C H A P T E R

7

Budgeting and Cost Estimation

PMBOK Guide

In Chapter 6, we reviewed the planning process and gave some guidelines for designing the project plan. We now begin our discussion of PMBOK knowledge area 4: *Project Cost Management*. We treat the subject here in terms of planning (or budgeting) for the costs of project resources but we will reconsider the issue in Chapter 9 when we discuss the allocation of resources to project tasks.

First priority is, of course, obtaining resources with which to do the work. Senior management approval of the project budget does exactly that. A budget is a plan for allocating resources. Thus, the act of budgeting is the allocation of scarce resources to the various endeavors of an organization. The outcomes of the allocation process often do not satisfy managers of the organization who must live and work under budget constraints. It is, however, precisely the pattern of constraints in a budget that embodies organizational policy. The degree to which the different activities of an organization are fully supported by an allocation of resources is one measure of the importance placed on the outcome of the activity. Most of the senior managers we know try hard to be evenhanded in the budgetary process, funding each planned activity at the "right" level—neither overfunding, which produces waste and encourages slack management, nor underfunding, which inhibits accomplishment and frustrates the committed. (This is not to suggest that subordinate managers necessarily agree with our assessment.)

The budget is not simply one facet of a plan, nor is it merely an expression of organizational policy; it is also a control mechanism. The budget serves as a standard for comparison, a baseline from which to measure the difference between the actual and planned uses of resources. As the manager directs the deployment of resources to accomplish some desired objective, resource usage should be monitored carefully. This allows deviations from planned usage to be checked against the progress of the project, and exception reports can be generated if resource expenditures are not consistent with accomplishments. Indeed, the pattern of deviations (variances) can be examined to see if it is possible, or reasonable, to forecast significant departures from budget. With sufficient warning, it is sometimes possible to implement corrective actions. In any event, such forecasting helps to decrease the number of undesirable surprises for senior management.

Budgets play an important role in the entire process of management. It is clear that budgeting procedures must associate resource use with the achievement of organizational goals or the planning/control process becomes useless. If budgets are not tied to achievement, management may ignore situations where funds are being spent far in advance of accomplishment but are within budget when viewed by time period. Similarly, management may misinterpret the true state of affairs when the budget is overspent for a given time period but outlays are appropriate for the level of task completion. Data must be collected and reported in a timely manner, or the value of the budget in identifying and reporting current problems or anticipating upcoming problems will be lost. The reporting process must be carefully designed and controlled. It is of no value if the data are sent to the wrong person or the reports take an inordinately long time to be processed through the system. For example, one manager of a now defunct, large, computer company complained that, based on third-quarter reports, he was instructed to act so as to alter the fourth-quarter results. However, he did not receive the instructions until the first quarter of the following year.

In Chapter 6, we described a planning process that integrated the planning done at different levels of the project. At the top level is the overall project plan, which is then divided and divided again and, perhaps, still again into a "nest" of plans. Project plans were shown to be the verbal equivalents of the WBS. If we cost the WBS, step by step, we develop a project budget. If we cost project plans, we achieve exactly the same end. Viewed in this way, *the budget is simply the project plan in another form*.

Let us now consider some of the various budgeting methods used in organizations. These are described in general first, then with respect to projects. We also address some problems of cost estimation, with attention to the details and pitfalls. We consider some of the special demands and concerns with budgeting for projects. Throughout the chapter attention is paid to dealing with budgetary risk, although the methods of handling risk will be covered in greater detail in Chapter 8. Finally, we present a method for reducing the risk in making estimations, and improving one's skills at budget estimation, or estimation and forecasting of any kind. Printouts of project budgets from PM software packages will be shown in Chapter 10 where we cover project management information systems.

7.1 ESTIMATING PROJECT BUDGETS

In order to develop a budget, we must forecast what resources the project will require, the required quantity of each, when they will be needed, and how much they will cost, including the effects of potential price inflation. Uncertainty is involved in any forecast, though some forecasts have less uncertainty than others. An experienced cost estimator can forecast the number of bricks that will be used to construct a brick wall of known dimensions within 1 to 2 percent. The errors, however, are apt to be much larger for an estimate of the number of programmer hours or lines of code that will be required to produce a specific piece of software.

Project Management in Practice
Pathfinder Mission to Mars—on a Shoestring

In 1976, NASA's two Viking Mars-lander missions took six years and $3 billion (in 1992 dollars) to develop. Twenty-one years later, on July 4, 1997, Mars Pathfinder and Sojourner Rover landed on Mars once again, but at a development cost of only $175 million, representing a whopping 94 percent cost reduction over the earlier mission. This amazing cost reduction was achieved through a variety of means but the most important was perhaps the philosophical one that this was a design-to-cost project rather than a design-to-performance project. Given this philosophy, the scope of the mission was intentionally limited and "scope-creep" was never an issue:

The Pathfinder Rover explores Martian terrain.

- to achieve a successful landing
- return of engineering telemetry
- acquisition and transmission of a *single*, partial panoramic image
- successful rover deployment and 7 sol (Martian day) operation on the surface
- completion of a 30 sol lander mission meeting all engineering, science, and technology objectives
- *one* successful alpha proton X-ray spectrometer measurement of a Martian rock and soil sample.

The means of limiting the cost of the mission were multiple and creative:

- development was cost-capped, with no opportunity for more funds
- identifying a set of "de-scope" options which could be implemented in case the cost grew beyond the fixed budget
- mission, flight, and ground systems designs were driven by existing hardware and system capability
- a project cash reserve of 27 percent of the total budget was held back and carefully planned for time-phased release throughout the duration of the project
- mission designers/builders transitioned into the testers/operators to save documentation, time, labor cost, and chance of error
- existing NASA mission infrastructure was used rather than designing new systems
- instituting time-phased "what if" and lien lists for real or potential current and anticipated items of cost growth during the project
- choosing to use a "single-string" but higher risk design and offsetting the risk by using more reliable parts
- 70 percent of major procurements contracts were fixed-price rather than cost-plus
- creative procurement, such as existing equipment spares, and accounting, such as lower burden rate personnel

On July 5, the Mars Sojourner Rover rolled down its deployment ramp and the resulting pictures made the headlines on newspapers around the world. The mission continued for almost three months and returned 2.6 gigabites of scientific and engineering data, 16,000 lander camera images, 550 rover camera images, 8.5 million environmental measurements, and the results of 16 chemical rock/soil experiments and 10 technology rover experiments.

Source: C. Sholes and N. Chalfin, "Mars Pathfinder Mission," *PM Network*, January 1999, pp. 30–35.

While the field of software science makes such estimates possible, the level of uncertainty is considerably higher and the typical error size is much larger.

