost, operating	5	(.12)
Cost, original	10	(.24)
Handling	7	(.17)
Reliability	5	(.12)
Total	41	.99

*The criteria and weights were picked arbitrarily for this example. Because this is typically an individual or family decision, techniques like Delphi or successive comparisons are not required.

Table B. Automobile Selection Criteria, Measures and Data Sources

Appearance	Subjective judgment, personal
Braking	Distance in feet, 60–0 mph, automotive magazine[a]
Comfort	Subjective judgment, 30 min. road test
Cost, operating	Annual insurance cost plus fuel cost[b]
Cost, original	Dealer cost, auto-cost service[c]
Handling	Average speed through standard slalom, automotive magazine[a]
Reliability	Score on *Consumer Reports*, "Frequency-of-Repair" data (average of 2 previous years)

[a]Many automotive periodicals conduct standardized performance tests of new cars.

[b]Annual fuel cost is calculated as (17,500 mi/DOE ave. mpg) − $1.25/gal.

[c]There are several sources for dealer-cost data (e.g., AAA, which provides a stable database on which to estimate the price of each alternative).

Prior to consideration of performance standards and sources of information for the criteria we have chosen, we must ask, "Are there any characteristics that must be present (or absent) in a candidate automobile for it to be acceptable?" Assume, for this example, that to be acceptable, an alternative must not be green, must have air conditioning, must be able to carry at least four adults, must have at least 10 cubic feet of luggage space, and must be priced less than $34,000. If an alternative violates any of these conditions, it is immediately rejected.

For each criterion, we need some way of measuring the estimated performance of each alternative. In this case, we might adopt the measures shown in Table B. Our purpose is to transform a measure of the degree to which an alternative meets a criterion into a score, the s_{ij}, that is a general measure of the utility or value of the alternative with respect to that criterion. Note that this requires us to define the criterion precisely, as well as to specify a source for the information.

Figure A shows the scores for each criterion transformed to a 5-point scale, which will suffice for our ratings.

Using the performance scores shown in Figure A, we can evaluate the cars we have identified as our alternatives: the Leviathan 8, the NuevoEcon, the Maxivan, the Sporticar 100, and the Ritzy 300. Each car is scored on each criterion according to the categories shown in Figure A. Then each score is multiplied by the criterion weight and the result is entered into the appropriate box in Figure B. Last, the results for each alternative are summed to represent the weighted score.

According to this set of measures, we prefer the Ritzy 300, but while it is a clear winner over the Leviathan 8 and the Maxivan, and scores about 8 percent better than the Sporticar, it rates only about 0.13 points or 4 percent above the NuevoEcon. Note that if we overrated the Ritzy by one point on comfort or handling, or if we underrated the NuevoEcon by one point on either of these criteria, the result would have been reversed. (We assume that the original cost data are accurate.) With the scores this close, we might want to evaluate these two cars by

Scores					
Criteria	***1***	***2***	***3***	***4***	***5***
Appearance	Ugh	Poor	Adequate	Good	WOW
Braking	>165	165–150	150–140	140–130	<130
Comfort	Bad	Poor	Adequate	Good	Excellent
Cost, operating*	>$2.5	$2.1–2.5	$1.9–2.1	$1.6–1.9	<$1.6
Cost, original*	>$32.5	$26–32.5	$21–26	$17–21	<$17
Handling	<45	45–49.5	49.5–55	55–59	>59
Reliability	Worst	Poor	Adequate	Good	Excellent

*Cost data in $1000s

Figure A Performance measures and equivalent scores for selection of an automobile.

	Criteria and Weights							
Alternatives	***Appearance (0.10)***	***Braking (0.07)***	***Comfort (0.17)***	***Cost, operating (0.12)***	***Cost, original (0.24)***	***Handling (0.17)***	***Reliability (0.12)***	$\Sigma s_{ij} w_j$
Leviathan 8	3 × 0.10 = 0.30	1 × 0.07 = 0.07	4 × 0.17 = 0.68	2 × 0.12 = 0.24	1 × 0.24 = 0.24	2 × 0.17 = 0.34	3 × 0.12 = 0.36	2.23
NuevoEcon	3 × 0.10 = 0.30	3 × 0.07 = .21	2 × 0.17 = 0.34	5 × 0.12 = 0.60	4 × 0.24 = 0.96	2 × 0.17 = 0.34	4 × 0.12 = 0.48	3.23
Maxivan	2 × 0.10 = 0.20	1 × 0.07 = 0.07	4 × 0.17 = 0.68	4 × 0.12 = 0.48	3 × 0.24 = 0.72	1 × 0.17 = 0.17	3 × 0.12 = 0.36	2.68
Sporticar 100	5 × 0.10 = 0.50	4 × 0.07 = 0.28	3 × 0.17 = 0.51	2 × 0.12 = 0.24	2 × 0.24 = 0.48	5 × 0.17 = 0.85	2 × 0.12 = 0.24	3.10
Ritzy 300	4 × 0.10 = 0.40	5 × 0.07 = 0.35	5 × 0.17 = 0.85	2 × 0.12 = 0.24	1 × 0.24 = 0.24	4 × 0.17 = 0.68	5 × 0.12 = 0.60	3.36

Figure B Scores for alternative cars on selection criteria.

additional criteria (e.g., ease of carrying children, status, safety features like dual airbags or ABS) prior to making a firm decision.

All in all, if the decision maker has well-delineated objectives, and can determine how specific kinds of performance contribute to those criteria, and finally, can measure those kinds of performance for each of the alternative courses of action, then the scoring model is a powerful and flexible tool. To the extent that criteria are not carefully defined, performance is not well linked to the criteria, and is carelessly or wrongly measured, the scoring model rests on a faulty foundation and is merely a convenient path to error.

Constrained Weighted Factor Scoring Model The temptation to include marginal criteria can be partially overcome by allowing additional criteria to enter the model as constraints rather than weighted factors. These constraints represent project characteristics that must be present or absent in order for the project to be acceptable. In our example concerning a product, we might have specified that we would not undertake any project that would significantly lower the quality of the final product (visible to the buyer or not).

We would amend the weighted scoring model to take the form:

$$S_i = \sum_{j=1}^{n} s_{ij} w_j \prod_{k=1}^{v} c_{ik}$$

where $c_{ik} = 1$ if the ith project satisfies the kth constraint, and 0 if it does not. Other elements in the model are as defined earlier.

Although this model is analytically tidy, in practice we would not bother to evaluate projects that are so unsuitable in some ways that we would not consider supporting them regardless of their expected performance against other criteria. For example, except under extraordinary circumstances, Procter & Gamble would not consider a project to add a new consumer product or product line:

- that cannot be marketed nationally;
- that cannot be distributed through mass outlets (grocery stores, drugstores);

- that will not generate gross revenues in excess of $—million;
- for which Procter & Gamble's potential market share is not at least 50 percent; and
- that does not utilize Procter & Gamble's scientific expertise, manufacturing expertise, advertising expertise, or packaging and distribution expertise.

Again, a caveat is in order. Exercise care when adopting constraints. It may seem obvious that we should not consider a project if it has no reasonable assurance of long-run profitability. Such a constraint, however, can force us to overlook a project that, though unprofitable itself, might have a strong, positive impact on the profitability of other potential projects.

Other Scoring Models Goal programming is a variation of the general linear programming method that can optimize an objective function with multiple objectives. A detailed discussion of goal programming is beyond the scope of this book. The interested reader should consult any modern text on management science, for example, Meredith, Shafer, and Turban (2002). As was the case with profitability models, scoring models have their own characteristic advantages and disadvantages. The advantages are:

1. These models allow multiple criteria to be used for evaluation and decision making, including profit/profitability models and both tangible and intangible criteria.
2. They are structurally simple and therefore easy to understand and use.
3. They are a direct reflection of managerial policy.
4. They are easily altered to accommodate changes in the environment or managerial policy.
5. Weighted scoring models allow for the fact that some criteria are more important than others.
6. These models allow easy sensitivity analysis. The trade-offs between the several criteria are readily observable.

The disadvantages are the following:

1. The output of a scoring model is strictly a relative measure. Project scores do not represent the value or "utility" associated with a project and thus do not directly indicate whether or not the project should be supported.
2. In general, scoring models are linear in form and the elements of such models are assumed to be independent.
3. The ease of use of these models is conducive to the inclusion of a large number of criteria, most of which have such small weights that they have little impact on the total project score.
4. Unweighted scoring models assume all criteria are of equal importance, which is almost certainly contrary to fact.
5. To the extent that profit/profitability is included as an element in the scoring model, this element has the advantages and disadvantages noted earlier for the profitability models themselves.

An interesting alternative to scoring models is an iterative rating process developed by Raz (1997). His method starts with a set of attributes that can be used to rank potential projects. He then removes all attributes that do not differentiate between the alternatives and all projects that are dominated by others. If a choice can then be made, it is made. If not, the process is repeated. In another paper, Pascale et al. compare a weighted scoring model with an unweighted scoring model for the evaluation of innovations. They conclude that the former works well with incremental change, and the latter works better when the innovation is a "new idea" (Pascale, Carland, and Carland, 1997). They also investigate the impact of the evaluation methods on idea generation.

A recent paper by Åstebro (2004) reports on a study of more than 500 R & D projects. He found that four project characteristics were excellent predictors of project commercial success: (1) expected profitability, (2) technological opportunity, (3) development risk, and (4) appropriability. This finding is particularly important because the experimental design was free of the hindsight bias that is so common in studies of project success and failure. The model correctly predicted almost 80 percent of the project failures and almost 75 percent of the project successes.

Choosing a Project Selection Model

Selecting the type of model to aid the evaluation/selection process depends on the philosophy and wishes of management. Liberatore and Titus (1983) conducted a survey of 40 high-level staff persons from 29 *Fortune 500* firms. Eighty percent of their respondents report the use of one or more financial models for R & D project decision making. Although their sample is small and nonrandom, their findings are quite consistent with the present authors' experience. None of the respondent firms used mathematical programming techniques for project selection or resource allocation.

We strongly favor weighted scoring models for three fundamental reasons. First, they allow the multiple objectives of all organizations to be reflected in the important decision about which projects will be supported and which will be rejected. Second, scoring models are easily adapted to changes in managerial philosophy or changes in the environment. Third, they do not suffer from the bias toward the short run that is inherent in profitability models that discount future cash flows. This is not a prejudice against discounting and most certainly does not argue against the inclusion of profits/profitability as an important factor in selection, but rather *it is an argument against the exclusion of nonfinancial factors* that may require a longer-run view of the costs and benefits of a project. For a powerful statement of this point, see Hayes and Abernathy (1980).

It is also interesting to note that Liberatore and Titus (1983, p. 969) found that firms with a significant amount of contract research funded from outside the organization used scoring models for project screening much more frequently than firms with negligible levels of outside funding. It was also found that firms with significant levels of outside funding were much less likely to use a payback period.

The structure of a weighted scoring model is quite straightforward. Its virtues are many. Nonetheless, the actual use of scoring models is not as easy as it might seem. Decision makers are forced to make difficult choices and they are not always comfortable doing so. They are forced to reduce often vague feelings to quite specific words or numbers. Multiattribute, multiperson decision making is not simple. [For an interesting discussion of this process, see Irving and Conrath (1988).] Finally, a multiattribute, multiperson decision model could be constructed from Åstebro's study of key characteristics of technological R & D projects.

2.5 ANALYSIS UNDER UNCERTAINTY— THE MANAGEMENT OF RISK

During the past several years, increasing attention has been paid to the subject of managing some of the risks inherent in most projects. The subject first appeared in PMI's 1987 edition of *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2001). For the most part, risk has been interpreted as being unsure about project task durations and/or costs, but uncertainty plagues all aspects of the work on projects and is present in all stages of project life cycles. In this section, we will consider uncertainty as it affects the selection process. The impact of imperfect knowledge on the way a project is organized and on its budget and schedule will be discussed in the chapters devoted to those subjects.

Before proceeding, it is useful to discuss briefly the distinction between two words, "risk," and "uncertainty." The outcome of any decision depends on two things: (1) what the decision maker does; and (2) what nature does—"nature" being the set of exogenous factors that interact with the decision maker's course of action to produce an outcome. If the decision maker knows the probability of each and every state of nature and thus of each and every outcome, she can find the *expected value* of each alternative course of action she has. The expected value of an action is the sum of the values of each outcome associated with the action times the probability that it will occur. She can select the course of action associated with the best of these expected outcomes. This is decision making under conditions of *risk.*

If the decision maker's information is not so complete and she does not know and cannot collect sufficient data to determine the probability of occurrence for some states of nature, she cannot find the expected value for each of her alternative actions. This is decision making under conditions of *uncertainty*. There is no way to solve problems under uncertainty without altering the nature of the problem. One can estimate, guess, or call "Psychic Friend" to assume some probability for each known state of nature and then deal with the problem as if it were one of risk. If the decision maker elects to ignore all states of nature except the one she thinks most likely, she then assumes there is one and only one possible outcome—which is decision making under conditions of *certainty*. Finally, the decision maker could assume that an opponent controls the state of nature and try to use *game theory* to solve her problem of decision making under conditions of *conflict*.

In the real world of project management, it has been common to deal with estimates of task durations, costs, etc. as if the information were known with certainty. On occasion, project task workers inflated times and costs and deflated specifications on the grounds that the boss would arbitrarily cut the project budget and duration and add to the specifications, thereby treating the problem as a decision under conflict with the boss as an opponent.

In fact, a great majority of all decisions made in the course of managing a project are actually made under conditions of uncertainty. In general, we will adopt the view that it is usually best to act as if decisions were made under conditions of risk. This will force us to make some estimates about the probability of various outcomes. If we use appropriate methods for doing this, we can apply what knowledge we have to solving project decision problems. We will not always be correct, but we will be doing the best we can. Such estimates are called "subjective probabilities," and are dealt with in most elementary courses on probability and statistics. While such probabilities are no more than guesses, they can be processed just as empirically determined probabilities are. Schuyler (1995) presents a brief, basic description of the use of subjective probability in decision-making problems. In the world of project management, a best guess is always better than no information at all. Now we can examine some of the effects of uncertainty on project selection.

At times an organization may wish to evaluate a project about which there is little information. R & D projects sometimes fall into this general class. But even in the comparative mysteries of R & D activities, the level of uncertainty about the outcomes of R & D is not beyond analysis. As we noted earlier, there is actually not much uncertainty about whether a product, process, or service can be developed, but there can be considerable uncertainty about *when* it will be developed and at *what* cost.

As they are with R & D projects, time and cost are also often uncertain in other types of projects. When the organization undertakes projects in which it has little or no recent experience—for example, the installation of a computer network, investment in an unfamiliar business, engaging in international trade, and a myriad of other projects common enough to organizations, in general, but uncommon to any single organization—there are three distinct areas of uncertainty. First, there is uncertainty about the timing of the project and the cash flows it is expected to generate. Second, though not as common as generally believed, there may be uncertainty about the direct outcomes of the project—that is, what it will accomplish. Third, there is uncertainty about the side effects of the project—its unforeseen consequences.

Typically, we try to reduce such uncertainty by the preparation of *pro forma* documents. *Pro forma* profit and loss statements and break-even charts are examples of such documents. The results, however, are not very satisfactory unless the amount of uncertainty is reflected in the data that go into the documents. When relationships between inputs and outputs in the projects are complex, Monte Carlo simulation (Evans and Olson, 1998; Law and Kelton, 1990; Meredith, Shafer, and Turban, 2002) can handle such uncertainty by exposing the many possible consequences of embarking on a project. *Risk analysis* is a method based on such a procedure. With the great availability of microcomputers and user-friendly software (e.g., Crystal Ball®), these procedures are becoming very common.

Risk Analysis and Simulation

As we noted in Chapter 1, risk analysis techniques will be introduced when they are relevant to a problem at hand. The information associated with project selection is characterized by uncertainty and is thus appropriate for the application of risk analysis. Before proceeding to demonstrate analytic techniques, however, it is helpful to understand the underlying nature of risk analysis.

The duration of project activities, the amounts of various resources that will be required to complete a project, the estimates made of the value of accomplishing a project, all these and many other aspects of a project are uncertain. While a project manager may be able to reduce uncertainty, it cannot be eliminated. Decisions must be made in the face of the ambiguity that results from uncertain information. Risk analysis does not remove the ambiguity, it simply describes the uncertainties in a way that provides the decision maker with a useful insight into their nature.

To apply risk analysis, one must make assumptions about the probability distributions that characterize key parameters and variables associated with a decision and then use these to estimate the *risk profiles* or probability distributions of the outcomes of the decision. This can be done analytically or by Monte Carlo simulation. When the decisions involve several input variables or parameters, simulation is highly preferable to the tedious calculations required by analytic methods. The simulation software (in our case Crystal Ball®, an Excel® Add-In) allows the decision to be represented by a mathematical model and then selects samples from the assumed distributions for each input. The software then plugs these inputs into the model and finds the outcome(s) of the decision.

This process is repeated many times and the statistical distribution of the outcomes is then displayed. The object of this process is to show the decision maker the distribution of the outcomes. This risk profile is used to assess the value of the decision along with other factors that might be relevant such as strategic concerns, socio/political factors, and impact on market share. Following a few comments about the nature of the input data and assumptions as in the case of R & D projects, we illustrate the use of Crystal Ball® (CB) to aid in the project selection decision.