In many fields, cost-estimating methods are well codified. For example, in fields such as construction, costs can often by estimated by *scaling* the various cost elements appropriately. For example, building one mile of a four-lane road can be estimated from the individual cost elements of previously constructed two-lane roads—e.g., the asphalt cost may be double while the cost of the road's shoulders may be the same. Similarly, *parametric estimating* relies on well-known statistical correlations between various factors such as the total cost of a house relative to the square feet of living area. The databases of purchasing departments include multitudes of information devoted to the techniques of estimating the quantities of materials and labor required to accomplish specific jobs. Also on the Internet are links detailing what materials, services, and machines are available, and from whom. Every business has its own rules of thumb for cost estimating. These usually distill the collective experience gained by many estimators over many years. An experienced producer of books, for example, can leaf through a manuscript and, after asking a few questions about the number and type of illustrations and the quality of paper to be used, can make a fairly accurate estimate of what it will cost to produce a book.

We will have more to say about gathering budget data shortly. Before doing so, however, it is helpful to understand that developing project budgets is much more difficult than developing budgets for more permanent organizational activities. The influence of history is strong in the budget of an ongoing activity. Many entries are simply "last year's figure plus X percent," where X is any number the budgeter feels "can be lived with" and is probably acceptable to the person or group who approves the budgets. While the project budgeter cannot always depend on tradition as a basis for estimating the current project budget, it is not uncommon for the budgeter to have budgets and audit reports for similar past projects to serve as guides. Although we maintain that all projects are unique, many are not very different from their predecessors and can serve as reasonable guides when forecasting current project budgets. Tradition also aids the estimation process in another way. In the special case of R & D projects, it has been found (Dean et al., 1969) that project budgets are stable over time when measured as a percent of the total allocation to R & D from the parent firm, though within the project the budget may be reallocated among activities. There is no reason to believe that the situation is different for other kinds of projects, and we have some evidence that shows stability similar to R & D projects.

This notion has been formalized in the practice of "life cycle costing." The life cycles of past projects are studied as models for the way costs accrue over the life cycles of similar projects. Given information about costs during the early life of a project, the model can be used to forecast the total cost over the project's life cycle.*

A more interesting estimation technique that also depends on actual costs early in the life of a project is based on earned value analysis (Zwikael et al., 2000). (For a description of earned value analysis, see Chapter 10.) Early actual costs on a project are compared to their estimates, and the remaining costs are adjusted by assuming a constant actual-to-estimate cost ratio. The assumption of a constant ratio gives the lowest average estimation error (11 percent) of the five different predictors tested.

For multiyear projects, another problem is raised. The plans and schedules for such projects are set at the beginning of project life, but over the years, the forecast resource usage may be altered by the availability of alternate or new materials, machinery, or personnel—available at different costs than were estimated, giving rise to both the risk of inflation and technological risk. The longer the project life, the less the PM can trust that traditional methods and costs will be relevant.

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*We do not demonstrate it here, but Crystal Ball® can fit distributions to historical data. This is done by selecting the *F*it button in CB's Distribution Gallery window. Then specify the location of the data. CB considers a wide variety of probability distributions and offers the user optional goodness-of-fit tests—see the Crystal Ball® *User Manual*.

Tradition has still another impact on project budgeting. Every organization has its idiosyncrasies. One firm charges the project's R & D budget with the cost of training sales representatives on the technical aspects of a new product. Another adopts special property accounting practices for contracts with the government. Unless the PM understands the organizational accounting system, there is no way to exercise budgetary control over the project. The methods for project budgeting described below are intended to avoid these problems as much as possible, but complete avoidance is out of the question. The PM simply must be familiar with the organization's accounting system!

One aspect of cost estimation and budgeting that is not often discussed has to do with the *actual* use of resources as opposed to the accounting department's assumptions about how and when the resources will be used. For instance, presume that you have estimated that $5,000 of a given resource will be used in accomplishing a task that is estimated to require five weeks. The actual use of the resource may be none in the first week, $3,000 worth in the second week, none in the third week, $1,500 in the fourth week, and the remaining $500 in the last week. Unless this pattern of expenditure is detailed in the plan, the accounting department, which takes a linear view of the world, will spread the expenditure equally over the five-week period. This may not affect the project's budget, but it most certainly affects the project's cash flow. The PM must be aware of both the resource requirements and the specific time pattern of resource usage. This subject will be mentioned again in Chapter 9.

Another aspect of preparing budgets is especially important for project budgeting. Every expenditure (or receipt) must be identified with a specific project task (and with its associated milestone, as we will see in the next chapter). Referring back to Figure 6-6, we see that each element in the WBS has a unique account number to which charges are accrued as work is done. These identifiers are needed for the PM to exercise budgetary control.

With these things in mind, the issue of how to gather input data for the budget becomes a matter of some concern. There are two fundamentally different strategies for data gathering, top-down and bottom-up.

Top-Down Budgeting

This strategy is based on collecting the judgments and experiences of top and middle managers, and available past data concerning similar activities. These managers estimate overall project cost as well as the costs of the major subprojects that comprise it. These cost estimates are then given to lower-level managers, who are expected to continue the breakdown into budget estimates for the specific tasks and work packages that comprise the subprojects. This process continues to the lowest level.

The process parallels the hierarchical planning process described in the last chapter. The budget, like the project, is broken down into successively finer detail, starting from the top, or most aggregated level following the WBS. It is presumed that lower-level managers will argue for more funds if the budget allocation they have been granted is, in their judgment, insufficient for the tasks assigned. This presumption is, however, often incorrect. Instead of reasoned debate, argument sometimes ensues, or simply sullen silence. When senior managers insist on maintaining their budgetary positions—based on "considerable past experience"—junior managers feel forced to accept what they perceive to be insufficient allocations to achieve the objectives to which they must commit.

Discussions between the authors and a large number of managers support the contention that lower-level managers often treat the entire budgeting process as if it were a zero-sum game, a game in which any individual's gain is another individual's loss. Competition among junior managers is often quite intense.

The advantage of this top-down process is that aggregate budgets can often be developed quite accurately, though a few individual elements may be significantly in error. Not only are budget categories stable as a percent of the total budget, the statistical distribution of each category (e.g., 5 percent for R & D) is also stable, making for high predictability (Dean et al., 1969). Another advantage of the top-down process is that small yet costly tasks need not be individually identified, nor need it be feared that some small but important aspect has been overlooked. The experience and judgment of the executive is presumed automatically to factor all such elements into the overall estimate. Questions put to subordinates, however, indicate that senior management has a strong bias toward underestimating costs.

Bottom-Up Budgeting

In this method, elemental tasks, their schedules, and their individual budgets are constructed, again following the WBS. The people doing the work are consulted regarding times and budgets for the tasks to ensure the best level of accuracy. Initially, estimates are made in terms of resources, such as labor hours and materials. These are later converted to dollar equivalents. Standard analytic tools such as learning curve analysis (discussed in the next section) and work sampling are employed where appropriate to improve the estimates. Differences of opinion are resolved by the usual discussions between senior and junior managers. If necessary, the project manager and the functional manager(s) may enter the discussion in order to ensure the accuracy of the estimates. The resulting task budgets are aggregated to give the total direct costs of the project. The PM adds such indirect costs as general and administrative (G&A), possibly a project reserve for contingencies, and then a profit figure to arrive at the final project budget.