General Simulation Analysis

Simulation combined with sensitivity analysis is also useful for evaluating R & D projects while they are still in the conceptual stage. Using the net present value approach, for example, we would support an R & D project if the net present value of the cash flows (including the initial cash investment) is positive and represents the best available alternative use of the funds. When these flows are estimated for purposes of analysis, it is well to avoid the *full-cost* philosophy that is usually adopted. The full-cost approach to estimating cash flows necessitates the inclusion of arbitrarily determined overheads in the calculation—overheads which, by definition, are not affected by change in product or process and, thus, are not relevant to the decision. The only relevant costs are those that will be changed by the implementation of the new process or product.

The determination of such costs is not simple. If the concept being considered involves a new process, it is necessary to go to the detailed *route sheet*, or *operations sequence sheet*, describing the operation in which the new process would be used. Proceeding systematically through the operating sequence step-by-step, one asks whether the present time and cost required for this step are likely to be altered if the new process concept is installed. If, and only if, the answer is yes, three estimates (optimistic, most likely, and pessimistic) are made of the size of the expected change. These individual estimated changes in production cost and time, together with upstream- or downstream-time and cost changes that might also result (e.g., a production method change on a part might also alter the cost of inspecting the final product), are used to generate the required cash flow information—presuming that the time savings have been properly costed. This estimation process will be explained in detail in Chapter 8.

The analysis gives a picture of the proposed change in terms of the costs and times that will be affected. The uncertainty associated with each individual element of the process is included. Simulation runs will then indicate the likelihood of achieving various levels of savings. Note also that investigation of the simulation model will expose the major sources of uncertainty in the final cost distributions.

Those without considerable experience in simulation should use this tool with caution. Simulation software is indifferent to assumptions-contrary-to-fact, and cares not a wit that the experimenter specifies a statistical distribution that implies a universe that never was nor ever will be. In such cases, the results of the simulation—often taken by the unwary as an estimate of reality—are apt to mislead.

PsychoCeramic Sciences Revisited

There is great value in performing risk analysis in order to confront the uncertainties in project selection. 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 in Table 2-2 for convenience. We found that the project cleared the barrier of a 12 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 3 percent annual inflation, the net present value of the 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.

Now let us assume that the expenditures in this example are fixed by contract with an outside vendor. Thus, there is no uncertainty about the outflows, but there is, of course, uncertainty about the inflows. Assume that the estimated inflows are as shown in Table 2-3 and include a most likely estimate, a minimum (pessimistic) estimate, and a maximum (optimistic) estimate. (In Chapters 7, "Budgeting and Cost Estimation" and 8, "Scheduling", we will deal in more detail with the methods and meaning of making such estimates.) Both the beta and the triangular statistical distributions 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 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 3 percent rate with a normal distribution, plus or minus 1 percent (i.e., 1 percent represents three standard deviations).

It is important to remember that other approaches in which only the most likely estimate of each variable is used are equivalent to an assumption of 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 (as the estimator sees reality) than a single "most likely" value, the distribution of outcomes developed by simulation is a better forecast of uncertain future

Table 2-2. Single-Point Estimate of the Cash Flows for PsychoCeramic Sciences, Inc.

	A	B	C	D	E	F	G
1					**Discount**	**Net Present**	
2	**Year**	**Inflow**	**Outflow**	**Net Flow**	**Factor**	**Value**	**Inflation**
3	**A**	**B**	**C**	**D = (B − C)**	**$1/(1 + K + p)^t$**	**D × (Disc. Factor)**	**Rate**
4	2006*	$0	$125,000	−$125,000	1.0000	−$125,000	0.03
5	2006	0	100,000	−100,000	0.8696	−$86,957	0.03
6	2007	0	90,000	−$90,000	0.7561	−$68,053	0.03
7	2008	50,000	0	$50,000	0.6575	$32,876	0.03
8	2009	120,000	15,000	$105,000	0.5718	$60,034	0.03
9	2010	115,000	0	$115,000	0.4972	$57,175	0.03
10	2011	105,000	15,000	$90,000	0.4323	$38,909	0.03
11	2012	97,000	0	$97,000	0.3759	$36,466	0.03
12	2013	90,000	15,000	$75,000	0.3269	$24,518	0.03
13	2014	82,000	0	$82,000	0.2843	$23,310	0.03
14	2015	65,000	0	$65,000	0.2472	$16,067	0.03
15	2015	35,000		$35,000	0.2472	$8,651	
16							
17	Total	$759,000	$360,000	$399,000		$17,997	
18							
19		*t = 0 at the beginning of 1996					
20							
21	**Formulae**						
22	Cell D4		= (B4-C4) copy to D5:D15				
23	Cell E4		= 1/(1 + .12 + G4)^0				
24	Cell E5		= 1/(1 + .12 + G5)^1				
25	Cell E6		= 1/(1 + .12 + G6)^(A6-2005) copy to E7:E15				
26	Cell F4		= D4*E4 copy to F5:F15				
27	Cell B17		Sum(B4:B15) copy to C17, D17, F17				

reality than a forecast of any single outcome can be. As any security analyst knows, a forecast of corporate quarterly earnings of $0.50–0.58 per share is far more likely to be accurate than a forecast of $0.54 per share. 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 are defined as *assumption cells*. For the PsychoCeramic Sciences case, these are the cells in Table 2-2, columns B and G, the inflows and the rate of inflation, respectively. The cells that contain outcomes of the model are called *forecast cells*, cell F17 in Table 2-2. 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.

Table 2-3. Pessimistic, Most Likely, and Optimistic Estimates of the Cash Flows for PsychoCeramic Sciences, Inc.

Year	*Minimum Inflow*	*Most Likely Inflow*	*Maximum Inflow*
2008	$35,000	$50,000	$60,000
2009	95,000	120,000	136,000
2010	100,000	115,000	125,000
2011	88,000	105,000	116,000
2012	80,000	97,000	108,000
2013	75,000	90,000	100,000
2014	67,000	82,000	91,000
2015	51,000	65,000	73,000
2015	30,000	35,000	38,000
Total	$621,000	$759,000	$847,000

To illustrate the process of defining an assumption cell, consider cell B7, the cash inflow estimate for 2008. We can see from Table 2-3 that the minimum expected cash 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.

Once one has entered the original information in Table 2-2, 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 2-3.
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 2-4. In the Assumption Name textbox at the top of the dialog box enter a descriptive label, e.g., *Cash Inflow-2008*. 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 changes from the most likely entry to the *mean* of the triangular distribution which is (Min + Likeliest + Max) / 3.

*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.

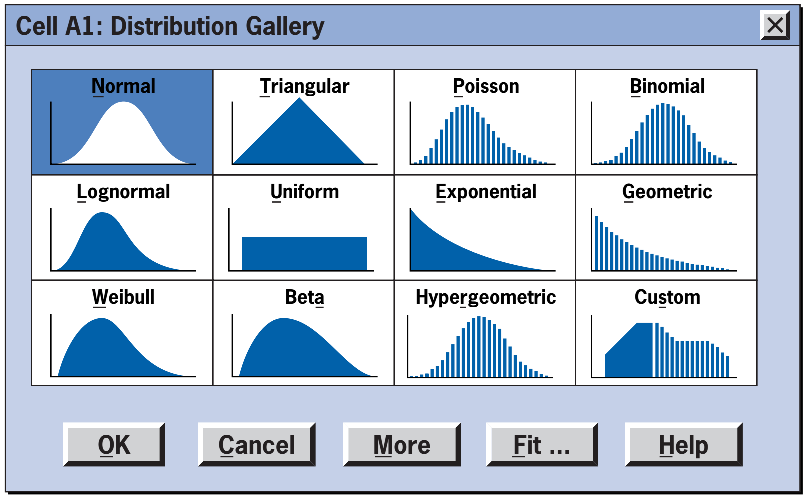


Figure 2-3 Crystal Ball® 2000's Distribution Gallery.

Now repeat steps 1–6 for the remaining cash flow assumption cells (cells B8:B15). Remember that the proper information to be entered is found in Table 2-3.

When finished with the cash flow cells, repeat the six-step procedure for assumption cells G4:G15. For this assumption select the **Normal** distribution and the entry for each cell in the series will be identical. We decided earlier to use a 3 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

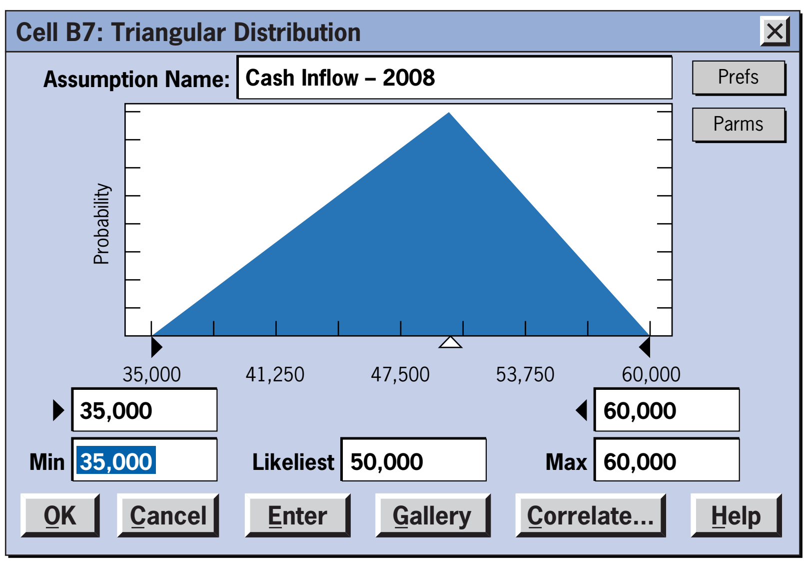


Figure 2-4 Crystal Ball® 2000 dialog box for model inputs assuming the triangular distribution.

or minus three standard deviations includes 99+ percent of the data. The normal distribution dialog box, Figure 2-5, calls for the distribution's mean and its standard deviation. The mean will be 0.03 (3 percent) for all cells. The standard deviation will be .0033 (one third of 1 percent) for all cells. (Note that Figure 2-5 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 3 percent and a range from 2 percent to 4 percent.

Note that there are two cash flows for the year 2006, 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 logical reason for an entry in G-4. CB seems to like one, however, so go ahead and enter it. In the **Assumption Name:** textbox for the G4 entry type *Inflation rate—2005*. Each of the following entries should be labeled with its appropriate year. The year 2015 raises a similar problem with two cash flows, but these both occur at the end of the year. When you constructed the spreadsheet, you probably copied cell E6 to the range E7:E15. If the inflation rate is fixed at 3 percent, that raises no problem, but when we make the inflation rate a random variable, that would allow G14 and G15, inflation for 2015, to be different. The fix is simple. First, click on **E15**. Then press the key **F2**. This shows the formula for E15 in its cell and it should appear as follows: = 1/(1 + 0.12 + G15)^(A15-2005). Move your cursor next to the "5" in "G15." Delete the "5" and change it to "4." You may now delete the entry in cell G15; the same inflation rate will now be used for both 2015 calculations.*

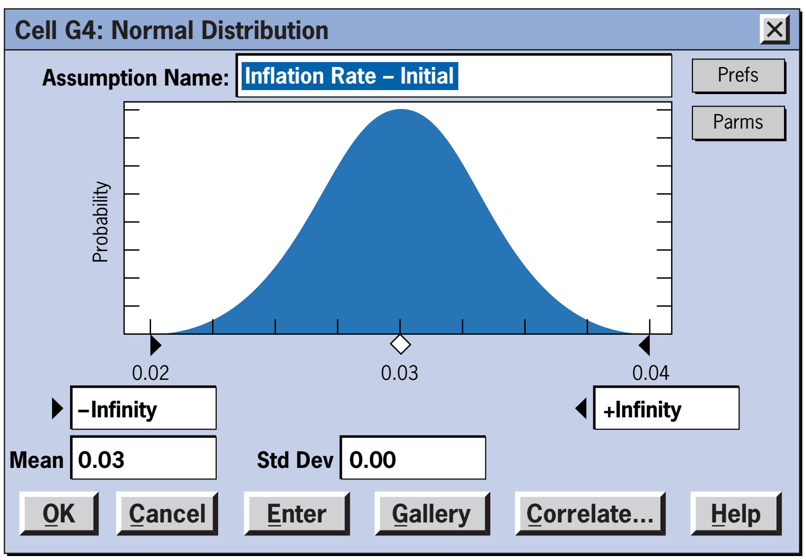


Figure 2-5 Crystal Ball® 2000 dialog box for model inputs assuming the normal distribution.

*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.

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 as shown in Figure 2-6. 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 there may be several. Use the same five steps for each.

When you have completed all entries, what was Table 2-2 is now changed and appears as Table 2-4.

We are now ready to simulate. CB randomly selects a value for each assumption cell based on the probability distributions 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 1,000 times, select the **Run** menu item from the toolbar at the top of the page. In the dropdown box that appears, select **Run Preferences**. In the Run Preferences dialog box that appears, enter **1,000** in the

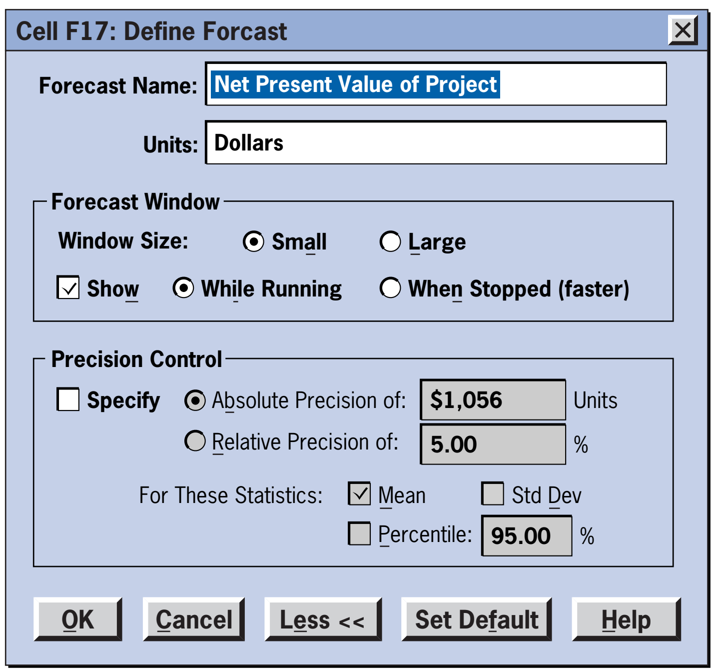


Figure 2-6 Crystal Ball® 2000 dialog box for the model forecast or outcome.

Table 2-4. Three-Point Estimates of Cash Flows and Inflation Rate for PsychoCeramic Sciences, Inc. All Assumptions and Forecast Cells Defined.

	A	B	C	D	E	F	G
1					**Discount**	**Net Present**	
2	**Year**	**Inflow**	**Outflow**	**Net Flow**	**Factor**	**Value**	**Inflation**
3	**A**	**B**	**C**	**D = (B − C)**	**$1/(1 + K + p)^t$**	**D × (Disc. Factor)**	**Rate**
4	2006*	$0	$125,000	−$125,000	1.0000	−$125,000	0.03
5	2006	0	100,000	−100,000	0.8696	−$86,957	0.03
6	2007	0	90,000	−$90,000	0.7561	−$68,053	0.03
7	2008	48,333	0	$48,333	0.6575	$31,780	0.03
8	2009	117,000	15,000	$102,000	0.5718	$58,319	0.03
9	2010	113,333	0	$113,333	0.4972	$56,347	0.03
10	2011	103,000	15,000	$88,00	0.4323	$38,045	0.03
11	2012	95,000	0	$95,000	0.3759	$35,714	0.03
12	2013	88,333	15,000	$73,333	0.3269	$23,973	0.03
13	2014	80,000	0	$80,000	0.2843	$22,741	0.03
14	2015	63,000	0	$63,000	0.2472	$15,573	0.03
15	2015	34,333		$34,333	0.2472	$8,487	
16							
17	Total	$742,333	$360,000	$382,333		$10,968	
18		*t = 0 at the beginning of 2006					

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 2-7.

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 toolbar and then select **Statistics** from the dropdown menu that appears. The Statistics view for the frequency chart (Figure 2-7) is illustrated in Figure 2-8.

Figure 2-8 contains some interesting information. Both the mean and median outcomes from the simulation are nicely positive and thus well above the hurdle rate of 12 percent There are, however, several negative outcomes and those are below the hurdle rate. What is the likelihood that this project will achieve an outcome at or above the hurdle rate? With CB, the answer is easy. Using the display shown in Figure 2-9, erase *–Infinity* from the box in the lower left corner. Type *$0* (or *$1*) in that box and press **Enter**. Figure 2-7 now changes as shown in Figure 2–9. The boxes at the bottom of Figure 2–9 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 yield an outcome at or above the 12 percent hurdle rate.