Bottom-up budgets should be, and usually are, more accurate in the detailed tasks, but it is critical that all elements be included. It is far more difficult to develop a complete list of tasks when constructing that list from the bottom up than from the top down. Just as the top-down method may lead to budgetary game playing, the bottom-up process has its unique managerial budget games. For example, individuals overstate their resource needs because they suspect that higher management will probably cut all budgets. Their suspicion is, of course, quite justified, as Gagnon (1982, 1987) and others have shown. Managers who are particularly persuasive sometimes win, but those who are consistently honest and have high credibility win more often.

The advantages of the bottom-up process are those generally associated with participative management. Individuals closer to the work are apt to have a more accurate idea of resource requirements than their superiors or others not personally involved. In addition, the direct involvement of low-level managers in budget preparation increases the likelihood that they will accept the result with a minimum of grumbling. Involvement also is a good managerial training technique, giving junior managers valuable experience in budget preparation as well as the knowledge of the operations required to generate a budget.

While top-down budgeting is common, true bottom-up budgets are rare. Senior managers see the bottom-up process as risky. They tend not to be particularly trusting of ambitious subordinates who may overstate resource requirements in an attempt to ensure success and build empires. Besides, as senior managers note with some justification, the budget is the most important tool for control of the organization. They are understandably reluctant to hand over that control to subordinates whose experience and motives are questionable. This attitude is carried to an extreme in one large corporation that conducts several dozen projects simultaneously, each of which may last five to eight years and cost millions of dollars. Project managers do not participate in the budgeting process in this company, nor did they, until recently, have access to project budgets during their tenure as PMs. Reconciling top-down with bottom-up budgets is obviously an area where the earlier principles of negotiation and conflict management, as described in Chapter 4, would be useful.

Work Element Costing

The actual process of building a project budget—either top-down or bottom-up or, as we will suggest, a combination of both—tends to be a straightforward but tedious process. Each work element in the action plan or WBS is evaluated for its resource requirements, and the cost of each resource is estimated.

Suppose a work element is estimated to require 25 hours of labor by a technician. The specific technician assigned to this job is paid \$17.50/hr. Overhead charges to the project are 84 percent of direct labor charges. The appropriate cost appears to be

$$25 \text{ hr} \times \$17.50 \times 1.84 = \$805.00$$

but the accuracy of this calculation depends on the precise assumptions behind the 25-hr estimate. Industrial engineers have noted that during a normal eight hour day, no one actually works for all eight hours. Even on an assembly line, workers need breaks called "personal time." This covers such activities as visiting the water cooler, the toilet, having a cigarette, blowing one's nose, and all the other time consuming activities engaged in by normal people in a normal workplace. A typical allowance for personal time is 12 percent of total work time. If personal time was not included in the 25-hr estimate made above, then the cost calculation becomes

$$1.12 \times 25 \text{ hr} \times \$17.50 \times 1.84 - \$901.60^*$$

The uncertainty in labor cost estimating lies in the estimate of hours to be expended. Not including personal time ensures an underestimate.

Direct costs for resources and machinery are charged directly to the project, and are not usually subject to overhead charges. If a specific machine is needed by the project and is the property of a functional department, the project may "pay" for it by transferring funds from the project budget to the functional department's budget. The charge for such machines will be an operating cost (\$/hr or \$/operating cycle), plus a depreciation charge based on either time or number of operating cycles. Use of general office equipment, e.g., copy machines, drafting equipment, and coffeemakers, is often included in the general overhead charge.

In addition to these charges, there is also the *General and Administrative* (*G&A*) charge. This is composed of the cost of senior management, the various staff functions, and any other expenses not included in overhead. G&A charges are a fixed percent of either the direct costs or the total of all direct and indirect costs.

Thus, a fully costed work element would include direct costs (labor, resources, and special machinery) plus overhead and G&A charges. We advise the PM to prepare two budgets, one with overheads and G&A charges, and one without. The full cost budget is used by the accounting group to estimate the profit earned by the project. The budget that contains only direct costs gives the PM the information required to manage the project without being confounded with costs over which the PM has no control. Let us now consider a combination of top-down and bottom-up budgeting.

*In a weak matrix project, the Technical Assistance Group representing the technician would submit a lump-sum charge to the project, calculated in much the same way. The charge would, of course, include the costs noted in the rest of this section.

Project Management in Practice

Managing Costs at Massachusetts' Neighborhood Health Plan

Between 1994 and 1996, Medicaid reduced its rate of reimbursement by 20 percent while the State of Massachusetts imposed higher eligibility requirements for health subscribers, thereby significantly reducing Neighborhood Health Plan's (NHP) revenues and threatening its viability. In the past, NHP had controlled costs by controlling hospital bed utilization and increasing preventive medicine. However, no matter how low hospital utilization is, if hospital contract rates are expensive the cost to NHP will be high. Thus, in November 1995, NHP chartered a project team to help it manage costs through better selection and management of hospital contracts. More specifically, the team's charter was to develop a method to examine hospital contracts to assure that proposed rates were financially viable to NHP but high-quality care would be available when needed.

The team first selected the top 10 to 20 hospitals based on total annual payments from NHP for analysis. From these they determined that to control costs effectively, NHP's contracting philosophy would have to change from the current 95 percent of all line items per episode to a fixed cost per episode or per day per type of stay. The team then constructed a spreadsheet that allowed cost comparisons to be made across hospitals which allowed management to bargain for lower rates or, if hospitals were inflexible, suggest to health centers what alternative hospitals to refer patients to. This and later developments by the team significantly enhanced management's ability to contain their costs while guaranteeing that quality care would be available when needed. It also allowed management to examine and respond to contracts and proposed contract changes in a timely and informed manner.

Source: J. H. Hertenstein and K. A. Vallancourt, "Contract Management = Cost Management," *PM Network*, July 1997, pp. 31–34.

An Iterative Budgeting Process—Negotiation-in-Action

In Chapter 6, we recommended an iterative planning process with subordinates* developing action plans for the tasks for which they were responsible. Superiors review these plans, perhaps suggesting amendments. (See also the latter part of Section 6.3.) The strength of this planning technique is that primary responsibility for the design of a task is delegated to the individual accountable for its completion, and thus it utilizes participative management (or "employee involvement"). If done correctly, estimated resource usage and schedules are a normal part of the planning process at all planning levels. Therefore, the superior constructing an action plan at the highest level would estimate resource requirements and durations for each of the steps in the action plan. Let us refer to the superior's resource requirements for a particular task as R. Similarly, the subordinate responsible for that task estimates the resource requirements as r.

In a perfect world, R would equal r. We do not, however, live in a perfect world. As a matter of fact, the probable relationship between the original estimates made at the different levels is $R << r$. This is true for several reasons, three of which are practically universal. First, the farther one moves up the organizational chart away from immediate responsibility for doing the work, the easier, faster, and cheaper the job looks to the superior than to the one

*We use the terms "superior" and "subordinate" here for the sole purpose of identifying individuals working on different relative levels of a project's action plan. We recognize that in a matrix organization it is not uncommon for PMs ("superiors") to delegate work to individuals ("subordinates") who do not report to the PM and who may even be senior to the PM on the parent firm's organizational chart.

who has to do it. This is because the superior either does not know the details of the task, or has conveniently forgotten the details, as well as how long the job takes and how many problems can arise. Second, wishful thinking leads the superior to underestimate cost (and time), because the superior has a stake in representing the project to senior management as a profitable venture. Third, the subordinate is led to build-in some level of protection against failure by adding an allowance for "Murphy's Law" onto a budget that already may have a healthy contingency allowance.

Assuming that the superior and subordinate are reasonably honest with one another (any other assumption leads to a failure in win-win negotiations), the two parties meet and review the subordinate's action plan. Usually, the initial step toward reducing the difference in cost estimates is made by the superior who is "educated" by the subordinate in the realities of the job. The result is that the superior's estimate rises. The next step is typically made by the subordinate. Encouraged by the boss's positive response to reason, the subordinate surrenders some of the protection provided for by the budgetary "slop," and the subordinate's estimate falls. The subordinate's cost estimate is still greater than the superior's, but the difference is considerably decreased.

The pair now turn their attention to the technology of the task at hand. They carefully inspect the subordinate's work plan, trying to find a more efficient way to accomplish the desired end; that is, they practice total quality management (TQM) and/or value engineering. It may be that a major change can be made that allows a lower resource commitment than either originally imagined. It may be that little or no further improvement is possible. Let us assume that moderate improvement is made, but that the subordinate's estimate is still somewhat greater than the superior's, although both have been altered by the negotiations thus far. What should the superior do, accept the subordinate's estimate or insist that the subordinate make do with the superior's estimate? In order to answer this question, we must digress and reconsider the concept of the project life cycle. In Chapter 1, we presented the usual view of the project life cycle in Figure 1-3, shown here as Figure 7-1 for convenience. This view of the life cycle shows decreasing returns to inputs as the project nears completion. Figure 1-5 is also shown here as Figure 7-2 for convenience. In this case, the project shows increasing returns to inputs as the project nears completion. In order to decide whether to adopt the subordinate's

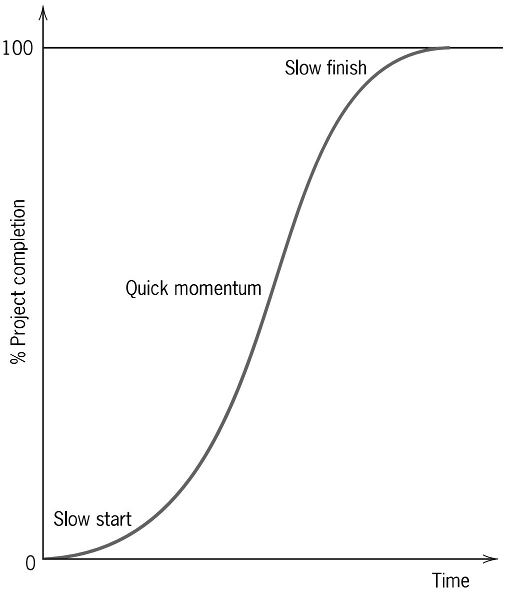


Figure 7-1 The project life cycle. (Figure 1-3 reproduced.)

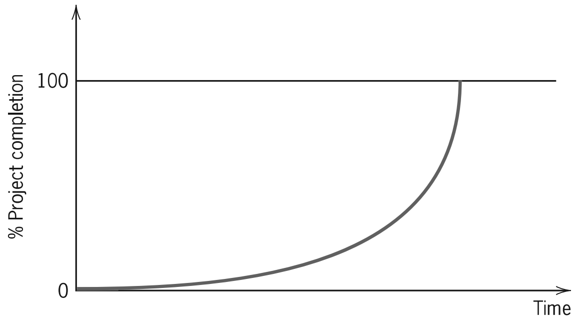


Figure 7-2 Another possible project life cycle. (Figure 1-5 reproduced.)

resource estimate or the superior's, we need to know which picture of the life cycle represents the task under consideration. Note that we are treating the subordinate's action plan as if it were a project, which is perfectly all right because it has the characteristics of a project that were described in Chapter 1. Also note that we do not need to know the shape of the life cycle with any precision, merely if its last stage is concave or convex to the horizontal axis.

Remember that the superior's and subordinate's resource estimates are not very far apart as a result of the negotiations preceding this decision. If the latter part of the life cycle curve is concave (as in Figure 7-1), showing diminishing marginal returns, we opt for the superior's estimate because of the small impact on completion that results from withholding a small amount of resources. The superior might say to the subordinate, "Jeremy, what can you get me for $\$R$? We will have to live with that." If, on the other hand, the life cycle curve is convex, showing increasing marginal returns as in Figure 7-2, the subordinate's estimate should be chosen because of the potentially drastic effect a resource shortage would have on project completion. In this event, the superior might say, "OK, Brandon, we have got to be sure of this job. We'll go with your numbers." If the disagreement had concerned schedule (duration) instead of resources, the negotiation process and underlying logic would be unaltered.

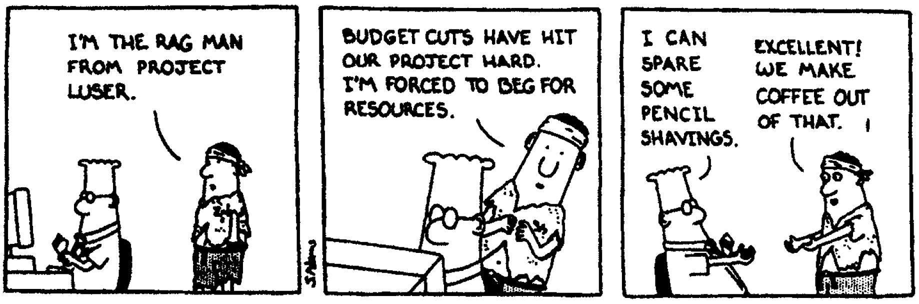
This is a time-consuming process. At the same time the PM is negotiating with the several subordinates responsible for the pieces of the PM's action plan, each of the subordinates is negotiating with their subordinates, and so on. This multilevel process is messy and not particularly efficient, but it allows a free-flow of ideas up and down the system at all levels. This iterative process tends to reduce the uncertainty in budget estimations. The debate over processes and their associated costs means that the uncertainty in budget estimates is very likely to be reduced.

It is worth emphasizing that ethics is just as important in negotiations within an organization as in negotiations between an organization and an outside party. In this case, the superior and subordinate have the responsibility to be honest with each other. For one thing, they must continue to work together in the future under the conditions of mutual trust. Second, it is ethically necessary to be honest in such negotiations.

Comments on the Budget Request Process

The budget process often begins with an invitation from top management for each division to submit a *budget request* for the coming year. Division heads pass the invitation along to departments, sections, and subsections, each of which presumably collects requests from below, aggregates them, and passes the results back up the organizational ladder.