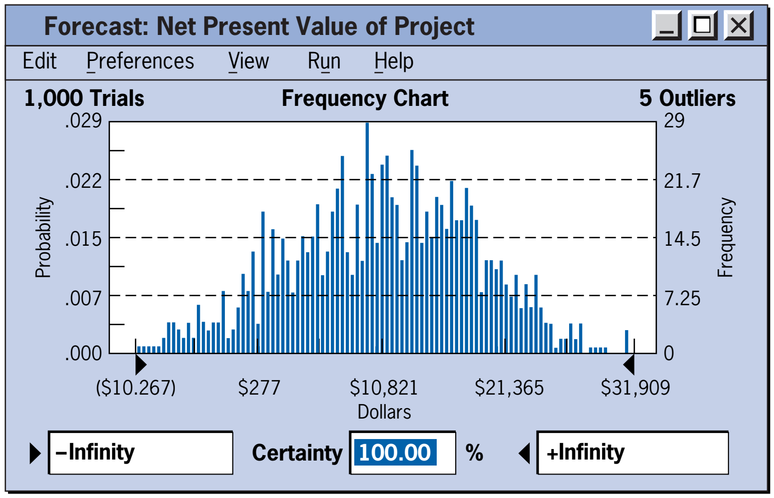


Figure 2-7 Frequency chart of the simulation output for net present value of PsychoCeramic Sciences project.

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

Forecast: Net Present Value of Project

Edit Preferences View Run Help

Cell F17 **Statistics**

Statistic	Value
Trials	1,000
Mean	$10,965
Median	$11,296
Mode	—
Standard Deviation	$8,066
Variance	$65,052,849
Skewness	–0.21
Kurtosis	2.71
Coeff. of Variability	0.74
Range Minimum	($15,656)
Range Maximum	$31,909
Range Width	$47,566
Mean Std. Error	$255.05

Figure 2-8 Summary statistics of the simulation output for net present value of PsychoCeramic Sciences project.

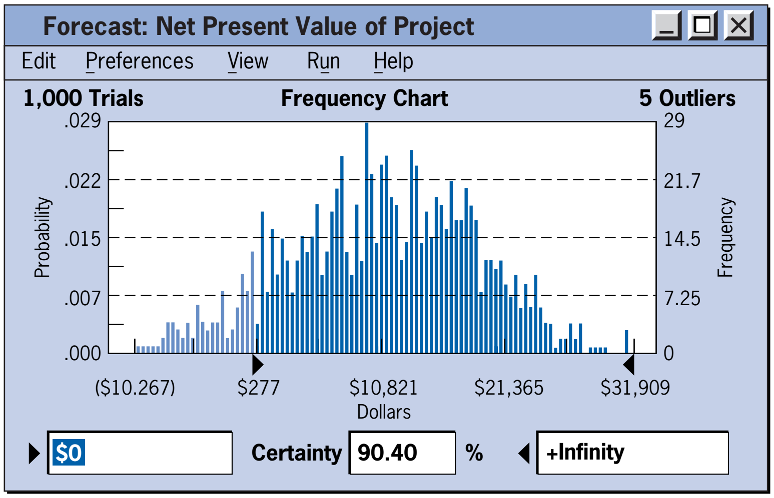


Figure 2-9 Calculating the probability that the net present value of the PsychoCeramic Sciences project is equal to or greater than the firm's hurdle rate.

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.

Window-of-Opportunity Analysis In the early stages of new product development, one may know little more than the fact that the potential product seems technically feasible. That one can achieve a new technology does not necessarily imply that the new technology is worth implementing, or economically profitable. Fundamentally, the decision to invest in the development of a new process or product depends on an estimate of cash flows and other benefits expected to result if the innovation is successful—a difficult problem at best. The traditional approach has been to implement the technology in question (or a pilot version of it) and then test it to see if it qualifies as useful and economic. This is often a wasteful process because it assumes the innovation will be successful—a condition not always met in practice.

Given some idea for a new product or process, we can invert this traditional approach by attempting to determine the cost and performance specifications that must be met by the new technology before any R & D is undertaken. (This is called the *window-of-opportunity* for the innovation.) The method for conducting such an analysis is straightforward. Given a potential production process, for example, the current production process is analyzed in detail and any element of that process that might be affected by the innovation is noted. Baseline data on the current process is collected (e.g., its cycle time, its cost) and the effect of the innovation is estimated relative to (usually some fraction or multiple of) the baseline system. Having thus estimated the economic impact of the innovation, the decision of whether or not to undertake the development project is much simpler. For an example of such an approach see Evans and Mantel (1985) and Mantel, Evans, and Tipnis (1985).

2.6 COMMENTS ON THE INFORMATION BASE FOR SELECTION

Our bias in favor of weighted scoring models is quite clear and weighted scoring models can be simulated because both the scores and the weights are usually estimates. But irrespective of which model is chosen for project selection, a data base must be created and maintained to furnish input data for the model. Directions for the actual construction of the data base go beyond the scope of this book, but some comments about the task are in order.

The use of any project selection model assumes that the decision-making procedure takes place in a reasonably rational organizational environment. Such is not always the case. In some organizations, project selection seems to be the result of a political process, and sometimes involves questionable ethics, complete with winners and losers (Baker and Menon, 1995). In others, the organization is so rigid in its approach to decision making that it attempts to reduce all decisions to an algorithmic proceeding in which predetermined programs make choices so that humans have minimal involvement—and responsibility. Here too, Saaty's (1990) Analytic Hierarchy Process can lend rationality to a sometimes irrational process. In an interesting paper, Huber (1981) examines the impact that the organizational environment has on the design of decision support systems.

The remainder of this section deals with three special problems affecting the data used in project selection models.

Accounting Data

Whether managers are familiar with accounting systems or not, they can find it useful to reflect on the methods and assumptions used in the preparation of accounting data. Among the most crucial are the following:

1. Accountants live in a linear world. With few exceptions, cost and revenue data are assumed to vary linearly with associated changes in inputs and outputs.
2. The accounting system often provides cost-revenue information that is derived from standard cost analyses and equally standardized assumptions regarding revenues. These standards may or may not be accurate representations of the cost-revenue structure of the physical system they purport to represent.
3. As noted in the previous section, the data furnished by the accounting system may or may not include overhead costs. In most cases, the decision maker is concerned solely with cost-revenue elements that will be changed as a result of the project under consideration. Incremental analysis is called for, and great care should be exercised when using pro forma data in decision problems. Remember that the assignment of overhead cost is always arbitrary. The accounting system is the richest source of information in the organization, and it should be used—but with great care and understanding.

Measurements

It is common for those who oppose a project, for whatever reason, to complain that information supporting the project is "subjective." This epithet appears to mean that the data are biased and therefore untrustworthy.

To use the scoring methods discussed or to practice risk management in project selection, we need to *represent*, though not necessarily *collect*, expected project performance for each criterion in numeric form. If a performance characteristic cannot be measured directly as a number, it may be useful to characterize performance verbally and then, through a word/number equivalency scale, use the numeric equivalents of verbal characterizations as model inputs.

Subjective versus Objective The distinction between subjective and objective is generally misunderstood. All too often the word *objective* is held to be synonymous with *fact* and *subjective* is taken to be a synonym for *opinion*—where fact = true and opinion = false. The distinction in measurement theory is quite different, referring to the location of the standard for measurement. A measurement taken by reference to an external standard is said to be "objective." Reference to a standard that is internal to the system is said to be "subjective." A yardstick, incorrectly divided into 100 divisions and labeled "meter," would be an objective but inaccurate measure. The eye of an experienced judge is a subjective measure that may be quite accurate.

Quantitative versus Qualitative The distinction between quantitative and qualitative is also misunderstood. It is not the same as numeric and nonnumeric. Both quantity and quality may be measured numerically. The number of words on this page is a quantity. The color of a red rose is a quality, but it is also a wavelength that can be measured numerically, in terms of microns. The true distinction is that one may apply the law of addition to quantities but not to qualities (van Gigch, 1978). Water, for example, has a volumetric measure and a density measure. The former is quantitative and the latter qualitative. Two one-gallon containers of water poured into one larger container give us two gallons, but the density of the water, before and after joining the two gallons, is still the same: 1.0.

Reliable versus Unreliable A data source is said to be reliable if repetitions of a measurement produce results that vary from one another by less than a prespecified amount. The distinction is important when we consider the use of statistical data in our selection models.

Valid versus Invalid Validity measures the extent to which a piece of information actually means what we believe it to mean. A measure may be reliable but not valid. Consider our mismarked 36-inch yardstick pretending to be a meter. It performs consistently, so it is reliable. It does not, however, match up accurately with other meter rules, so it would not be judged valid.

To be satisfactory when used in the previous project selection models, the measures may be either subjective or objective, quantitative or qualitative, but they must be numeric, reliable, and valid. Avoiding information merely because it is subjective or qualitative is an error and weakens decisions. On the other hand, including information of questionable reliability or validity in selection models, even though it may be numeric, is dangerous. It is doubly dangerous if decision makers are comfortable dealing with the selection model but are unaware of the doubtful character of some input data. A condition a colleague has referred to as GIGO—garbage in, *gospel* out—may prevail.

Uncertain Information

In the section on weighted scoring models, we noted some useful methods for finding the numeric weights and criteria scores when they take the form of verbal descriptors rather than numbers. These same methods are also useful when estimating the inputs for risk analysis models. Indeed, one of the first applications of the Delphi method (Dalkey, 1969) was technological forecasting—forecasting the time period in which some specific technological capability would be available. These methods are commonly used when a group must develop a consensus concerning such items as the importance of a technological change, an estimate of cash flows, a forecast of some economic variable, and similar uncertain future conditions or events.

In Chapter 4 we will deal with the problem of organizing the activity of risk analysis and making such estimates as are required for dealing with uncertainty, either through simulation or by analytic methods. Next, we exemplify the project selection process described previously by detailing an eight-step process that holds promise for improving an organization's project management maturity and at the same time ties the projects more closely to the organization's goals.

2.7 PROJECT PORTFOLIO PROCESS (PPP)

Important inputs to this process are the organization's goals and strategies, and we assume here that the organization has already identified its mission, goals, and strategies—by using some formal analytic method such as SWOT analysis (strengths, weaknesses, opportunities, threats), and that these are well known throughout the organization. If this is not the case, then any attempt to tie the organization's projects to its goals is folly and the PPP will have little value.

If the goals and strategies have been well articulated, however, then the PPP can serve many purposes:

- To identify proposed projects that are not really projects and should be handled through other processes
- To prioritize the list of available projects
- To intentionally limit the number of overall projects being managed so the important projects get the resources and attention they need
- To identify projects that best fit the organization's goals and strategy
- To identify projects that support multiple organizational goals and cross-reinforce other important projects
- To eliminate projects that incur excessive risk and/or cost
- To eliminate projects that bypassed a formal selection process and may not provide benefits corresponding to their risks and/or costs
- To keep from overloading the organization's resource availability
- To balance the resources with the needs
- To balance short-, medium-, and long-term returns

The 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. On occasion this will mean shutting down projects prior to their completion because their risks have become excessive, their costs have escalated out of line with their expected benefits, another (or a new) project does a better job of supporting the goals, or any variety of similar reasons. It should be noted that a significant portion of the administration of this process could be managed by the Project Management Office, a concept to be discussed in Chapter 4.

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 those projects spanning internal or external boundaries of the organization, such as cross-departmental or joint venture. Thus, senior managers must play a major role in this council. Without the commitment of senior management, the PPP will be incapable of achieving its main objectives. 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, others who should be members of the project council are:

- the project managers of major projects;
- the head of the Project Management Office, if one exists;
- particularly relevant general managers;
- those who can identify key opportunities and risks facing the organization; and
- anyone who can derail the progress of the PPP later on 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 discriminate between very good and even better projects. The criteria are also weighted to reflect their relative importance. Identifying separate categories not only facilitates achievement of multiple organizational goals (e.g., long term, short term, internal, external, tactical, strategic) but also keeps projects from competing with each other on inappropriate categories.

The first task in this step is to list the goals of each existing and proposed project—what is the mission, or purpose, of this 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. Some of these were noted above but another way to position some of the projects (particularly product/service development projects) is in terms of their 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 2-10. 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 thus 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

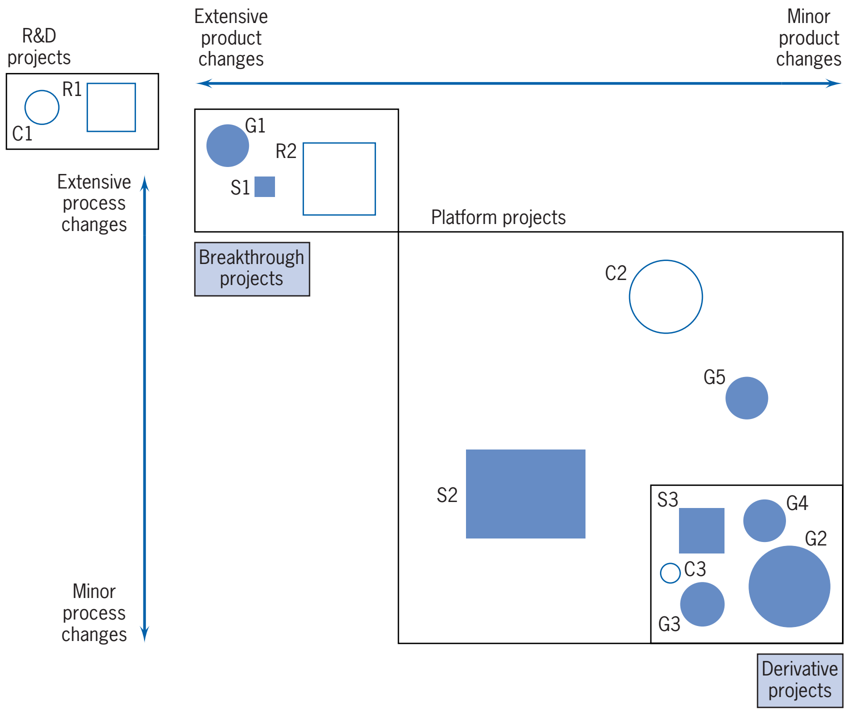


Figure 2-10 An example aggregate project plan.

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, e.g., 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 for many purposes:

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

Next, the council should develop separate criteria and cost ranges for each category that determine those projects that will support the organizational strategy and goals. Example criteria might include alignment with the organization's goals/strategy, riskiness of the project, financial return, probability of success, likelihood of achieving a breakthrough in a critical offering, appeal to a large (or new) market, impact on customer satisfaction, contribution to employee development, knowledge acquisition, and availability of staff/resources.

Scales also need to be determined for each criterion to measure how different projects score on each of them. The scales on which these criteria are measured should be challenging so that the scores separate the best projects from those that are merely good. The scales should also serve as an initial screen, to start the process of winnowing out the weakest projects. Thus, they should include limits on their extremes, such as minimum rate of return (if a financial criterion is appropriate), maximum probability of technical failure given proposed budget and schedule, or minimum acceptable potential market share.

Finally, the council needs to set an importance weighting for the various criteria in each category. Note that even if the same criteria apply to multiple categories, their weights might be different. For example, if a firm needs to develop high-level, skilled project managers for their strategic projects, employee development might be more important for breakthrough projects but less important for derivative projects. Also, the weights might change depending on the life cycle stage of the project. For example, early in a project's life, strategic considerations are often most important while in the midpoint of a project, tactical considerations might be more important.

The model we have described above is a "weighted, factor scoring model," as described earlier. As noted then, there are some standard, well-known tools to help develop the weights, scales, and criteria such as the Delphi method (Dalkey, 1969), the analytic hierarchy process (AHP), (Saaty, 1980), a simplified version of AHP by Frame (1997), and even software such as *Expert Choice*®. For more complex situations, with large numbers of projects and or large councils, the more sophisticated approaches are often more helpful, particularly if used with software that automatically calculates the scores and ranks the projects.

Step 3: Collect Project Data

For each existing and proposed project, assemble the data appropriate to that category's criteria. Be sure to update the data for ongoing projects and not just use the data from the previous evaluation. For cost data, use "activity based costs" (see Section 7.1) rather than incremental costs. Challenge and try to verify all data; get other people involved in validating the data, perhaps even customers (e.g., market benefit). 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 this data. Then document any assumptions made so that they can be checked in the future as the project progresses. If the project is new, you may want to fund only enough work on the project to verify the assumptions or determine the window-of-opportunity for the proposed product or process, holding off full funding until later. Similarly, identify any projects that can be deferred to a later time period, those that must precede or follow other projects, those that support other projects or should be done in conjunction with them, those that can be outsourced, and other such special aspects of the projects.

Next, use the criteria score limits to screen out the weaker projects: 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? Does a competitor's new entry obviate the advantages of a project? Does a new (or old) project dominate an existing or proposed project in terms of its benefits, furtherance of organizational goals, reduced costs? Also, screen *in* any projects that do not require deliberation, such as projects mandated by regulations or laws, projects that are operating or competitive necessities, 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, leaving time for vacations, personal needs, illness, holidays, and most important, regular functional (nonproject) work. After allowing for all of these things that limit labor availability, add a bit more, perhaps 10 percent, to allow for the well-known fact that human beings need occasional short breaks to rest or meet other human needs. 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. This is the major subject of Chapter 9.

Step 5: Reduce the Project and Criteria Set

In this step, multiple screens are employed to try to narrow down 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
- How profitable the offering is likely to be
- 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 organization's 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

One way to evaluate the dominance of some projects over others, and at the same time eliminate nondifferentiating criteria, is by comparing the coefficients of variation of each of the criteria across the projects. This technique allows an analyst to maximize the variation within the project set across relevant criteria, eliminating similar projects that are dominated, and identifying criteria that, at least in this evaluation round, do not differentiate among the projects. See Raz (1997) for an example of this approach.

The result of this step may involve canceling some ongoing projects or replacing them with new, more promising projects. Beware, however, of the tendency to look more favorably upon new, untested concepts than on current projects experiencing the natural problems and hurdles of any promising project.

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 or other methods and used in the weighted factor scoring model. It should be remembered that such criteria as riskiness are usually composite measures of a set of "risks" in different areas. The same is true of criteria like "development of new knowledge."

When checking the results of this step, however, reconsider the projects in terms of their benefits first and their resource costs second. The former are commonly more difficult to assess and a reconsideration based on more familiarity with the project profiling process and other project evaluations may suggest interchanging the priority of neighboring projects. This could be especially critical around the project cutoff point. Because the projects competing around the cutoff point are typically quite close in benefit/cost scores, there are usually no serious consequences resulting from "errors." This is, however, an excellent problem on which to use *sensitivity analysis*.

It is also possible at this time for the council to summarize the "returns" from the projects to the organization. However, this 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 an important one: determining the mix of projects across the various categories (and aspects, if used) and time periods. Next, be sure to leave some percent (often 10–15 percent) 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 a good practice to include some speculative projects in each category to allow future options, knowledge improvement, additional experience in new areas, and such.

Overall, 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 some, if any, were defunded. One special type of delayed project mentioned earlier is sometimes called an "out-plan" project (in contrast to the selected "in-plan" projects) (Englund and Graham, 2000). Out-plan projects are those that appear promising but are awaiting further investigation before a final decision is made about their funding, which could occur in the next PPP cycle or sooner, if they warrant the use of some of the 10–15 percent funding holdout.

The result of this step (and most of the project portfolio process) is illustrated in the Plan of Record shown in Figure 2-11. Here, the mix across categories is listed, the priorities and resource needs of each project are given, the timing (schedule) of each project over the PPP cycle (6 months assumed here) is shown (to match resource availability), the out-plan projects, if any, are shown, and the total resource needs and availabilities are listed.

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 non-selection as was mentioned earlier. Top management must now make their commitment to this project portfolio process totally clear by supporting the process and the results. This may require a PPP champion near the top of the organization. As project proposers

Category	*Priority*	*Project*	*Resources*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*
Derivative									
50% of mix	1	R	500						
	2	K	800						
	3	M	300						
Total			1600						
Available			(1800)						
External									
20% of mix	1	S	500						
	2	V	150						
	out-plan	LT							
Total			650						
Available			(720)						
Strategic									
30% of mix	1	A	600						
	2	W	370						
	out-plan	SB							
Total			970						
Available			(1080)						
Aggregate Total			3220						
Unspent			380						
10% reserve			400						
Total Available			4000						

Figure 2-11 Plan of Record.

come to understand 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 not appropriate 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. The council needs to be wary of interpersonal or interdepartmental competition entering the scene at this point also. In some organizations, individuals with their own particular agenda will ignore committees and processes (they may be heard to argue that committees never affect anything anyway) until implementation time rolls around, and then they attempt to exercise their political power to undermine the results of others' long labors. If this does occur, it is indicative of serious organizational problems and the PPP process will fail until the problems are corrected.

Of course, the process will need to be repeated on a regular basis. The council should determine how often this should be, and to some extent it depends on the speed of change in the industry the organization is in. For some industries, quarterly analysis may be best while in slow-moving industries, yearly may be fine.

Finally, the process should be flexible and improved continuously. Instinct may suggest ways that the process may be altered to better match the competitive environment, or to reflect more closely the organization's goals. The process should be changed when it is found appropriate to do so, including categories, criteria, steps, the order of tasks, and so on.

We offer a final note on this subject of creating and managing a portfolio of projects. In the preceding description of portfolio building it was tacitly assumed that the projects were independent and could be dealt with individually. At times, the projects in a portfolio are not independent. Dickinson, Thornton, and Graves (2001) describe a model developed for the Boeing Company that optimizes a portfolio of interdependent product improvement projects. The model includes risk as well as cost/benefit analysis.

2.8 PROJECT PROPOSALS

Now that project selection methods have been discussed, it is appropriate to consider what documentation is needed to evaluate a project that is being considered. The set of documents submitted for evaluation is called the *project proposal*, whether it is brief (a page or two) or extensive, and regardless of the formality with which it is presented. Several issues face firms preparing proposals, particularly firms in the aerospace, construction, defense, and consulting industries. These are:

1. Which projects should be bid on?
2. How should the proposal-preparation process be organized and staffed?
3. How much should be spent on preparing proposals for bids?
4. How should the bid prices be set? What is the bidding strategy? Is it ethical?

Generally, these decisions are made on the basis of their overall expected values, perhaps as reflected in a scoring model. In-house proposals submitted by a firm's personnel to that firm's top management do not usually require the extensive treatment given to proposals submitted to outside clients or agencies such as the Department of Defense. For the Department of Defense, a proposal must be precisely structured to meet the requirements contained in the official Request for Proposal (RFP) or Request for Quotation (RFQ)—more specifically, in the Technical Proposal Requirements (TPR) that is part of the RFP or RFQ.

The construction and preparation of a proposal to be submitted to the government or other outside funder is beyond the scope of this book. Fortunately, the subject has been well treated by Knutson (1996a, 1996b, and 1996c) in a three-part paper that begins with a discussion of the decision whether or not to seek some particular business.

The series then covers the composition of a team to write the proposal and Knutson's view of how to structure, price, and submit the proposal. The interested reader is also referred to Rosenau (1991). Finally, it should be noted that customs, practices, rules, and laws concerning proposals vary from nation to nation (e.g., see Jergeas and Cooke, 1997).

All proposals should begin with a short summary statement (an "Executive Summary") covering the fundamental nature of the proposal in *minimally technical language*, as well as the general benefits that are expected. All proposals should be accompanied by a "cover letter." Roman (1986, pp. 67–68) emphasizes that the cover letter is a key marketing document and is worthy of careful attention. In addition to the Executive Summary and the cover letter, every proposal should deal with four distinct issues: (1) the nature of the technical problem and how it is to be approached; (2) the plan for implementing the project once it has been accepted; (3) the plan for logistic support and administration of the project; and (4) a description of the group proposing to do the work, plus its past experience in similar work.

The precise way in which the contents of a proposal are organized usually follows the directions found in the TPR or RFP, the stated requirements of a specific potential funder, the traditional form used by the organization issuing the proposal, or, occasionally, the whim of the writer. As is the case with most products, the highest probability of acceptance will occur when the proposal meets the expectations of the "buyer," as to form and content. At times there is a tendency to feel that "nontechnical" projects (by which is usually meant projects that are not concerned with the physical sciences or a physical product) are somehow exempt from the need to describe how the problem will be approached and how the project will be implemented—including details such as milestones, schedules, and budgets. To deal with nontechnical projects casually is folly and casts considerable doubt on the proposer's ability to deliver on promises. (It is all too common for projects concerned with the development of art, music, drama, and computer software, among other "nontechnical" areas, to be quite vague as to deliverables, deadlines, and costs.) On the other hand, when the proposal is aimed at another division or department of the same parent organization, the technical requirements of the proposal may be greatly relaxed, but the technical approach and implementation plan are still required—even if their form is quite informal.

The Technical Approach

The proposal begins with a general description of the problem to be addressed or project to be undertaken. If the problem is complex, the major subsystems of the problem or project are noted, together with the organization's approach to each. The presentation is in sufficient detail that a knowledgeable reader can understand what the proposer intends to do. The general method of resolving critical problems is outlined. If there are several subsystems, the proposed methods for interfacing them are covered.

In addition, any special client requirements are listed along with proposed ways of meeting them. All test and inspection procedures to assure performance, quality, reliability, and compliance with specifications are noted.

The Implementation Plan

The implementation plan for the project contains estimates of the time required, the cost, and the materials used. Each major subsystem of the project is listed along with estimates of its cost. These costs are aggregated for the whole project, and totals are shown for each cost category. Hours of work and quantities of material used are shown (along with the wage rates and unit material costs). A list of all equipment costs is added, as is a list of all overhead and administrative costs.

Depending on the wishes of the parent organization and the needs of the project, time charts, Program Evaluation and Review Technique (PERT)/Critical Path Method (CPM), or Gantt charts are given for each subsystem and for the system as a whole. (See Chapter 8 for more about PERT/CPM and Gantt charts.) Personnel, equipment, and resource usages are estimated on a period-by-period basis in order to ensure that resource constraints are not violated. Major milestones are indicated on the time charts. Contingency plans are specifically noted. For any facility that might be critical, load charts are prepared to make sure that the facility will be available when needed.

The Plan for Logistic Support and Administration

The proposal includes a description of the ability of the proposer to supply the routine facilities, equipment, and skills needed during any project. Having the means to furnish artist's renderings, special signs, meeting rooms, stenographic assistance, reproduction of oversized documents, computer graphics, word processing, video teleconferencing, and many other occasionally required capabilities provides a "touch of class." Indeed, their unavailability can be irritating. Attention to detail in all aspects of project planning increases the probability of success for the project—and impresses the potential funder.

It is important that the proposal contain a section explaining how the project will be administered. Of particular interest will be an explanation of how control over subcontractors will be administered, including an explanation of how proper subcontractor performance is to be insured and evaluated. The nature and timing of all progress reports, budgetary reports, audits, and evaluations are covered, together with a description of the final documentation to be prepared for users of the proposed deliverables. Termination procedures are described, clearly indicating the disposition of project personnel, materials, and equipment at project end.

A critical issue, often overlooked, that should be addressed in the administrative section of the proposal is a reasonably detailed description of how *change orders* will be handled and how their costs will be estimated. Change orders are a significant source of friction (and lawsuits) between the organization doing the project and the client. The client rarely understands the chaos that can be created in a project by the introduction of a seemingly simple change. To make matters worse, the group proposing the project seems to have a penchant for misleading the potential client about the ease with which "minor" changes can be adopted during the process of implementing the project. Control of change orders is covered in Chapter 11.

Past Experience

All proposals are strengthened by including a section that describes the past experience of the proposing group. It contains a list of key project personnel together with their titles and qualifications. For outside clients, a full résumé for each principal should be attached to the proposal. When preparing this and the other sections of a proposal, the proposing group should remember that the basic purpose of the document is to convince a potential funder that the group and the project are worthy of support. The proposal should be written accordingly.

SUMMARY

This chapter initiated our discussion of the project management process by describing procedures for strategically evaluating and selecting projects. We first described the strategic objective of using projects to help achieve the organization's goals and strategy, and a project portfolio process to help achieve this. We then outlined some criteria for project selection models and then discussed the general nature of these models. The chapter then described the types of models in use and their advantages and disadvantages. Considering the degree of uncertainty associated with many projects, a section was devoted to evaluating the impact of risk and uncertainty. Concluding the discussion, some general comments were made about data requirements and the use of these models. The final section discussed the documentation of the evaluation/selection process via project proposals.

The following specific points were made in this chapter:

- The role of projects in achieving the organization's goals and strategy is critical.
- The eight-step project portfolio process is an effective way to select and manage projects that are tied to the organization's goals.
- Primary model selection criteria are realism, capability, flexibility, ease of use, and cost.
- Preparatory steps in using a model include: (1) identifying the firm's objectives; (2) weighting them relative to each other; and (3) determining the probable impacts of the project on the firm's competitive abilities.
- Project selection models can generally be classified as either numeric or nonnumeric; numeric models are further subdivided into profitability and scoring categories.
- Nonnumeric models include: (1) the sacred cow; (2) the operating necessity; (3) the competitive necessity; and (4) comparative benefit.
- Profitability models include standard forms such as: (1) payback period; (2) average rate of return; (3) discounted cash flow; (4) internal rate of return; and (5) profitability index.
- Project management maturity measurement is a way of assessing an organization's ability to conduct projects successfully.
- Scoring models—the authors' preference—include: (1) the unweighted 0–1 factor model; (2) the unweighted factor scoring model; (3) the weighted factor scoring model; and (4) the constrained weighted factor scoring model.
- For handling uncertainty: (1) pro forma documents; (2) risk analysis; (3) and simulation with sensitivity analysis are all helpful.
- Special care should be taken with the data used in project selection models. Of concern are data taken from an accounting data base, how data are measured and conceived, and the effect of technological shock.
- Project proposals generally consist of a number of sections: (1) the technical approach; (2) the implementation plan; (3) the plan for logistic support and administration; and (4) past experience.

In the next chapter we consider the selection of the appropriate manager for a project and what characteristics are most helpful for such a position. We also address the issue of the project manager's special role, and the demands and responsibilities of this critical position.

GLOSSARY

Decision Support System A computer package and data base to aid managers in making decisions. It may include simulation programs, mathematical programming routines, and decision rules.

Delphi A formalized method of group decision making that facilitates drawing on the knowledge of experts in the group.

Deterministic Predetermined, with no possibility of an alternate outcome. Compare with stochastic.

Expert System A computer package that captures the knowledge of recognized experts in an area and can make inferences about a problem based on decision rules and data input to the package.

Maturity The sophistication and experience of an organization in managing multiple projects.

Model A way of looking at reality, usually for the purpose of abstracting and simplifying it, to make it understandable in a particular context.

Network A group of items connected by some common mechanism.

Portfolio A group or set of projects with varying characteristics.

Pro forma Projected or anticipated, usually applied to financial data such as balance sheets and income statements.

Programming An algorithmic methodology for solving a particular type of complex problem, usually conducted on a computer.

Project portfolio process An eight-step procedure for selecting, implementing, and reviewing projects that will help an organization achieve its strategic goals.

Risk analysis A procedure that uses a distribution of input factors and probabilities and returns a range of outcomes and their probabilities.

Sensitivity analysis Investigation of the effect on the outcome of changing some parameters or data in the procedure or model.

Simulation A technique for emulating a process, usually conducted a considerable number of times to understand the process better and measure its outcomes under different policies.

Stochastic Probabilistic, or not deterministic.

QUESTIONS

Material Review Questions

1. What are the four parts of a technical proposal?
2. By what criteria do you think managers judge selection models? What criteria *should* they use?
3. Contrast the competitive necessity model with the operating necessity model. What are the advantages and disadvantages of each?
4. What is a sacred cow? Give some examples.
5. Give an example of a Q-Sort process for project selection.
6. What are some of the limitations of project selection models?
7. What is the distinction between a qualitative and a quantitative measure?
8. How does the discounted cash flow method answer some of the criticisms of the payback period and average rate of return methods?
9. What are some advantages and disadvantages of the profit/profitability numeric models?
10. How is sensitivity analysis used in project selection?
11. Contrast risk with uncertainty. Describe the window-of-opportunity approach.
12. Describe the eight-step project portfolio process.
13. What does the term "maturity" mean?
14. How does a risk analysis operate? How does a manager interpret the results?

Class Discussion Questions

15. Which of the many purposes of the project portfolio process are most important to a firm with a low project management maturity? Which to a firm with high maturity?

16. On what basis does the real options model select projects?

17. What is the real difference between profitability and scoring models? Describe a model that could fit both categories.

18. Can risk analysis be used for nonproject business decision making? Explain how.

19. Discuss how the following project selection models are used in real-world applications.
  (a) Capital investment with discounted cash flow.
  (b) Simulation models.

20. Why do you think managers underutilize project selection models?

21. Would uncertainty models be classified as profitability models, scoring models, or some other type of model?

22. Contrast validity with reliability. What aspects, if any, are the same?

23. Contrast subjective and objective measures. Give examples of the proper use of each type of measure when evaluating competing projects.

24. Can a measure be reliable, yet invalid? Explain.

25. Is project management maturity focused on doing better on multiple projects or single projects?

26. Are there certain types of projects that are better suited for nonnumeric selection methods as opposed to numeric ones?

27. Identify some of the ethical issues that can arise in a bid response to an RFP.

28. Interpret the columns of data in Table 2-4. Does the $10,968 value mean that the project is expected to return only this amount of discounted money?

29. How would you find the probability in Figure 2-9 of an NPV of over $20,000?

30. Reconsider Table 2-3 to explain why the simulated outcome in Table 2-4 is only about half as much as the value originally obtained in Table 2-2. Does the spread of the data in Table 2-3 appear realistic?

31. What important comparisons does the aggregate project plan in Figure 2-10 allow?

32. What does the plan of record illustrate that the aggregate project plan does not?

Questions for Project Management in Practice

Implementing Strategy through Projects at Blue Cross/Blue Shield

33. Is the new project management approach to implementing strategy bottom-up or top-down?

34. What is the role of projects and their management in this new process? That is, wouldn't a functional approach have worked just as well?

35. What other benefits might you expect from a system such as this?

Project Selection for Spent Nuclear Fuel Cleanup

36. Why did it take five months to explain the problem to the stakeholders?

37. Why do you think the stakeholders no longer trusted the authorities?

38. What might have been the problems with options 1, 2, and 4?

39. How is option 3 a solution?

PROBLEMS

1. Two new Internet site projects are proposed to a young start-up company. Project A will cost $250,000 to implement and is expected to have annual net cash flows of $75,000. Project B will cost $150,000 to implement and should generate annual net cash flows of $52,000. The company is very concerned about their cash flow. Using the payback period, which project is better, from a cash flow standpoint?

2. Sean, a new graduate at a telecommunications firm, faces the following problem his first day at the firm: What is the average rate of return for a project that costs $200,000 to implement and has an average annual profit of $30,000?

3. A four-year financial project has net cash flows of $20,000; $25,000; $30,000; and $50,000 in the next four years. It will cost $75,000 to implement the project. If the required rate of return is 0.2, conduct a discounted cash flow calculation to determine the NPV.