This sounds like bottom-up budgeting, but there is an important difference between this procedure and a true bottom-up system. Along with the formal invitation for submission of a budget request, in the iterative system another message is passed down—a much less formal message that carries the following kinds of information: the percent by which the wage bill of



Source: DILBERT: © Scott Adams/Dist. by United Feature Syndicate, Inc.

the organization may be increased or must be decreased, organizational policy on adding to or cutting the work force, the general attitude toward capital expenditures, knowledge about which projects and activities are considered to be high priority and which are not, and a number of other matters that, in effect, prescribe a set of limits on lower-level managers. As the budget requests are passed back up the organization, they are carefully inspected for conformity to guidelines. If they do not conform, they are "adjusted," often with little or no consultation with the originating units. Senior management tends to adopt an autocratic stance on budget making for many reasons, but two are very common: the need to feel in control of the budget, and the feeling that a tight budget will somehow motivate subordinates to perform more efficiently. We know of no particular evidence to support such views, but they are quite common. Moreover, they lead to budgetary game playing and increase the uncertainty surrounding the budgetary process.

The less autocratic the organization (and the less pressured it is by current financial exigencies), the greater the probability that this process will allow dialogue and some compromise between managerial levels. Even the most *participative* firms, however, will not long tolerate lower-level managers who are not sensitive to messages relating to budget limitations. It makes little difference whether budget policy is passed down the system by means of formal, written policy statements or as a haphazard set of oral comments informally transmitted by some senior managers and practically neglected by others; the PM's budget request is expected to conform to policy. Ignorance of the policy is no excuse. Repeated failure to conform will be rewarded with a ticket to "corporate Siberia." It is the budget originator's responsibility to find out about budget policy. Again we see the importance of political sensitivity. The PM's channels of communication must be sensitive enough to receive policy signals even in the event that a noncommunicative superior blocks those signals.

Cost Category Budgeting vs. Program/Activity Budgeting

Another facet of budgeting has to do with the degree to which a budget is category-oriented or program/activity-oriented, a distinction we have mentioned before. The traditional organizational budget is category-oriented often based upon historical data accumulated through a traditional, category-based, cost accounting system (Coburn, 1997; Vandament et al., 1993). Individual expenses are classified and assigned to basic budget *lines* such as phone, materials, personnel-clerical, utilities, direct labor, etc. or to production centers or processes (Brimson, 1993). These expense lines are gathered into more inclusive categories, and are reported by organizational unit—for example, by section, department, and division. In other words, the budget can be overlaid on the organizational chart. Table 7-1 shows one page of a typical, category-oriented monthly budget report for a real estate project.

Table 7-1. Typical Monthly Category Budget for a Real Estate Project (page 1 of 6)

	Current			
	Actual	***Budget***	***Variance***	***Pct.***
Corporate—Income Statement				
Revenue				
8430 Management fees				
8491 Prtnsp reimb—property mgmt	7,410.00	6,222.00	1,188.00	119.0
8492 Prtnsp reimb—owner acquisition	.00	3,750.00	3,750.00–	.0
8493 Prtnsp reimb—rehab	.00	.00	.00	.0
8494 Other income	.00	.00	.00	.0
8495 Reimbursements—others	.00	.00	.00	.0
Total revenue	7,410.00	9,972.00	2,562.00–	74.3
Operating expenses				
Payroll & P/R benefits				
8511 Salaries	29,425.75	34,583.00	5,157.25	85.0
8512 Payroll taxes	1,789.88	3,458.00	1,668.12	51.7
8513 Group ins & med reimb	1,407.45	1,040.00	387.45–	135.3
8515 Workmen's compensation	43.04	43.00	.04–	100.0
8516 Staff apartments	.00	.00	.00	.0
8517 Bonus	.00	.00	.00	.0
Total payroll & P/R benefits	32,668.12	39,124.00	6,457.88	83.5
Travel & entertainment expenses				
8512 Travel	456.65	300.00	156.65–	152.2
8522 Promotion, entertainment & gift	69.52	500.00	430.48	13.9
8523 Auto	1,295.90	1,729.00	433.10	75.0
Total travel & entertainment exp	1,822.07	2,529.00	706.93	72.1
Professional fees				
8531 Legal fees	419.00	50.00	369.00–	838.0
8532 Accounting fees	289.00	.00	289.00–	.0
8534 Temporary help	234.58	200.00	34.58–	117.2

With the advent of project organization, it became necessary to organize the budget in ways that conformed more closely to the actual pattern of fiscal responsibility. Under traditional budgeting methods, the budget for a project could be split up among many different organizational units, which diffused control so widely that it was frequently nonexistent. It was often almost impossible to determine the actual size of major expenditure activities in a project's budget. In light of this problem, ways were sought to alter the budgeting process so that budgets could be associated directly with the projects that used them. This need gave rise to program budgeting. Table 7-2 shows a program-oriented project budget divided by task/activity and expected time of expenditure. In an interesting paper, Brimson (1993) critiques both systems separately, and then combines them.

If a program consists of a set of separate projects, the use of program budgeting for each project allows those project budgets to be aggregated for the program as a whole by time periods. Moreover, the program can also have it's own monthly category budget (as shown in Table 7-1, with the categories down the left side), but this will require dividing up the revenues

Table 7-2. Project Budget by Task and Month

		Monthly Budget (£)							
Task	**Estimate**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
A	7000	5600	1400						
B	9000		3857	5143					
C	10000		3750	5000	1250				
D	6000		3600	2400					
E	12000				4800	4800	2400		
F	3000				3000				
G	9000			2571	5143	1286			
H	5000					3750	1250		
I	8000						2667	5333	
J	6000								6000
	75000	5600	12607	15114	14193	9836	6317	5333	6000

Source: Harrison, 1983.

(if any) and expenses for each of the projects' activities (tasks) into the appropriate categories. As well, each organizational unit can also present its projects' revenues and expenses by adding additional columns to Table 7-1, with one column for "regular operations" and the other columns for each project (or program). Again, however, this may take extra effort to break out the tasks by organizational unit as well as activity if the tasks involve more than one organizational unit.

The estimation of capital costs raises special problems. Accounting systems in different industries handle capital costs differently. Further, estimation requires highly specialized knowledge because the prices of some durable goods, e.g., machine tools, rise and fall in response to much different forces than affect the prices of other equipment, e.g., computer systems or aircraft. In an interesting two-part article, Sigurdsen (1996a, 1996b) notes that capital costs are variant with quantity of output and compares two methods of making capital cost estimates.

7.2 IMPROVING THE PROCESS OF COST ESTIMATION

The cooperation of several people is required to prepare cost estimates for a project. If the firm is in a business that routinely requires bids to be submitted to its customers, it will have "professional" (experienced) cost estimators on its staff. The major responsibility of the professional estimators is to reduce the level of uncertainty in cost estimations so that the firm's bids can be made in the light of expert information about its potential costs. In these cases, it is the job of the PM to generate a description of the work to be done on the project in sufficient detail that the estimator can know what cost data must be collected. Frequently, the project will be too complex for the PM to generate such a description without considerable help from experts in the functional areas.