4. 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?

5. Calculate the profitability index for Problem 3. For Problem 4.

6. A four-year financial project has estimates of net cash flows shown in the following table:

Year	Pessimistic	Most Likely	Optimistic
1	$14,000	$20,000	$22,000
2	19,000	25,000	30,000
3	27,000	30,000	36,000
4	32,000	35,000	39,000

It will cost $65,000 to implement the project, all of which must be invested at the beginning of the project. After the fourth year, the project will have no residual value.

Using the most likely estimates of cash flows, conduct a discounted cash flow calculation assuming a 20 percent hurdle rate with no inflation. (You may use either Excel or a paper-and-pencil calculation.) What is the discounted profitability index of the project?

7. Given the table in Problem 6, assume that the cash flow estimates for each year are best represented by a triangular distribution and that the hurdle rate is 20 percent.

(a) Use Crystal Ball to find the expected NPV of the project.

(b) What is the probability that the project will yield a return greater than the 20 percent hurdle rate?

8. If an inflation rate of 2 percent, normally distributed with a standard deviation of .333 percent, is assumed, what is the expected NPV of the project in Problem 7, and what is the probability that it will qualify?

9. Use a weighted score model to choose between three methods (A, B, C) of financing the acquisition of a major competitor. The relative weights for each criterion are shown in the following table as are the scores for each location on each criterion. A score of 1 represents unfavorable, 2 satisfactory, and 3 favorable.

	Method			
Category	***Weight***	***A***	***B***	***C***
Consulting costs	20	1	2	3
Acquisition time	20	2	3	1
Disruption	10	2	1	3
Cultural differences	10	3	3	2
Skill redundancies	10	2	1	1
Implementation risks	25	1	2	3
Infrastructure	10	2	2	2

10. Develop a spreadsheet for Problem 9.

(a) What would your recommendation be if the weight for the implementation risks went down to 10 and the weight of cultural differences went up to 25?

(b) Suppose instead that method A received a score of 3 for implementation risks. Would your recommendation change under these circumstances?

(c) The vice president of finance has looked at your original 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 methods on tax considerations as follows: method A received a score of 3, method B received a score of 2, and method C received a score of 1. How would this additional information affect your recommendation?

11. Nina is trying to decide in which of four shopping centers to locate her new boutique. Some locations attract a higher class of clientele than others, some are in an indoor mall, some have a much greater customer traffic volume than others, and, of course, rent varies considerably from one location to another. Because of the nature of her store, she has decided that the class of clientele is the most important consideration, the higher the better. 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, however, 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 traffic 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
Traffic volume	Good	Fair	Good	Poor

12. Referring to Problem 11, develop a spreadsheet to help Nina select a location for her boutique. Suppose Nina is able to negotiate a lower rent at location 3 and thus raise its ranking to "good." How does this affect the overall rankings of the four locations?

13. A dot-com startup has decided to upgrade its server computers. It is also contemplating a shift from its Unix-based platform to a Windows-based platform. Three major cost items will be affected whichever platform they choose: hardware costs, software conversion costs, and employee training costs. The firm's technical group has studied the matter and has made the following estimates for the cost changes.

Using Crystal Ball® and assuming that the costs may all be represented by triangular distributions, simulate the problem 1000 times. Given the information resulting from the simulation, discuss the decision problem.

	A	B	C	D	E	F	G	H
1			**Windows Platform**				**Unix Platform**	
2		**Low**	**Likeliest**	**High**		**Low**	**Likeliest**	**High**
3	Hardware cost	$100,000	$125,000	$200,000		$80,000	$110,000	$210,000
4	Software conversion cost	$275,000	$300,000	$500,000		$250,000	$300,000	$525,000
5	Employee training cost	$9,000	$10,000	$15,000		$8,000	$10,000	$17,500
6								
7	Likeliest Total Project Cost		$435,000				$420,000	

INCIDENTS FOR DISCUSSION

Portillo, Inc.

Portillo, Inc. is a manufacturer of small household appliances and cooking utensils. Working with Johanna Portillo, the CEO of the firm, her executive team has developed a scoring model to analyze and select new items to be added to the product line. The model is also used to select old items to be dropped from the line. It employs both objective and subjective estimates of scores for the financial and nonfinancial elements that make up the model. The model is used by a Drop/Add Committee she appointed.

Ms. Portillo is pleased with the construct of the model and feels that it includes all of the factors relevant to the drop/add decision. She is also comfortable with the factor weights developed by her executives.

Following a review of the past year's meetings of the Drop/Add Committee, Ms. Portillo discovered that several managers made significant errors when estimating costs and benefits of many projects. After a careful study of the estimates, she noticed that the sponsors of a product seemed to overestimate its benefits and underestimate its costs. It also appeared that other managers might be underestimating benefits and overestimating costs.

She was not sure about her suspicions and wondered how to find out if her notions were correct. Even if they were correct, she wondered what to do about it.

Questions: How can Ms. Portillo find out if her suspicions are correct? What are her options if her idea is supported?

L & M Power

In the next two years, a large municipal gas company must begin constructing new gas storage facilities to accommodate the Federal Energy Regulatory Commission's Order 636 deregulating the gas industry. The vice-president in charge of the new project believes there are two options. One option is an underground deep storage facility (UDSF) and the other is a liquified natural gas facility (LNGF). The vice-president has developed a project selection model and will use it in presenting the project to the president. For the models she has gathered the following information:

	Initial Cost	Operating Cost/ Cu.Ft.	Expected Life	Salvage Value
UDSF	$10,000,000	$0.004	20 years	10%
LNGF	25,000,000	0.002	15	5

Since the vice-president's background is in finance, she believes the best model to use is a financial one, net present value analysis.

Questions: Would you use this model? Why or why not? Base your answer on the five criteria developed by Souder and evaluate this model in terms of the criteria.

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The following case concerns a European firm trying to choose between almost a dozen capital investment projects being championed by different executives in the firm. However, there are many more projects available for funding than there are funds available to implement them, so the set must be narrowed down to the most valuable and important to the firm. Financial, strategic, and other data are given concerning the projects in order to facilitate the analysis needed to make a final investment recommendation to the Board of Directors.

C A S E

PAN-EUROPA FOODS S.A.*

C. Opitz and R. F. Bruner

In early January 1993, the senior-management committee of Pan-Europa Foods was to meet to draw up the firm's capital budget for the new year. Up for consideration were 11 major projects that totaled over (European Currency Unit) ECU208 million. Unfortunately, the board of directors had imposed a spending limit of only ECU80 million; even so, investment at that rate would represent a major increase in the firm's asset base of ECU656 million. Thus the challenge for the senior managers of Pan-Europa was to allocate funds among a range of compelling projects: new-product introduction, acquisition, market expansion, efficiency improvements, preventive maintenance, safety, and pollution control.

The Company

Pan-Europa Foods, headquartered in Brussels, Belgium, was a multinational producer of high-quality ice cream, yogurt, bottled water, and fruit juices. Its products were sold throughout Scandinavia, Britain, Belgium, the Netherlands, Luxembourg, western Germany, and northern France. (See Exhibit 1 for a map of the company's marketing region.)

The company was founded in 1924 by Theo Verdin, a Belgian farmer, as an offshoot of his dairy business. Through keen attention to product development, and shrewd marketing, the business grew steadily over the years. The company went public in 1979 and by 1993 was listed for trading on the London, Frankfurt, and Brussels exchanges. In 1992, Pan-Europa had sales of almost ECU1.1 billion.

Ice cream accounted for 60 percent of the company's revenues; yogurt, which was introduced in 1982, contributed about 20 percent. The remaining 20 percent of sales was divided equally between bottled water and fruit juices. Pan-Europa's flagship brand name was "Rolly," which was represented by a fat, dancing bear in farmers' clothing. Ice cream, the company's leading product, had a loyal base of customers who sought out its high butterfat content, large chunks of chocolate, fruit, nuts, and wide range of original flavors.

Pan-Europa sales had been static since 1990 (see Exhibit 2), which management attributed to low population growth in northern Europe and market saturation in some areas. Outside observers, how-

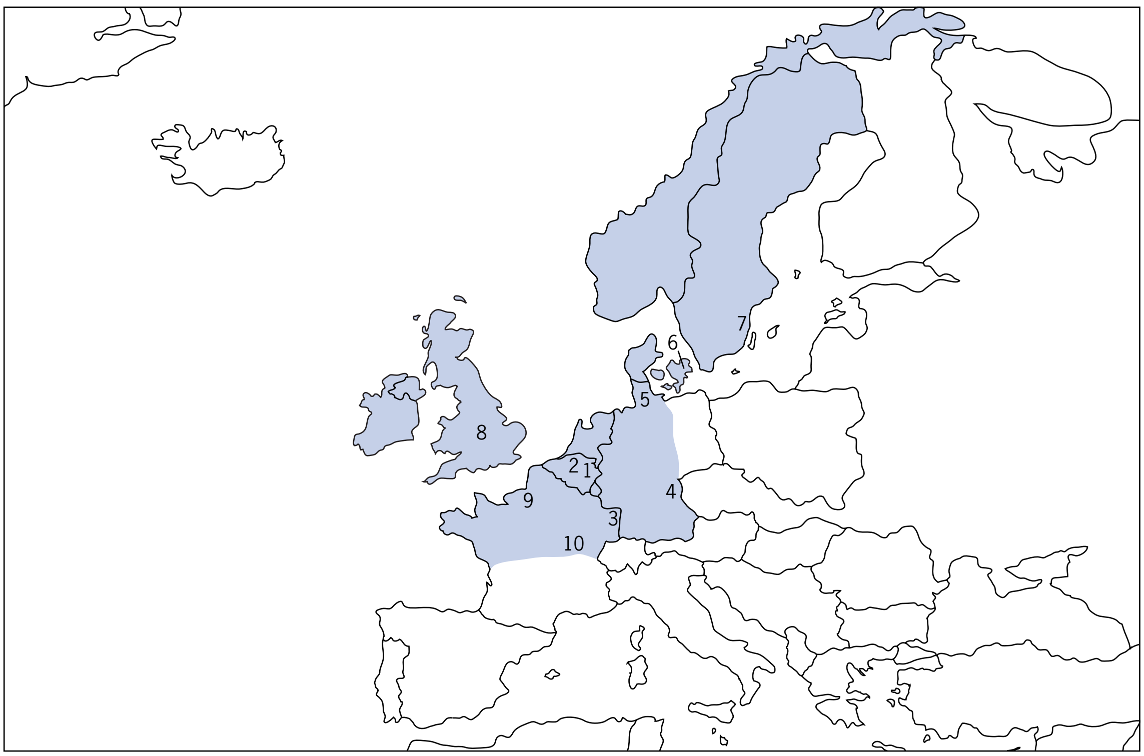

EXHIBIT 1 Pan-Europa Foods S. A. Nations where Pan-Europa Competed

Note: The shaded area in this map reveals the principal distribution region of Pan-Europa's products. Important facilities are indicated by the following figures:

1. Headquarters, Brussels, Belgium
2. Plant, Antwerp, Belgium
3. Plant, Strasbourg, France
4. Plant, Nuremberg, Germany
5. Plant, Hamburg, Germany
6. Plant, Copenhagen, Denmark
7. Plant, Svald, Sweden
8. Plant, Nelly-on-Mersey, England
9. Plant, Caen, France
10. Plant, Melun, France

EXHIBIT 2 Summary of Financial Results (all values in ECU millions except per-share amounts)

	Fiscal Year Ending December 31		
	1990	***1991***	***1992***
Gross sales	1,076	1,072	1,074
Net income	51	49	37
Earnings per share	0.75	0.72	0.54
Dividends	20	20	20
Total assets	477	580	656
Shareholders' equity (book value)	182	206	235
Shareholders' equity (market value)	453	400	229

ever, faulted recent failures in new-product introductions. Most members of management wanted to expand the company's market presence and introduce more new products to boost sales. These managers hoped that increased market presence and sales would improve the company's market value. Pan-Europa's stock was currently at eight times earnings, just below book value. This price/earnings ratio was below the trading multiples of comparable companies, but it gave little value to the company's brands.

Resource Allocation

The capital budget at Pan-Europa was prepared annually by a committee of senior managers who then presented it for approval by the board of directors. The committee consisted of five managing directors, the *président directeur-général* (PDG), and the finance director. Typically, the PDG solicited investment proposals from the managing directors. The proposals included a brief project description, a financial analysis, and a discussion of strategic or other qualitative considerations.

As a matter of policy, investment proposals at Pan-Europa were subjected to two financial tests, payback and internal rate of return (IRR). The tests, or hurdles, had been established in 1991 by the management committee and varied according to the type of project:

Type of Project	*Minimum Acceptable IRR*	*Maximum Acceptable Payback Years*
1. New product or new markets	12%	6 years
2. Product or market extension	10%	5 years
3. Efficiency improvements	8%	4 years
4. Safety or environmental	No test	No test

In January 1993, the estimated weighted-average cost of capital (WACC) for Pan-Europa was 10.5 percent. In describing the capital-budgeting process, the finance director, Trudi Lauf, said, "We use the sliding scale of IRR tests as a way of recognizing differences in risk among the various types of projects. Where the company takes more risk, we should earn more return. The payback test signals that we are not prepared to wait for long to achieve that return."

Ownership and the Sentiment of Creditors and Investors

Pan-Europa's 12-member board of directors included three members of the Verdin family, four members of management, and five outside directors who were prominent managers or public figures in northern Europe. Members of the Verdin family combined owned 20 percent of Pan-Europa's shares outstanding, and company executives owned 10 percent of the shares. Venus Asset Management, a mutual-fund management company in London, held 12 percent. Banque du Bruges et des Pays Bas held 9 percent and had one representative on the board of directors. The remaining 49 percent of the firm's shares were widely held. The firm's shares traded in London, Brussels, and Frankfurt.

At a debt-to-equity ratio of 125 percent, Pan-Europa was leveraged much more highly than its peers in the European consumer-foods industry. Management had relied on debt financing significantly in the past few years to sustain the firm's capital spending and dividends during a period of price wars initiated by Pan-Europa. Now, with the price wars finished, Pan-Europa's bankers (led by Banque du Bruges) strongly urged an aggressive program of debt reduction. In any event, they were not prepared to finance increases in leverage beyond the current level. The president of Banque du Bruges had remarked at a recent board meeting,

> Restoring some strength to the right-hand side of the balance sheet should now be a first priority. Any expansion of assets should be financed from the cash flow after debt amortization until the debt ratio returns to a more prudent level. If there are crucial investments that cannot be funded this way, then we should cut the dividend!

At a price-to-earnings ratio of eight times, shares of Pan-Europa common stock were priced below the average multiples of peer companies and the average multiples of all companies on the exchanges where Pan-Europa was traded. This was attributable to the recent price wars, which had suppressed the company's profitability, and to the well-known recent failure of the company to seize significant market share with a new product line of flavored mineral water. Since January 1992, all of the major securities houses had been issuing "sell" recommendations to investors in Pan-Europa shares. Venus Asset Management in London had quietly accumulated shares during this period, however, in the expectation of a turnaround in the firm's performance. At the most recent board meeting, the senior managing director of Venus gave a presentation in which he said,

> Cutting the dividend is unthinkable, as it would signal a lack of faith in your own future. Selling new shares of stock at this depressed price level is also unthinkable, as it would impose unacceptable dilution on your current shareholders. Your equity investors expect an improvement in performance. If that improvement is not forthcoming, or worse, if investors' hopes are dashed, your shares might fall into the hands of raiders like Carlo de Benedetti or the Flick brothers.[1]

[1]De Benedetti of Milan and the Flick brothers of Munich were leaders of prominent hostile-takeover attempts in recents years.

At the conclusion of the most recent meeting of the directors, the board voted unanimously to limit capital spending in 1993 to ECU80 million.

Members of the Senior Management Committee

The capital budget would be prepared by seven senior managers of Pan-Europa. For consideration, each project had to be sponsored by one of the managers present. Usually the decision process included a period of discussion followed by a vote on two to four alternative capital budgets. The various executives were well known to each other:

Wilhelmina Verdin (Belgian), PDG, age 57. Granddaughter of the founder and spokesperson on the board of directors for the Verdin family's interests. Worked for the company her entire career, with significant experience in brand management. Elected "European Marketer of the Year" in 1982 for successfully introducing low-fat yogurt and ice cream, the first major roll-out of this type of product. Eager to position the company for long-term growth but cautious in the wake of recent difficulties.

Trudi Lauf (Swiss), finance director, age 51. Hired from Nestlé in 1982 to modernize financial controls and systems. Had been a vocal proponent of reducing leverage on the balance sheet. Also had voiced the concerns and frustrations of stockholders.

Heinz Klink (German), managing director for Distribution, age 49. Oversaw the transportation, warehousing, and order-fulfillment activities in the company. Spoilage, transport costs, stock-outs, and control systems were perennial challenges.

Maarten Leyden (Dutch), managing director for Production and Purchasing, age 59. Managed production operations at the company's 14 plants. Engineer by training. Tough negotiator, especially with unions and suppliers. A fanatic about production-cost control. Had voiced doubts about the sincerity of creditors' and investors' commitment to the firm.

Marco Ponti (Italian), managing director for Sales, age 45. Oversaw the field sales force of 250 representatives and planned changes in geographical sales coverage. The most vocal proponent of rapid expansion on the senior-management committee. Saw several opportunities for ways to improve geographical positioning. Hired from Unilever in 1985 to revitalize the sales organization, which he successfully accomplished.