Even with the finest of experts working to estimate resource usage, the one thing that is certain is that things will not go precisely as planned. There are two fundamentally different ways to manage the risks associated with the chance events that occur on every project. The simpler and far more common way is to make an allowance for contingencies—usually 5 or 10 percent of the estimated cost. Just why these numbers are chosen in preference to $6\frac{7}{8}$ or $9\frac{1}{4}$ for instance, we do not know. We strongly prefer another method in which the forecaster

Project Management in Practice

Completing the Limerick Nuclear Facility Under Budget

When the Limerick nuclear power generating facility in Pennsylvania began commercial operation, it set a construction record for nuclear facilities. In an era when it is common to hear of nuclear plants that massively overrun their budgets and completion schedules, Limerick was completed eight months ahead of its 49-month schedule and came in $400 million under its $3.2 billion budget. Limerick has truly set a standard for the industry.

It was no accident that Limerick was completed ahead of schedule and under budget. When construction started in February 1986, a project goal was to complete the project eight months ahead of the planned completion, which would help keep the costs under the budget limit as well. To achieve this early target, a series of innovative approaches were taken. Two of the major ones were to accelerate ramp-up staffing and to use an extensive, fully-supported second shift. The momentum of the speedy start-up set the fast pace for the remainder of the project. The second shift earned a very favorable premium, as well as having a full complement of managers and engineers to work with the manual workers. In this fashion, the second shift productivity was equal to, if not higher than, the first shift's.

Other decisions and actions further helped either the cost or the schedule. For example, it was decided that overtime would not be worked since a second shift was being used. And as a condition of the project approval, a project labor agreement with the local unions (rather than the national) had to be developed that would eliminate strikes, lockouts, and delays and provide for peaceful resolution of disputes. Also, an incentive fee contract with the building contractor was signed whereby the contractor would share equally in cost/schedule overruns or underruns, with limits set. With such attention to the goal of an early and under-budget completion, the team, numbering almost 3000 workers at the start, worked diligently and with high morale, beating its 4-year deadline by almost a year!

Source: T. P. Gotzis, "Limerick Generating Station No. 2," *PM Network*, January 1991.

selects "most likely, optimistic, and pessimistic" estimates. We adopted this method in Chapter 2 when we applied simulation to the discounted cash flow problem in the PsychoCeramic Sciences case. The method is described in detail in Chapter 8 when we cover the issue of estimating the duration of elements in the action plan. The method described in Chapter 8 is applicable, unchanged, to the estimation of resource requirements and costs for the determination of project budgets.

Turning now to the problem of estimating direct costs,* project managers often find it helpful to collect direct cost estimates on a form that not only lists the estimated level of resource needs, but also indicates when each resource will be needed, and notes if it is available (or will be available at the appropriate time). Figure 7-3 shows such a form. It also has a column for identifying the person to contact in order to get specific resources. This table can be used for collating the resource requirements for each task element in a project, or for aggregating the information from a series of tasks onto a single form.

*Our emphasis on estimating direct costs and on focusing on resources that are "direct costed" in the action plan is based on our belief that the PM should be concerned with only those items over which he or she has some control—which certainly excludes overheads. The PM, however, may wish to add some nonchargeable items to the resource column of the action plan simply to "reserve" that item for use at a specific time.

Note that Figure 7-3 contains no information on overhead costs. The matter of what overhead costs are to be added and in what amounts is unique to the firm, beyond the PM's control, and generally a source of annoyance and frustration to one and all. The allocation of overhead is arbitrary by its nature, and when the addition of overhead cost causes an otherwise attractive project to fail to meet the organization's economic objectives, the project's supporters are apt to complain bitterly about the "unfairness" of overhead cost allocation.

At times, firms support projects that show a significant incremental profit over direct costs but are not profitable when fully costed. Such decisions can be justified for a number of reasons, such as:

- To develop knowledge of a technology
- To get the organization's "foot in the door"

Project Name____________________
Date____________________
Task Number ____________________

RESOURCES NEEDED

Resources	**Person to Contact**	**How Many/ Much Needed**	**When Needed**	**Check ( ) If Available**
People: Managers, Supervisors				
Professional & Technical				
Nontechnical				
Money				
Materials: Facilities				
Equipment				
Tools				
Power				
Space				
Special Services: Research & Test				
Typing/clerical				
Reproduction				
Others				

Figure 7-3 Form for gathering data on project resource needs.

- To obtain the parts or service portion of the work
- To be in a good position for a follow-on contract
- To improve a competitive position
- To broaden a product line or a line of business

All of these are adequate reasons to fund projects that, in the short term, may lose money but provide the organization with the impetus for future growth and profitability. It is up to senior management to decide if such reasons are worth it.

Learning Curves*

If the project being costed is one of many similar projects, the estimation of each cost element is fairly routine. If the project involves work in which the firm has little experience, cost estimation is more difficult, particularly for direct labor costs. For example, consider a project that requires 25 units of a complex electronic device to be assembled. The firm is experienced in building electronic equipment but has never before made this specific device, which differs significantly from the items routinely assembled.

Experience might indicate that if the firm were to build many such devices, it would use about 70 hours of direct labor per unit. If labor is paid a wage of \$12 per hour, and if benefits equal 28 percent of the wage rate, the estimated labor cost for the 25 units is

$$(1.28)(\$12/\text{hr})(25\ \text{units})(70\ \text{hr/unit}) = \$26{,}880$$

In fact, this would be an underestimate of the actual labor cost because more time per unit output is used early in the production process. Studies have shown that human performance usually improves when a task is repeated. In general, performance improves by a fixed percent each time production doubles. More specifically, *each time the output doubles, the worker hours per unit decrease to a fixed percentage of their previous value*. That percentage is called the *learning rate*. If an individual requires 10 minutes to accomplish a certain task the first time it is attempted and only 8 minutes the second time, that person is said to have an 80 percent learning rate. If output is doubled again from two to four, we would expect the fourth item to be produced in

$$8(0.8) = 6.4\ \text{min}$$

Similarly, the eighth unit of output should require

$$6.4(0.8) = 5.12\ \text{min}$$

and so on. The time required to produce a unit of output follows a well-known formula:

$$T_n = T_1 n^r$$

where

T_n = the time required for the nth unit of output,
T_1 = the time required for the initial unit of output,
n = the number of units to be produced, and
r = log decimal learning rate/log 2.

The total time required for all units of a production run of size N is

$$\text{total time} = T_1 \sum_{n=1}^{N} n^r$$

* Occasionally, particular sections will be shaded, meaning that they can be skipped without loss of continuity.

Tables are widely available with both unit and total values for the learning curves, and have been calculated for many different improvement ratios (learning rates—e.g., see Shafer et al., 1998).