Fabienne Morin (French), managing director for Marketing, age 41. Responsible for marketing research, new-product development, advertising, and, in general, brand management. The primary advocate of the recent price war, which, although financially difficult, realized solid gains in market share. Perceived a "window of opportunity" for product and market expansion and tended to support growth-oriented projects.

Nigel Humbolt (British), managing director for Strategic Planning, age 47. Hired two years previously from a well-known consulting firm to set up a strategic-planning staff for Pan-Europa. Known for asking difficult and challenging questions about Pan-Europa's core business, its maturity, and profitability. Supported initiatives aimed at growth and market share. Had presented the most aggressive proposals in 1992, none of which were accepted. Becoming frustrated with what he perceived to be his lack of influence in the organization.

The Expenditure Proposals

The forthcoming meeting would entertain the following proposals:

Project	*Expenditure (ECU millions)*	*Sponsoring Manager*
1. Replacement and expansion of the truck fleet	22	Klink, Distribution
2. A new plant	30	Leyden, Production
3. Expansion of a plant	10	Leyden, Production
4. Development and introduction of new artificially sweetened yogurt and ice cream	15	Morin, Marketing
5. Plant automation and conveyor systems	14	Leyden, Production
6. Effluent water treatment at four plants	4	Leyden, Production
7. Market expansion eastward	20	Ponti, Sales
8. Market expansion southward	20	Ponti, Sales
9. Development and roll-out of snack foods	18	Morin, Marketing
10. Networked, computer-based inventory-control system for warehouses and field representatives	15	Klink, Distribution
11. Acquisition of a leading schnapps brand and associated facilities	40	Humbolt, Strategic Planning

1. *Replacement and expansion of the truck fleet.* Heinz Klink proposed to purchase 100 new refrigerated tractor-trailer trucks, 50 each in 1993 and 1994. By doing so, the company could sell 60 old, fully depreciated trucks over the two years for a total of ECU1.2 million. The purchase would expand the fleet by 40 trucks within two years. Each of the new trailers would be larger than the old trailers and afford a 15 percent increase in cubic meters of goods hauled on each trip. The new tractors would also be more fuel and maintenance efficient. The increase in number of trucks would permit more flexible scheduling and more efficient routing and servicing of the fleet than at present and would cut delivery times and, therefore, possibly inventories. It would also allow more frequent deliveries to the company's major markets, which would reduce the loss of sales caused by stock-outs. Finally, expanding the fleet would support geographical expansion over the long term.

As shown in Exhibit 3, the total net investment in trucks of ECU20 million and the increase in working capital to support added maintenance, fuel, payroll, and inventories of ECU2 million was expected to yield total cost savings and added sales potential of ECU7.7 million over the next seven years. The resulting IRR was estimated to be 7.8 percent, marginally below the minimum 8 percent required return on efficiency projects. Some of the managers wondered if this project would be more properly classified as "efficiency" than "expansion."

2. *A new plant.* Maarten Leyden noted that Pan-Europa's yogurt and ice-cream sales in the southeastern region of the company's market were about to exceed the capacity of its Melun, France, manufacturing and packaging plant. At present, some of the demand was being met by shipments from the company's newest, most efficient facility, located in Strasbourg, France. Shipping costs over that distance were high, however, and some sales were undoubtedly being lost when the marketing effort could not be supported by delivery. Leyden proposed that a new manufacturing and packaging plant be built in Dijon, France, just at the current southern edge of Pan-Europa's marketing region, to take the burden off the Melun and Strasbourg plants.

The cost of this plant would be ECU25 million and would entail ECU5 million for working capital. The ECU14 million worth of equipment would be amortized over seven years, and the plant over ten years. Through an increase in sales and depreciation, and the decrease in delivery costs, the plant was expected to yield after-tax cash flows totaling ECU23.75 million and an IRR of 11.3 percent over the next ten years. This project would be classified as a market extension.

3. *Expansion of a plant.* In addition to the need for greater production capacity in Pan-Europa's southeastern region, its Nuremberg, Germany, plant had reached full capacity. This situation made the scheduling of routine equipment maintenance difficult, which, in turn, created production-scheduling and deadline problems. This plant was one of two highly automated facilities that produced Pan-Europa's entire line of bottled water, mineral water, and fruit juices. The Nuremberg plant supplied central and western Europe. (The other plant, near Copenhagen, Denmark, supplied Pan-Europa's northern European markets.)

The Nuremberg plant's capacity could be expanded by 20 percent for ECU10 million. The equipment (ECU7 million) would be depreciated over seven years, and the plant over ten years. The increased capacity was expected to result in additional production of up to ECU1.5 million per year, yielding an IRR of 11.2 percent. This project would be classified as a market extension.

4. *Development and introduction of new artificially sweetened yogurt and ice cream.* Fabienne Morin noted that recent developments in the synthesis of artificial sweeteners were showing promise of significant cost savings to food and beverage producers as well as stimulating growing demand for low-calorie products. The challenge was to create the right flavor to complement or enhance the other ingredients. For ice-cream manufacturers, the difficulty lay in creating a balance that would result in the same flavor as was obtained when using natural sweeteners; artificial sweeteners might, of course, create a superior taste.

ECU15 million would be needed to commercialize a yogurt line that had received promising results in laboratory tests. This cost included acquiring specialized production facilities, working capital, and the cost of the initial product introduction. The overall IRR was estimated to be 17.3 percent.

Morin stressed that the proposal, although highly uncertain in terms of actual results, could be viewed as a means of protecting present market share, because other high-quality ice-cream producers carrying out the same research might introduce these products; if the Rolly brand did not carry an artificially sweetened line and its competitors did, the Rolly brand might suffer. Morin also noted the parallels between innovating with artificial sweeteners and the company's past success in introducing low-fat products. This project would be classed in the new-product category of investments.

5. *Plant automation and conveyor systems.* Maarten Leyden also requested ECU14 million to increase automation of the production lines at six of the company's older plants. The result would be improved throughput speed and reduced accidents, spillage, and production tie-ups. The last two plants

EXHIBIT 3 Free Cash Flows and Analysis of Proposed Projects1 (all values in ECU millions)

Project	*1* Expand Truck Fleet (note 3)	*2* New Plant	*3* Expanded Plant	*4* Artificial Sweetener	*5* Automation and Conveyer Systems	*7* Eastward Expansion (note 5)	*8* Southward Expansion (note 5)	*9* Snack Foods	*10* Inventory-Control System	*11* Strategic Acquisition (note 6)
Investment										
Property	20.00	25.00	10.00	15.00	14.00			15.00	15.00	30.00
Working Capital	2.00	5.00				20.00	20.00	3.00		10.00
Year	**EXPECTED FREE CASH FLOWS** (note 4)									
0	(11.40)	(30.00)	(10.00)	(5.00)	(14.00)	(20.00)	(20.00)	(18.00)	(12.00)	(15.00)
1	(7.90)	2.00	1.25	(5.00)	2.75	3.50	3.00	3.00	5.50	(20.00)
2	3.00	5.00	1.50	(5.00)	2.75	4.00	3.50	4.00	5.50	5.00
3	3.50	5.50	1.75	3.00	2.75	4.50	4.00	4.50	5.00	9.00
4	4.00	6.00	2.00	3.00	2.75	5.00	4.50	5.00		11.00
5	4.50	6.25	2.25	4.00	2.75	5.50	5.00	5.00		13.00
6	5.00	6.50	2.50	4.50	2.75	6.00	5.50	5.00		15.00
7	7.00	6.75	1.50	5.00	2.75	6.50	6.00	5.00		17.00
8		5.00	1.50	5.50		7.00	6.50	5.00		19.00
9		5.25	1.50	6.00		7.50	7.00	5.00		21.00
10		5.50	1.50	6.50		8.00	7.50	5.00		59.00
Undiscounted Sum	7.70	23.75	7.25	22.50	5.25	37.50	32.50	28.50	4.00	134.00
Payback (years)	6	6	6	7	6	5	6	5	3	5
Maximum Payback Accepted	4	5	5	6	4	6	6	6	4	6
IRR	7.8%	11.3%	11.2%	17.3%	8.7%	21.4%	18.8%	20.5%	16.2%	28.7%
Minimum Accepted ROR	8.0%	10.0%	10.0%	12.0%	8.0%	12.0%	12.0%	12.0%	8.0%	12.0%
Spread	−0.2%	1.3%	1.2%	5.3%	0.7%	9.4%	6.8%	8.5%	8.2%	16.7%
NPV at Corp. WACC (10.5%)	−1.92	0.99	0.28	5.21	−0.87	11.99	9.00	8.95	1.16	47.97
NPV at Minimum ROR	−0.13	1.87	0.55	3.88	0.32	9.90	7.08	7.31	1.78	41.43
Equivalent Annuity (note 2)	−0.02	0.30	0.09	0.69	0.06	1.75	1.25	1.29	0.69	7.33

[1]The effluent treatment program is not included in this exhibit.

[2]The equivalent annuity of a project is that level annual payment over 10 years that yields a net present value equal to the NPV at the minimum required rate of return for that project. Annuity corrects for differences in duration among various projects. For instance, project 5 lasts only 7 years and has an NPV of 0.32 million; a 10-year stream of annual cash flows of 0.05 million, discounted at 8.0 percent (the required rate of return) also yields an NPV of 0.32 million. In ranking projects on the basis of equivalent annuity, bigger annuities create more investor wealth than smaller annuities.

[3]This reflects ECU11 million spent both initially and at the end of year 1.

[4]Free cash flow = incremental profit or cost savings after taxes + depreciation - investment in fixed assets and working capital.

[5]Franchisees would gradually take over the burden of carrying receivables and inventory.

[6]ECU15 million would be spent in the first year, 20 million in the second, and 5 million in the third.

the company had built included conveyer systems that eliminated the need for any heavy lifting by employees. The systems reduced the chance of injury to employees; at the six older plants, the company had sustained an average of 75 missed worker-days per year per plant in the last two years because of muscle injuries sustained in heavy lifting. At an average hourly wage of ECU14.00 per hour, over ECU150,000 per year was thus lost, and the possibility always existed of more serious injuries and lawsuits. Overall cost savings and depreciation totaling ECU2.75 million per year for the project were expected to yield an IRR of 8.7 percent. This project would be classed in the efficiency category.

6. *Effluent water treatment at four plants.* Pan-Europa preprocessed a variety of fresh fruits at its Melun and Strasbourg plants. One of the first stages of processing involved cleaning the fruit to remove dirt and pesticides. The dirty water was simply sent down the drain and into the Seine or Rhine rivers. Recent European Community directives called for any waste water containing even slight traces of poisonous chemicals to be treated at the sources and gave companies four years to comply. As an environmentally oriented project, this proposal fell outside the normal financial tests of project attractiveness. Leyden noted, however, that the water-treatment equipment could be purchased today for ECU4 million; he speculated that the same equipment would cost ECU10 million in four years when immediate conversion became mandatory. In the intervening time, the company would run the risks that European Community regulators would shorten the compliance time or that the company's pollution record would become public and impair the image of the company in the eyes of the consumer. This project would be classed in the environmental category.

7. and **8.** *Market expansions eastward and southward.* Marco Ponti recommended that the company expand its market eastward to include eastern Germany, Poland, Czechoslovakia, and Austria and/or southward to include southern France, Switzerland, Italy, and Spain. He believed the time was right to expand sales of ice cream, and perhaps yogurt, geographically. In theory, the company could sustain expansions in both directions simultaneously, but practically, Ponti doubted that the sales and distribution organizations could sustain both expansions at once.

Each alternative geographical expansion had its benefits and risks. If the company expanded eastward, it could reach a large population with a great appetite for frozen dairy products, but it would also face more competition from local and regional ice-cream manufacturers. Moreover, consumers in eastern Germany, Poland, and Czechoslovakia did not have the purchasing power that consumers did to the south. The eastward expansion would have to be supplied from plants in Nuremberg, Strasbourg, and Hamburg.

Looking southward, the tables were turned: more purchasing power and less competition but also a smaller consumer appetite for ice cream and yogurt. A southward expansion would require building consumer demand for premium-quality yogurt and ice cream. If neither of the plant proposals (i.e., proposals 2 and 3) were accepted, then the southward expansion would need to be supplied from plants in Melun, Strasbourg, and Rouen.

The initial cost of either proposal was ECU20 million of working capital. The bulk of this project's costs was expected to involve the financing of distributorships, but over the ten-year forecast period, the distributors would gradually take over the burden of carrying receivables and inventory. Both expansion proposals assumed the rental of suitable warehouse and distribution facilities. The after-tax cash flows were expected to total ECU37.5 million for eastward expansion and ECU32.5 million for southward expansion.

Marco Ponti pointed out that eastward expansion meant a higher possible IRR but that moving southward was a less risky proposition. The projected IRRs were 21.4 percent and 18.8 percent for eastern and southern expansion, respectively. These projects would be classed in the new market category.

9. *Development and roll-out of snack foods.* Fabienne Morin suggested that the company use the excess capacity at its Antwerp spice- and nut-processing facility to produce a line of dried fruits to be test-marketed in Belgium, Britain, and the Netherlands. She noted the strength of the Rolly brand in those countries and the success of other food and beverage companies that had expanded into snack-food production. She argued that Pan-Europa's reputation for wholesome, quality products would be enhanced by a line of dried fruits and that name association with the new product would probably even lead to increased sales of the company's other products among health-conscious consumers.

Equipment and working-capital investments were expected to total ECU15 million and ECU3 million, respectively, for this project. The equipment would be depreciated over seven years. Assuming the test market was successful, cash flows from the project would be able to support further plant expansions in other strategic locations. The IRR was expected to be 20.5 percent, well above the required return of 12 percent for new-product projects.

10. *Networked, computer-based inventory-control system for warehouses and field representatives.* Heniz Klink had pressed for three years unsuccessfully for a state-of-the-art computer-based inventory-control system that would link field sales representatives, distributors, drivers, warehouses, and even possibly retailers. The benefits of such a system would be shortening delays in ordering and order processing, better control of inventory, reduction of spoilage, and faster recognition of changes in demand at the customer level. Klink was reluctant to quantify these benefits, because they could range between modest and quite large amounts. This year, for the first time, he presented a cash-flow forecast, however, that reflected an initial outlay of ECU12 million for the system, followed by ECU3 million in the next year for ancillary equipment. The inflows reflected depreciation tax shields, tax credits, cost reductions in warehousing, and reduced inventory. He forecasted these benefits to last for only three years. Even so, the project's IRR was estimated to be 16.2 percent. This project would be classed in the efficiency category of proposals.

11. *Acquisition of a leading schnapps brand and associated facilities.* Nigel Humbolt had advocated making diversifying acquisitions in an effort to move beyond the company's mature core business but doing so in a way that exploited the company's skills in brand management. He had explored six possible related industries, in the general field of consumer packaged goods, and determined that cordials and liqueurs offered unusual opportunities for real growth and, at the same time, market protection through branding. He had identified four small producers of well-established brands of liqueurs as acquisition candidates. Following exploratory talks with each, he had determined that only one company could be purchased in the near future, namely, the leading private European manufacturer of schnapps, located in Munich.

The proposal was expensive: ECU15 million to buy the company and ECU25 million to renovate the company's facilities completely while simultaneously expanding distribution to new geographical markets.[2] The expected returns were high: after-tax cash flows were projected to be ECU134 million, yielding an IRR of 28.7 percent. This project would be classed in the new-product category of proposals.

Conclusion

Each member of the management committee was expected to come to the meeting prepared to present and defend a proposal for the allocation of Pan-Europa's capital budget of ECU80 million. Exhibit 3 summarizes the various projects in terms of their free cash flows and the investment-performance criteria.

[2]Exhibit 3 shows negative cash flows amounting to only ECU35 million. The difference between this amount and the ECU40 million requested is a positive operating cash flow of ECU5 million in year 1 expected from the normal course of business.

QUESTIONS

1. Strategically, what must Pan-Europa do to keep from becoming the victim of a hostile takeover? What rows/categories in Exhibit 2 will thus become critically important in 1993? What should Pan-Europa do now that they have won the price war? Who should lead the way for Pan-Europa?

2. Using NPV, conduct a straight financial analysis of the investment alternatives and rank the projects. Which NPV of the three should be used? Why? Suggest a way to evaluate the Effluent project.
3. What aspects of the projects might invalidate the ranking you just derived? How should we correct for each investment's time value of money, unequal lifetimes, riskiness, and size?
4. Reconsider the projects in terms of:
   - are any "must do" projects of the non-numeric type?
   - what elements of the projects might imply greater or lesser riskiness?
   - might there be any synergies or conflicts between the projects?
   - do any of the projects have nonquantitative benefits or costs that should be considered in an evaluation?
5. Considering all the above, what screens/factors might you suggest to narrow down the set of most desirable projects? What criteria would you use to evaluate the projects on these various factors? Do any of the projects fail to pass these screens due to their extreme values on some of the factors?
6. Divide the projects into the four Project Profile Process categories of incremental, platform, breakthrough, and R&D. Draw an aggregate project plan and array the projects on the chart.
7. Based on all the above, which projects should the management committee recommend to the Board of Directors?

The following reading describes the approach Hewlett-Packard uses to select and monitor its projects for relevance to the firm's strategic goals. The article describes the behavioral aspects of the process as well as many of the technical tools, such as the aggregate project plan, the plan of record, and the software aids they employed. In addition, the authors give tips and identify pitfalls in the process so anyone else implementing their approach will know what problems to watch out for.

DIRECTED READING

FROM EXPERIENCE: LINKING PROJECTS TO STRATEGY

R. L. Englund and R. J. Graham

Growth in organizations typically results from successful projects that generate new products, services, or procedures. Managers are increasingly concerned about getting better results from the projects under way in their organizations and in getting better cross-organizational cooperation. One of the most vocal complaints of project managers is that projects appear almost randomly. The projects seem unlinked to a coherent strategy, and people are unaware of the total number and scope of projects. As a result, people feel they are working at cross-purposes, on too many unneeded projects, and on too many projects generally. Selecting projects for their strategic emphasis helps resolve such feelings and is a corner anchor in putting together the pieces of a puzzle that create an environment for successful projects [6].

This article covers a series of steps for linking projects to strategy. These steps constitute a process that can be applied to any endeavor. Included throughout are suggestions for action as well as guidelines to navigate many pitfalls along the path. Process tools help illustrate ways to prioritize projects. The lessons learned are from consulting with many firms over a

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long time period and from personal experiences in applying the lessons within Hewlett-Packard Company (HP), a $40 billion plus company where two thirds of its revenue derives from products introduced within the past 2 years.

The Importance of Upper Management Teamwork

Developing cooperation across an organization requires that upper managers take a systems approach to projects. That means they look at projects as a system of interrelated activities that combine to achieve a common goal. The common goal is to fulfill the overall strategy of the organization. Usually all projects draw from one resource pool, so they interrelate as they share the same resources. Thus, the system of projects is itself a project, with the smaller projects being the activities that lead to the larger project (organizational) goal.

Any lack of upper management teamwork reverberates throughout the organization. If upper managers do not model desired behaviors, there is little hope that the rest of the organization can do it for them. Any lack of upper management cooperation will surely be reflected in the behavior of project teams, and there is little chance that project managers alone can resolve the problems that arise.

A council concept is one mechanism used at HP to establish a strategic direction for projects spanning organizational boundaries. A council may be permanent or temporary, assembled to solve strategic issues. As a result, a council typically will involve upper managers. Usually its role is to set directions, manage multiple projects or a set of projects, and aid in cross-organizational issue resolution. Several of these council-like activities become evident through the examples in this article.

Employing a comprehensive and systematic approach illustrates the vast and important influence of upper management teamwork on project success. Increasingly evident are companies who initiate portfolio selection committees. We suggest that organizations begin by developing councils to work with project managers and to implement strategy. These councils exercise leadership by articulating a vision, discussing it with the project managers, asking them their concerns about and needs for implementing the strategy, listening carefully to them, and showing them respect so they become engaged in the process. In this way, upper managers and project managers develop the joint vision that is so necessary for implementation of strategy.

Process for Project Selection and Prioritization

Once the upper management team is established, they can follow a process to select sets of projects that achieve organizational goals. They are then ideally positioned to implement consistent priorities across all departments. Figure 1 represents a mental model of a way to structure this process. Outputs from the four steps interrelate in a true systems approach. This model comes from experience in researching and applying a thorough approach to all the issues encountered in a complex organization. It is both simple in concept and complex in richness. The authors use the model both as an educational tool and to facilitate management teams through the process.

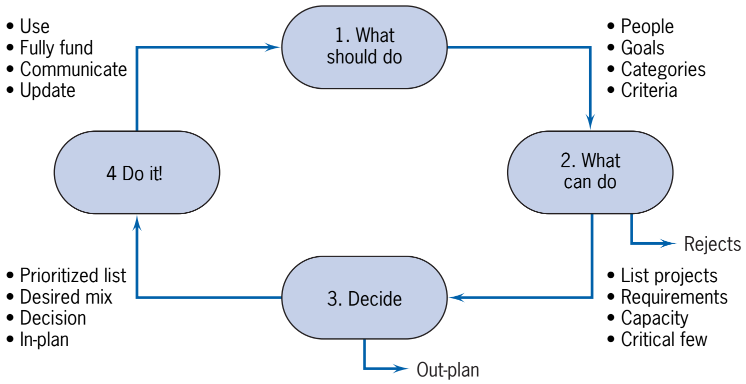

Figure 1 A systematic approach to selecting projects.

What the Organization Should Do and How to Know When You Are Doing It. First, identify who is leading the process and who should be on the management team. More time spent here putting together a "mission impossible" team pays dividends later by getting up-front involvement of the people who will be affected by the decisions that will be made. Take care not to overlook any key-but-not-so-visible players who later may speak up and jeopardize the plan. This team may consist solely of upper managers or may include project managers, a general manager, and possibly a customer. Include representation of those who can best address the key opportunities and risks facing the organization. Ideally they control the resources and are empowered to make decisions on all projects. The leader needs to get explicit commitment from all these people to participate actively in the process and to use the resulting plan when making related decisions. Be aware that behavioral issues become super urgent. This process hits close to home and may have a severe impact on projects that people care personally about. Uncertainty and doubt are created if management does not tread carefully and pay attention to people concerns.

The team begins by listing all projects proposed and under way in the organization. Many times this step is a revelation in itself. A usual reaction is, "I didn't realize we had so many projects going on." The intent is to survey the field of work and begin the organizing effort, so avoid going into detailed discussion about specific projects at this point.

The team clarifies or develops the goals expected from projects. Be careful not to get constrained through considering only current capabilities. Many teams get sidetracked by statements such as "We don't know how to do that," effectively curtailing discussion on whether the organization ought to pursue the goal and develop or acquire the capability. Rather, the discussions at this stage center around organizational purpose, vision, and mission. This is a crucial step that determines if the rest of the project selection process can be successful. In the authors' experience, those organizations with clear, convincing, and compelling visions about what they should be doing move ahead rapidly. Any lack of understanding or commitment to the vision by a member of the team leads to frustration, wheel spinning, and eventual disintegration of the whole process. This pattern is so prevalent that clarity of the goal or strategy is applied as a filter before agreeing to facilitate teams through the process.

Organize the projects into categories that will later make it easier to facilitate a decision-making process. Wheelwright and Clark [14] suggest using grids where the axes are the extent of product change and the extent of process change. Some organizations use market segments. The benefit to this effort is that seeing all projects and possible projects on a continuum allows checking for completeness, gaps, opportunities, and compliance with strategy. This might also be a good time to encourage "out-of-the-box" thinking about new ways to organize the work. Use creative discussion sessions to capture ideas about core competences, competitive advantage, and the like to determine a set of categories most effective for the organization. For example, the categories might be:

Evolutionary or derivative—sustaining, incremental, enhancing.

Platform—next generation, highly leveraged; and

Revolutionary or breakthrough—new core product, process, or business.

The actual products in Figure 2 were introduced to the market over time in alphabetical order and positioning shown. Although the figure represents a retrospective view, it illustrates a successful strategy of sequencing projects and products. There is a balanced mix of breakthrough products, such as A, followed by enhancements, B through E, before moving on to new platforms, F through H, and eventually developing a new architecture and product family with L. At the time, this strategy was improvisational [1]; it now represents a learning opportunity for planning new portfolios. No one area of the grid is overpopulated, and where large projects exist there are not too many of them.

Another reason to organize projects into these "strategic buckets" is to better realize what business(es) the organization is in. Almost every group the authors work with get caught in the "tyranny of the OR" instead of embracing the "genius of the AND" [2]. In trying to do too many projects and facing the need to make tradeoffs among them, the decision becomes *this* OR *that.* In reality, most organizations need a balanced portfolio that creates complete solutions for their customers. They need to do *this* AND *that.* The way to achieve this goal is to set limits on the size of each category and then focus efforts on selecting the best set of projects within each category. The collective

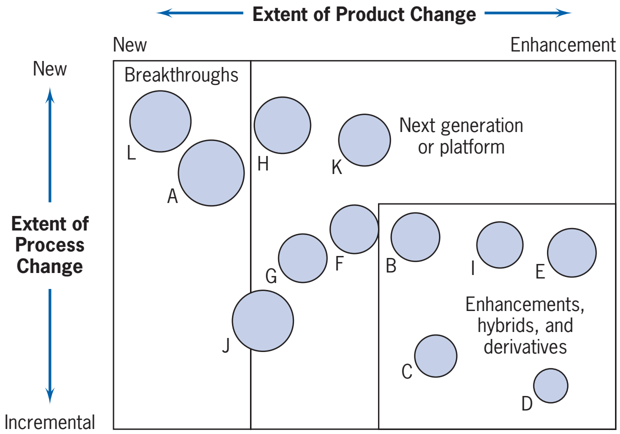

Figure 2 Bubble diagram of a product grid for one HP division. Size of bubble = size of project.

set of categories becomes the desired mix, a way of framing the work of the organization. The ideal percentage that constitutes the size of each category can be determined from the collective wisdom of the team or perhaps through experimentation. The organization can learn the right mix over time but only if it makes a concerted effort to do so.

Within each category, determine criteria that can assess the "goodness"—quality or best fit—of choices for the plan. A criterion is a standard on which a comparative judgment or decision may be based. Because the types of projects and the objectives within categories may be quite different, develop unique criteria for each category or have a core set of criteria that can be modified. Many teams never get to the point of developing or clarifying criteria, and they usually want to discuss projects before agreeing on criteria; reversing the order is much more effective.

Several works on research and development project selection [8, 9, 12] provide a robust set of criteria for consideration. Examples include strategic positioning, probability of success, market size, and availability of staff. Most important is to identify the criteria that are of greatest significance to the organization; fewer are better. However, teams usually need to brainstorm many criteria before focusing on the few.

The role of each criterion is to help compare projects, not specify them. Select criteria that can measurably compare how projects support the organizational strategy. For example, one criterion may be degree of impact on HP business as interpreted by a general manager. On a scaling model from 1 to 10, small impact scores a 2, strong a 6, critical to the success of one business an 8, and critical to the success of multiple businesses a 10. Most likely all proposed projects meet meaningful specifications and provide value to the organization. The task is to develop tough criteria to select the best of the best.

Some organizations use narratives to describe how each project contributes to the vision; others use numerical scores on whether one project is equal, moderate, or strongly better than another. It is also helpful to set thresholds or limits for projects that will be considered for the plan. These help to screen out projects so that later prioritization efforts can focus on fewer projects.

Writing a thorough description of each criterion helps ensure understanding of the intent and expectations of data that must be supplied to fulfill it. One team of three or four people at HP spent 5 days working only on the criteria they were to use for decision-making. And this was only the beginning; they next involved customers in the same discussion before reaching consensus and beginning to evaluate choices. An "Aha" occurred when people found they were wrong to assume that everyone meant the same thing by terms such as packaging; some used wider definitions than others did, and the misunderstanding only surfaced through group discussion. Asked if the selection process ever failed the team, its leader replied, "If the results didn't make sense, it was usually because the criteria weren't well defined." Unfortunately, most teams do not exhibit the same patience and discipline that allowed this team to be successful.

Before moving to the next step, the team should establish relative importance among criteria. Assign a weighting factor for each criterion. All criteria are important but some more so than others. The example in

Figure 3 is the result of one team's brainstorming session that ultimately led to selecting four criteria. Breakout groups subsequently defined each criterion with subcriteria. They also devised scoring methods to apply the criteria. Collectively they then determined the respective weighting or importance of each criterion (see the Process Tools section for how they did this). Unlike threshold criteria that "gate" whether a project is go or no-go, all projects have to satisfy selection criteria to some extent. Weighting of criteria is the technique that can optimize and determine the best of the best. Another "Aha" that helped teams get through the hurdle to develop effective criteria is when they realized the task at this point is "weighting, not gating."

It is the authors' experience that criteria, while universally desired, are usually lacking or not formalized. One benefit of effective criteria is the shaping effect it has on behavior in the organization. When people know how projects will be scored, they tend to shape proposals in positive ways to meet the criteria better. A pitfall is when people play games to establish criteria that support personal agendas. Then it is up to the leader to identify and question these tactics. Remind people to support the greater good of the organization. Significant effort could be devoted to the behavioral aspects that become relevant when deciding upon criteria; suffice to say, be warned that this is a touchy area to approach with sensitivity and persuasiveness.

What the Organization Can Do. The next step for the team is to gather data on all projects. Use similar factors when describing each project in order to ease the evaluation process. Engage people in extensive analysis and debate to get agreement on the major characteristics for each project. This is a time to ask basic questions about product and project types and how they contribute to a diversified set of projects. Reexamine customer needs, future trends, commercial opportunities, and new markets. The person consolidating the data should challenge assertions about benefits and costs instead of accepting assumptions that may have been put together casually. It is important for each member of the team to assess the quality of the data, looking closely at sources and the techniques for gathering the data. When putting cost figures together, consider using activity-based costing models instead of traditional models based on parts, direct labor, and overhead. Activity-based costing includes the communications, relationship building, and indirect labor costs that usually are required to make a project successful.

The team needs to constantly apply screening criteria to reduce the number of projects that will be analyzed in detail. Identify existing projects that can be canceled, downscaled, or reconceived because their resource consumption exceeds initial expectations, costs of materials are higher than expected, or a competitive entry to the market changed the rules of the game. The

Customer Satisfaction (28%) • Improves service levels • Results in more consistent and accurate information/transactions • Helps ensure services are delivered as expected	**Employee Satisfaction (7%)** • Improves employee knowledge • Increases employee efficiency or effectiveness • Improves work/life balance promised & • Positive impact to employee survey • Helps balance workload
Business Value (46%) • Achieves results that are critical for a specific window of opportunity • Minimizes risk for implementation and ongoing sustainability • Improves integration and relationships with partners • Provides a positive ROI in $<$ 2 yrs • Aligns with business goals	**Process Effectiveness (19%)** • Enables employees to do things right the first time • Increases the use of technology for service delivery • Reduces manual work and non-value added activities • Increases employee self-sufficiency

Figure 3 Sample criteria and weighting, plus subcriteria, developed by one HP team.

screening process helps eliminate projects that require extensive resources but are not justified by current business strategies; maybe the projects were conceived based on old paradigms about the business. The team can save discussion time by identifying must-do projects or ones that require simple go/no-go decisions, such as legal, personnel, or environmental projects. These fall right through the screens and into the allocation process. Determine if some projects can be postponed until others are complete or until new resources or funding become available. Can project deliverables be obtained from a supplier or subcontractor rather than internally? Involve customers in discussions. The team constantly tests project proposals for alignment with organizational goals.

It is not necessary to constrain the process by using the same criteria across all categories of projects. In fact, some teams found that different criteria for each category of projects was more effective. Also, consider adjusting the weighting of criteria as projects move through their life cycles. Kumar et al. [7] documented research showing that the most significant variable for initial screening of projects is the extent to which "project objectives fit the organization's global corporate philosophy and strategy." Other factors, such as available science and technology, become significant later during the commercial evaluation stage. A big "Aha" experienced by some teams when confronted with this data is that they usually did it the other way around. That explains why they got into trouble—by focusing on technology or financial factors before determining the link to strategic goals.

Cooper (and others before him) report that top-performing companies do not use financial methods for portfolio planning. Rather, they use strategic portfolio management methods where strategy decides project selection [3]. This lesson is still a hotly debated one, especially for those who cling to net present value as the single most important criterion. The difficulty lies in relying upon forecast numbers that are inherently fictitious. The authors' experience is that teams get much better results tapping their collective wisdom about the merits of each project based upon tangible assessments against strategic goals. Using computed financial numbers more often leads to arguments about computation methods and reliability of the data, resulting in unproductive team dynamics.

The next part of gathering data is to estimate the time and resources required for each potential and existing project. Get the data from past projects, statistical projections, or simulations. The HP Project Management Initiative particularly stresses in its organizational initiatives to get accurate bottom-up project data from work breakdown structures and schedules. Reconcile this data with top-down project goals. Document assumptions so that resource requirements can be revisited if there are changes to the basis for an assumption. For new or unknown projects, make a best estimate, focusing first on the investigation phase with the intent to fund only enough work to determine feasibility. The team can revisit the estimates when more information becomes available. Constantly improve estimation accuracy over time by tracking actuals with estimated task durations.

Next, the team identifies the resource capacity both within and outside the organization that will be available to do projects. Balance project with nonproject work by using realistic numbers for resource availability, taking into account other projects, vacations, meetings, personal appointments, and other interruptions. Tip: a wise planner consumes no more than about 50% of a person's available time.

One assessment about the quality of projects in a portfolio is to look at the rejects. In a story attributed to HP founder Bill Hewlett, he once established a single metric for how he would evaluate a portfolio manager's performance. He asked to see only the rejects. He reasoned that if the rejects looked good, then the projects that were accepted must be excellent.

All the actions in this step of the process are intended to screen many possible projects to find the critical few. The team may take a path through multiple screens or take multiple passes through screens with different criteria to come up with a short list of viable projects. Figure 4 represents one scenario where Screen 1 is a coarse screen that checks for impact on the strategic goal. Subsequent screens apply other criteria when more data are available. Any number of screens may be applied, up to the number *n,* until the team is satisfied that the remaining projects relate to compelling business needs. These steps actually save time because the next section on analysis can get quite extensive if all possible projects go through it.