In the example of the electronic device just given, assume that after producing the twentieth unit, there is no significant further improvement (i.e., assembly time has reached a steady state at 70 hours). Further assume that previous study established that the usual learning rate for assemblers in this plant is about 85 percent. We can estimate the time required for the first unit by letting $T_n = 70$ hours by the unit $n = 20$. Then

$$\begin{aligned} r &= \log 0.85/\log 2 \\ &= -0.1626/0.693 \\ &= -0.235 \end{aligned}$$

and

$$\begin{aligned} 70 &= T_1(20)r \\ T_1 &= 141.3 \text{ hr} \end{aligned}$$

Now we know the time for the initial unit. Using a table that shows the total time multiplier (see Shafer et al., 1998, pp. 343–346, for example), we can find the appropriate total time multiplier for this example—the multiplier for 20 units given a learning rate of 85 percent. With this multiplier, 12.40, we can calculate the total time required to build all 20 units. It is

$$(12.40)(141.3 \text{ hr}) = 1752.12 \text{ hr}$$

The last five units are produced in the steady-state time of 70 hours each. Thus the total assembly time is

$$1752.12 + 5(70 \text{ hr}) = 2102.12 \text{ hr}$$

We can now refigure the direct labor cost.

$$2102.12(\$12)(1.28) = \$32{,}288.56$$

Our first estimate, which ignored learning effects, understated the cost by

$$\$32{,}288.56 - \$26{,}880 = \$5{,}408.56$$

or about 17 percent. Figure 7-4 illustrates this source of the error.

In recent years, learning curves have received increasing interest from project managers, particularly in the construction industry. Methods have been developed for the approximation of composite learning curves for entire projects (Amor et al., 1998), and for the approximation of total cost from the unit learning curve (Camm et al., 1987). Badiru (1995) has included learning curve effects in his critical resource diagramming, which is discussed in Chapter 8.

Remember that we are attempting to reduce the risk inherent in estimating costs. Therefore, for any task where labor is a significant cost factor and the production run is reasonably short, the PM should take the learning curve into account when estimating costs.

The implications of this conclusion should not be overlooked. We do not often think of projects as "production," but they are. While the construction, electronics, and aircraft assembly industries have used learning curves for many years, other industrial areas have been slow to follow. For example, research (Gagnon et al., 1987) has shown that the learning curve effect is important to decisions about the role of engineering consultants on computer-assisted design (CAD) projects. The same is assuredly true for the design of advertising campaigns or charity drives. The failure to consider performance improvement is a significant cause of errors in project cost estimation.

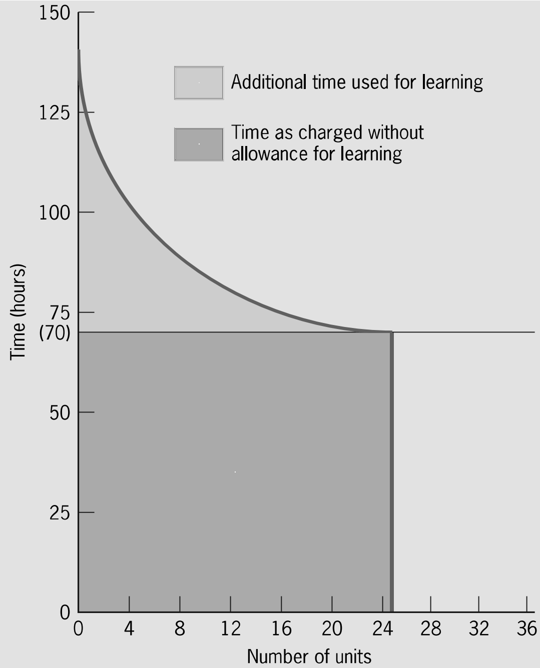


Figure 7-4 Effects of ignoring learning curve.

A Special Case of Learning—Technological Shock

If the parent organization is not experienced in the type of project being considered for selection, performance measures such as time to installation, time to achieve 80 percent efficiency, cost to install, and the like are quite uncertain and often will be seriously underestimated. It is interesting to observe that an almost certain, immediate result of installing a new, cost-saving technology is that costs rise. Sometimes we blame the cost increases on resistance to change, but a more sensible explanation is that when we alter a system, we disturb it and it reacts in unpredictable ways. A steelmaker recalling the installation of the then new technology for manufacturing tinplate by electrolysis remarked, "We discovered and installed the world's first electrolytic method for making scrap. It took a year before we had that line running the way it was designed." Of course, if the organization is experienced, underestimation is not likely to be a serious problem. The Reliance Electric Company undertook several "18-month" plant construction projects that they predicted, accurately, would require 36 months to build from decision to the point when the plant was capable of operating at or above three-fourths capacity. (Note the potential for ethical problems here.) To the extent possible, past knowledge of system actions and reactions should be built into estimates of future project performance.

Other Factors

Depending on the reference, anywhere from about three-fifths to five-sixths of projects fail to meet their time, cost, and/or specification objectives (see, for example, Frame, 1998). The record of Information Technology (IT) projects is particularly poor, according to article after article in the journals of the Project Management Institute. Possibly the problem is that Dilbert's pointy-haired boss sets arbitrary and impossible goals. Possibly scope-creep impacts all projects [though cost overruns are not necessarily associated with changing scope (Christensen et al., 1998)]. Possibly PMs use wildly optimistic estimates in order to influence the project selection process. Or maybe they are simply unaware of good cost (or time) estimating practices. For example, there are at least 45 estimating models available for IT projects, but few IT project managers use any of them (Lawrence, 1994; Martin, 1994). Some IT workers flatly refuse to estimate time and cost for IT projects on the grounds that there is too much uncertainty—and, we suspect, in an attempt to avoid responsibility. Possibly all of these things, and even others, act together to produce this unenviable track record.

While the number of things that can increase risk by producing errors in cost estimates is almost without limit, some problems occur with particularly high frequency. Changes in resource prices are one of these. The most commonly used solution to this problem is to increase all cost estimates by some fixed percentage. A more useful approach is to identify each input that accounts for a significant portion of project cost and estimate the direction and rate of price change for each.

The determination of which inputs account for a "significant" portion of project cost is not difficult, although it may be somewhat arbitrary. Suppose, for example, that our initial, rough cost estimate (with no provision for future price changes) for a project with an objective of setting up a small storefront accounting office is $1 million and is to be spent over a three-year period in approximately equal amounts per year. If we think personnel costs will comprise about 60 percent of that total, also spread equally over time, the wage/salary bill will be about $600,000. Split into three equal amounts, we have expenditures of $200,000 per year. If we estimate that wage/salary rates will increase by 6 percent per year, our expenses for the second year rise to $212,000 (an increase of $12,000), and to $224,720 in the third year (a further increase of $12,720). Failure to account for wage/salary inflation would result in an underestimate of project cost of $24,720. This is an error of slightly more than 4 percent of the estimated personnel cost and almost 2.5 percent of the total project budget.

Further improvements can be made by taking into account the fact that the prices of different inputs often change at very different rates and sometimes in different directions. A quick examination of the Bureau of Labor Statistics (BLS) wage and price indices, which cover a very large number of specific commodities and wage rates, will reveal that even in periods of stable prices, the prices of some things rise while others fall and still others do not change appreciably. Thus, the PM may wish to use different *inflators/deflators* for each of several different classes of labor or types of commodities. While most PMs are concerned only with price increases, any industry submitting competitive bids on projects must remember that failure to be aware of falling prices will lead to cost overestimation and uncompetitive bids.

The proper level of breakdown in estimating the impact of price changes simply depends on the organization's willingness to tolerate error. Assume that management is willing to accept a 5 percent difference between actual and estimated cost for each major cost category. In the example above, expected increases in wage/salary costs will use more than four-fifths of that allowance. That leaves less than one-fifth (about $5,300) of the allowable error, and the need to add one part-time clerk to the project for a single year would more than use the remaining allowance.