It usually is necessary to go through several validation cycles before finishing the next step: the upper management team proposes project objectives, project teams provide preliminary estimates based on scope, schedule, and resources back to management, management is not happy with this response and makes adjust-

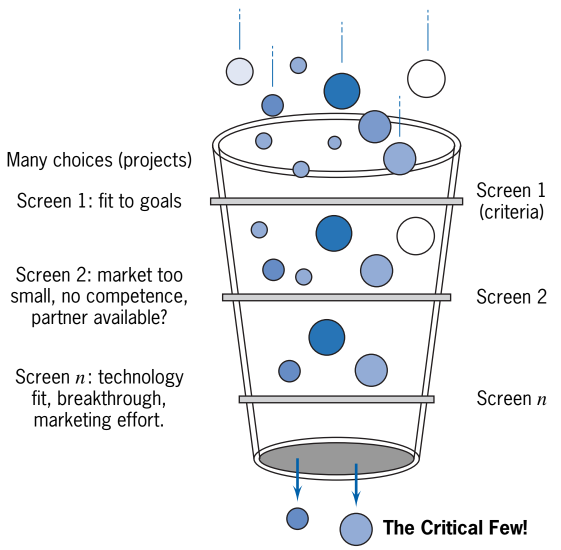

Figure 4 Application of criteria screens during a funneling process eliminates the *trivial many projects* from the *critical few* that the organization can realistically complete.

ments, and so on. This exercise in due diligence is a healthy negotiation process that results in more realistic projects getting through the funnel.

Analyze and Decide on Projects. The next step is to compare estimated resource requirements with available resources. A spreadsheet is useful to depict allocation of resources according to project priority.

Part of the analysis is qualitative: Consider the opportunity costs of committing to short-term, opportunistic, or poorly conceived projects that take resources away from future prospects that may be a better fit strategically. Also, avoid selecting "glamorous" new ideas over addressing the tough issues from ongoing projects. Some people lack the stamina to deal with the details of implementation and so are ready to jump to a new solution at the slightest glimmer of hope from the latest technology. This is a recipe for disaster. Also, be careful to balance the important projects rather than giving in to urgent, but not so important, demands.

Documenting all the findings and supportive data using a common set of descriptive factors makes it easier to compare similar factors across projects. Use a "project charter" form or a template where all information about each project, its sponsors, and key characteristics is recorded.

The team can now prioritize the remaining projects. Focus on project benefits before costs; that way the merits of each project get full consideration. Later include costs to determine the greatest value for the money. Compute overall return from the set of projects, not from individual projects, because some projects may have greater strategic than monetary value. Requiring each and every project to promise a high financial return actually diminishes cooperation across an organization. Also, optimize return over time and continuity or uniformity of revenue from the projects. Some future projects must be funded early to ensure a revenue stream when current projects taper off.

Using previously agreed-upon criteria and weighting factors, the team compares each project with every other one within a category. Repeat the process for each criterion. See the discussion and example later in this article about using an analytical hierarchy process (AHP) to facilitate this step. Consider using software to compute results—an ordered list of projects within each category. A pitfall to avoid that engenders fear among the team is showing one list that prioritizes all projects from top to bottom. People get concerned when their project is on the line. It is not fair to compare internal development projects with high grossing products; keep them separated and within their respective categories.

Finally, the team is ready to decide which projects to pursue. Be prepared to do fewer projects and to commit complete resources required by projects that are selected. Decide on a mix of projects consistent with business strategy, such as 50% platform projects, 20% derivative projects, 10% breakthrough projects, and 10% partnerships. Note that these total only 90%; taking some lessons from financial portfolio management, diversify the set of projects by investing in some speculative projects. The team may not be sure which markets or technologies will grow, so buy an "option" and make a small investment to investigate the possibilities. Include experimental projects. It is also important to leave a small percent of development capacity uncommitted to take advantage of unexpected opportunities and to deal with crises when they arise.

Wheelwright and Clark [14] cite an organization that reduced the number of its development projects from 30 to 11: "The changes led to some impressive gains . . .as commercial development productivity improved by a factor of three. Fewer products meant more actual work got done, and more work meant more products." Addressing an internal project management conference, an HP Executive Vice President emphasized the need to focus on doing fewer projects, especially those that are large and complex: "We have to be very selective. You can manage cross-organizational complex programs if you don't have very many. If you have a lot of them with our culture, it just won't work. First of all, we need to pick those opportunities very, very selectively. We need to then manage them aggressively across the company. That means have joint teams work together, strong project management and leadership, constant reviews, a framework, a vision, a strong owner—all those things that make a program and project successful." Subsequently, a number of organizations sought help from the HP Project Management Initiative to systematically reduce 120 projects down to 30. Another organization went from 50 projects down to 17. It appears counter-intuitive, but by prioritizing and more carefully selecting projects, organizations actually get more projects completed.

Figure 5 illustrates a document that captures the output of this process. Record projects that are fully funded in an aggregate project plan (*in-plan*). In a separate section or another document, list projects for future consideration (*out-plan*); also capture and communicate reasons for delaying or not funding projects. The *plan of record* (POR) is both a process and a tool used by some organizations at HP to keep track of the total list of projects. It lists all projects under way or under consideration by the entity. If a project is funded and has resources assigned, it has achieved *in-plan status*. Projects below the cutoff line of available resources or that have not yet achieved priority status are on the *out-plan.* The figure also categorizes the projects and specifies the desired mix.

Project managers at HP describe one benefit of the POR process as identifying gaps between required and actual resources. For flexible changes, the process gets all people into the communications loop. If people want to add something, the management team has to decide what should be deleted. The process helps two divisions that work together agree on one prioritized list instead of two. They utilize direct electronic connections for bottom-up entry of projects and resources by all project managers into a centralized administration point.

Implement the Plan. No job is complete until it is acted upon. The team needs to "evangelize" all others in the organization to use the aggregate project plan or POR to guide people who plan work, make decisions, and execute projects. Although it may be countercultural to do so, do not starve committed projects of the resources they need. The team or the responsible upper managers need to enforce the plan by fully staffing committed projects; that now becomes possible because fewer projects are happening simultaneously. Also, use the plan to identify opportunities for leverage across projects or for process reengineering. Match people skills to project categories to tap their strengths and areas for contribution.

The team or a program management office needs to maintain the plan in a central place, such as a project office or online. Make it known to, and accessible by, all people in the organization doing projects, subject to confidentiality requirements. All the work to this point may go for naught if the process, the steps, and the results are not widely communicated.

The same people who develop the plan are also the ones who can best update it periodically, perhaps quarterly or as changes occur. Use tools such as an online shared database to gather data directly from project managers about resources needed for each project. This system can be used both to gather data when developing the plan and to update it. View the plan as a "living document" that accurately reflects current realities.

The challenge for HP and many companies is to "master both adaptive innovation and consistent execution . . .again and again and again . . .in the context of relentless change . . . Staying on top means remaining poised on the edges of chaos and time . . . These edges are places of adaptive behavior. They are also unstable. This instability means that managers have to work at staying on the edge" [1]. The advice is clear: the plan is indispensable as a strategic guideline, but don't fall in love with it! Be prepared to adapt it and to communicate the changes.

Process Tools

One tool that can assist in the decision-making process is the AHP [10]. Because of the interactions among many factors affecting a complex decision, it is essential to identify the important factors and the degree that they affect each other before a clear decision can be made. The AHP helps structure a complex situation, identify its criteria and other intangible or concrete factors, measure the interactions among them in a simple way, and synthesize all the information to obtain priorities. The priorities then can be used in a benefit-to-cost

ID	Strategic Category	Priority	Project	Head Ct
1	**Platform (Mix = 40%)**			
2	In Plan	1	Proj F	2
3		2	Proj G	2
4		3	Proj H	4
5		4	Proj J	5
6		5	Proj K	3
7	Out Plan		Next Step	
8				
9	**Enhance (Mix = 20%)**			
10	In Plan	1	Proj B	2
11		2	Proj C	1
12		3	Proj D	1
13		4	Proj E	2
14		5	Proj I	1
15	Out Plan		Fat City	
16				
17	**R & D (Mix = 30%)**			
18	In Plan	1	Proj A	7
19		2	Proj L	5
20				
21				
22				
23	Out Plan		Blue Sky	
24				
25	**Infrastructure (Mix = 10%)**			
26	In Plan	1	Bus. Plan	1
27		2	Portfolio	1
28		3	Update plan	1
29				
30				
31	Out Plan		Corner Office	

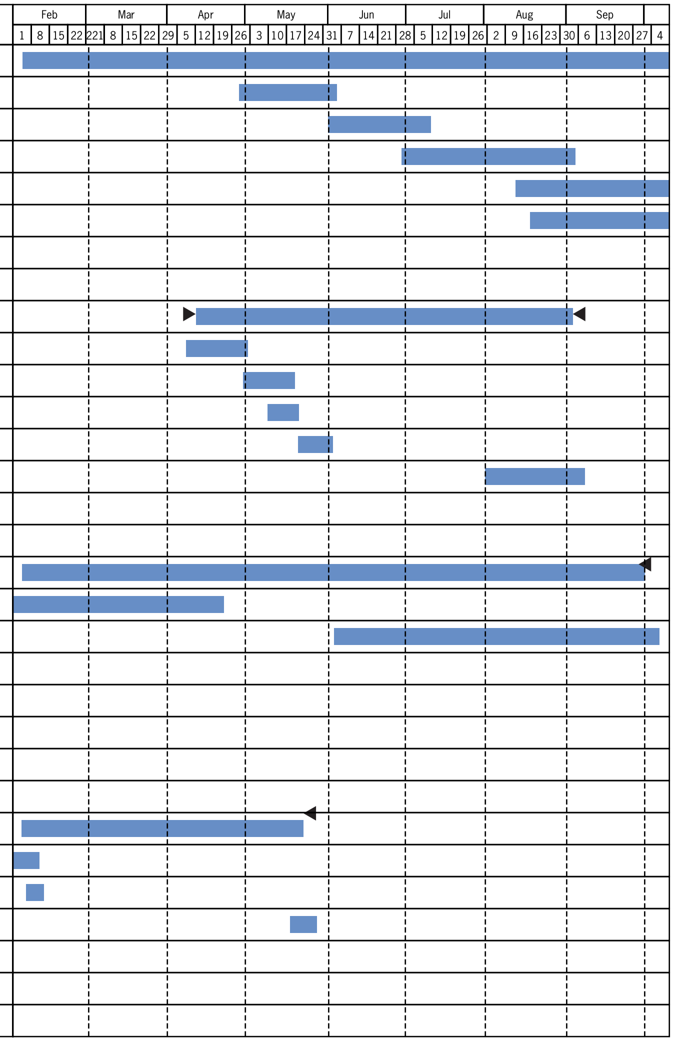

Figure 5 An example plan of record showing the mix of projects in priority order and the time line for each project.

determination to decide which projects to select. The AHP organizes feelings and intuition alongside logic in a structured approach to decision-making—helpful in complex situations where it is difficult to comprehend multiple variables together. An individual or team focuses on one criterion at a time and applies it step by step across alternatives. A number of sites across HP find value in using AHP.

In another example, a team got together to choose among a set of services they will offer to customers. More choices were available than the organization had capacity to support. After defining organizational strategy or product goals, the first task was to identify which criteria to enter into the decision-making process. After give-and-take discussion, they decided that the criteria were customer satisfaction, business value, process effectiveness, and employee satisfaction.

Next, the criteria were ranked according to priority by making pairwise comparisons between them. Which is the more desirable criterion and by how much, customer satisfaction or business value? Process effectiveness or employee satisfaction? Business value or process effectiveness? These questions were asked about all possible pairs.

Each potential project or service then was scored underneath each criterion, and decisions were made about which projects to include in the portfolio, based upon existing resources. This team went on to create a POR similar to Figure 5.

A detailed explanation for computing the priority scores and the final rank ordering list can be quite complex, involving eigenvalues and eigenvectors, so it is much easier to get a software package (Expert Choice [4]) that does the computations. As an alternative, a spreadsheet could be constructed to normalize the numbers.

This process appears complex and analytical but is easy when the software handles the computations, and the management team concentrates on the comparisons. It is thorough in guiding the team to consider all criteria, both emotional and logical, and to apply them to all projects. One team rejected the process as too analytical, so be aware that it does not work for everyone.

The key benefit in doing this process is the improved quality of dialogue that occurs among the management team members. In facilitating a number of teams at HP through this process, each one achieved far more progress than they thought possible. People admit that they become addicted to the AHP process. They immediately buy the software. The systematic approach is feasible whether selecting products for a product line, projects that comprise a portfolio, or the best supplier or candidate for a job. In reality, the discussions are more valuable than the analysis. The process in this case provides the discipline that makes the dialogue happen.

Frame [5] offers an alternative "poor man's hierarchy." He puts selection criteria along the side as well as across the top of a grid. If the criterion on the side is preferred to the one on the top, put a 1 in the cell. If the criterion on top is preferred, put a 0 in the cell. Diagonals are blanked out where criteria would be compared to themselves. Below the diagonal, put the opposite value from corresponding cells above the diagonal. Then add up the numbers across the rows to get total scores, which provide a rank order. One team at HP modified this process to replace the 1s and 0s with an actual count of how 18 people voted in each pairwise comparison of alternatives. Again, they added up the rows and normalized the results for a priority order and weighted ranking (Figure 6).

This simplified hierarchy is especially helpful for weighting criteria. It can be used for prioritizing projects when applied to one criterion at a time. It becomes bulky and less useful when applied to multiple projects over multiple criteria.

Barriers to Implementation

Now for a reality check. The model depicted in this article is thorough, and it integrates objective and subjective data. When all is said and done, however, people may throw out the results and make a different decision. Sometimes the reason is a hunch, an instinct, or simply a desire to try something different. Sometimes people have a pet project and use the process to justify its existence, or a hidden agenda may be at play—perhaps the need to maneuver among colleagues, trading projects for favors. Politics at this stage cannot be ignored, nor are they likely to disappear. It is imperative for leaders to become skilled in the political process. Any attempt at leading change in how an organization links projects to strategy is bound to meet resistance. The concept receives almost unanimous intellectual support. Implementing it into the heart and soul of all people in the organization is another story. It goes against the cultural norms in many organizations and conjures up all kinds of resistance if the values it espouses are not the norm in that organization. The path is full of pitfalls, especially if information is presented carelessly or perceived as final when it is work in process.

	Business	Customer	Technology	Employee		Total Votes	%
Business	***	16	16	18	=	50	46
Customer	2	***	13	15	=	30	28
Technology	2	5	***	14	=	21	19
Employee	0	3	4	***	=	7	7

Figure 6 A simplified hierarchy used by one HP team to weight criteria.

Some people resist because the process is too analytical. Some want decision-making to be purely interactive, intuitive, or the purview of a few people. A complete process cannot be forced upon people if the organization has more immediate concerns or unresolved issues. Resistance occurs when there is no strategy, the strategy is unclear, or people are uncomfortable with the strategy. Work on the process may come to a standstill when people realize how much work is involved to fully link projects to strategy. If the pain is not great enough with the status quo, people are not going to be ready to change.

And if people sense that the leader does not authentically believe in the elements, such as the goals, the process, or the tools, they are hesitant to follow with any enthusiasm. When the leader lacks integrity and exhibits incongruity between words and actions, people may go through the motions but do not exert an effort that achieves meaningful results.

Enablers for Effective Implementation

It is possible to lead people through this change process if the leader asks many questions, listens to the concerns of all people involved, and seeks to build support so that people feel they have an active role in developing the process [9]. A flexible process works better than a rigid one. Cultivate "champions" who have the credibility and fortitude to carry the process across the organization. Believe that change is possible.

When the effort appears too massive, one approach is to go after the low-hanging fruit. Start with one of the more pressing issues and use the general concepts of this model to address it. Still have a vision for what the organization ultimately can achieve but understand that patience and pacing are necessary to get there. Consider also that this process is hierarchical—it can be applied singularly or collectively, up or down the organization.

For people who get frustrated when all linkages are not present, the authors urge teams and individuals to "just do it." Small changes in initial conditions have enormous consequences. Eventually successes or small wins are noticed. The practices start to permeate an organization. This can happen in the middle, move up, and then over to other organizations. Incidentally, a corporate group like HP's Project Management Initiative helps facilitate this transformation. We do this by acting as a conduit for success stories and best practices.

Over the long run, we believe that organizations that follow a process similar to the one described increase their odds for greater success. This happens because teams of people following a systematic process and using convincing data to support their arguments more often produce better results than individuals. Their projects have more visibility, and the quality of dialogue and decision-making improve. The power of using criteria that are tightly linked with strategy and known by everyone in the organization is the mitigating effect it has to guide behavior in constructive ways. Having a process means it can be replicated and improved over time until it is optimized. It also means other people can learn the process and coach others, thereby creating a learning organization.

Questions

1. Why are successful projects so important to Hewlett-Packard?
2. How far should an evaluation team go in trying to quantify project contributions to the firm's mission or goals? What is the role of financial selection criteria in HP's project selection process?
3. Considerable attention is paid to the measures HP uses to evaluate its projects. Is the aim of carefully defining these measures to simplify the project selection process or something else?
4. What do the aggregate project plan and the plan of record illustrate to upper management?
5. When should out-plan projects be reconsidered for inclusion?
6. What was your impression of the impact that HP's project selection process had on the number of projects underway? How do you expect HP would score on project management maturity?
7. How did the new project selection process handle non-numeric type projects? Risk? How did this new process alter new project proposals at HP?

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