Other elements that need to be factored into the estimated project cost include an allowance for waste and spoilage. No sane builder would order "just enough" lumber to build a house. Also, personnel costs can be significantly increased by the loss and subsequent replacement of project professionals. Not only must new people go through a learning period—which, as we have seen, will have a negative effect on production—but professional starting salaries often rise faster than the general rate of annual salary increases. Thus, it may well cost more to replace a person who leaves the project with a newcomer who has approximately the same level of experience.

We have already mentioned the inclination PMs and project sponsors have toward understating the costs of a project in order to make it appear more profitable to senior managers, as well as the proclivity of lower-level project workers to overestimate costs in order to protect themselves. If the project is in its initial planning stage as a response to a Request for Proposal (RFP) from an outside organization, over- and underestimation of cost can have a serious impact on the probability of winning the contract—or on the level of profit, if a win occurs.

Serious ethical problems may arise during the process of estimating costs and submission of bids in response to an RFP. If the job is to be paid on a cost-plus basis, or even if it is a fixed-fee project, with fee increases allowed for special circumstances, some bidders may "low ball" a contract (submit underestimated costs). By doing this, they hope to win the bid, counting on the opportunity to increase costs or to plead special circumstances once the job is underway. At times, clients have been known to give favored bidders a "last look" at supposedly sealed bids so that the favored bidder can submit a winning bid, often with an unwritten agreement to allow some cost escalation at a later date. There is considerable opportunity for unethical behavior during cost estimation and bidding. Further, estimation and bidding practices vary widely from industry to industry.

Finally, there is plain bad luck. Delays occur for reasons that cannot be predicted. Machinery with the reliability of a railroad spike suddenly breaks down. That which has never failed fails. Every project needs an "allowance for contingencies."

Some writers and instructors differentiate four bases for estimating costs: experience, quantitative (statistical) methods, constraints, and worksheets. They discuss the advantages and disadvantages of each and then, typically, decide that one or another gives the best results. We feel strongly that all four are useful and that no single approach to cost estimation should be accepted as the best or rejected out of hand. The best estimators seem to employ an eclectic approach that uses, as one said, "anything that works." The wise PM takes into account as many known influences on the project budget as can be predicted. What cannot be predicted must then, by experience, simply be "allowed for." There are two other factors, particularly common to projects involving intangible outputs such as software programming, that need to be mentioned relating to cost-estimation and the schedule. These two factors have been identified in a classic and highly readable work—*The Mythical Man-Month*—by Brooks (1975).

First, most projects involve a tangible medium that tends not to be under our control—the wood splits, the paint smears—and thus we blame implementation problems of our "good" ideas on these physical elements. So, when we are working with a purely intellectual medium that has no physical elements, such as computer code, we are highly optimistic and foolishly assume that all will go well. However, when any project consisting of a series of components can only be successful if all of the components are successful, and each component has a small probability of failing, the chances of the overall project being successful may be very poor. Consider, for example, a software program consisting of 1000 lines of code, each of which is 0.999 reliable. The chance of the program itself working is only about 36 percent! Brooks' experience has led him to the following rule of thumb for software projects. As a fraction of the total time of the project, planning consumes about $\frac{1}{3}$, coding consumes $\frac{1}{6}$, component test consumes $\frac{1}{4}$, and system test consumes $\frac{1}{4}$. Thus, if a project estimate is made based on the expected coding time (the main element for which we can derive an estimate), this in reality will usually represent only about 17 percent of the entire project time rather than the 80 to 90 percent commonly assumed.

The second factor is what Brooks calls "the mythical man-month" and relates to our tendency to assume that workers and time are interchangeable. Thus, when a schedule slips, the traditional response is to add labor, which is like trying to douse a fire with gasoline. Our assumption that workers and time are interchangeable is correct only when a task can be partitioned such that there is no communication needed between the workers. Most projects, however, especially computer programming, are not set up that way and the more workers that are added require even more workers to train, as well as lines of communication to coordinate their efforts. Thus, three workers require three times as much pairwise intercommunication as two, and four require six times as much, etc. This result is captured in Brooks' law: *Adding manpower to a late software project makes it later*.

Project Management in Practice

The Emanon Aircraft Corporation

Emanon Aircraft is a major manufacturer of aircraft parts, specializing in landing gear parts and assemblies. They are located in a highly industrialized midwestern state. The local area suffers from somewhat higher than average unemployment, partly because Emanon has experienced a downturn in business. In the past three years, they have lost out on a number of landing gear contracts, being underbid by competitors from other areas of the country. Senior management studied the problem, but has come to no conclusion about what can be done. They have hired a consulting team from a nearby university to study the situation and make a recommendation.

Business in the aircraft industry is not significantly different than in many other industries specializing in the building of complex machines. Aircraft builders are primarily assembly operations. They build planes from subassemblies and parts manufactured by themselves or by subcontractors who, in turn, specialize in specific subassemblies; for example, landing gear, avionics, passenger seats, heating and air conditioning, etc. When an order is received to build some number of a given type of plane, the builder (prime contractor) requests bids for the proper number of a certain part or subassembly from appropriate subcontractors. All relevant specifications for the part or subassembly are included in the RFP. The subcontractors who wish to participate in the project submit proposals that include a complete description of the proposed subassembly together with price information, delivery dates, and any other pertinent conditions of sale.

The university consulting team studied three aspects of Emanon's landing gear operation: the manufacturing process, the cost structure, and the bidding behavior and profit structure on landing gear bids. They determined that the manufacturing process was reasonably efficient and not significantly different from Emanon's competitors. Second, they found that all competitors were using approximately the same level of mark-up when determining their cost-plus price. When examining the cost structure, however, they noted that in the past three years, the firm consistently ran negative cost variances in material accounts. That is, the amount of material actually used in the construction of landing gears was approximately 10 percent less than the plan indicated. The team was unsure of this finding because there were only a few winning contracts for landing gears during the past three years.

An investigation was conducted on the estimation and purchase of materials for this department. It exposed the following facts. Three-and-one-half years ago, Emanon was late making a delivery of landing gear parts. The firm paid a large penalty and was threatened with loss of further business with the prime contractor. The late delivery resulted when Emanon ordered an insufficient quantity of a special steel alloy used in landing gear struts, and was unable to purchase any on the open market. The steel company required a manufacturing lead time of more than 90 days, so Emanon's delivery was late.

As a result, the purchasing official who had responsibility for this contract was demoted. The new purchasing official handled the problem in a straightforward fashion by inflating the material estimates by approximately 10 percent. The cost of material is about half of the total cost of landing gear production, which resulted in bids that were approximately 5 percent above the competition..

Source: S. J. Mantel, Jr. Consulting project.

On Making Better Estimates*

Let us begin with the assumption that budget estimation errors are not the result of deliberate dishonesty, but derive from honest errors on the part of the PM, project cost estimators, or anyone else involved. We have already noted that there are many reasons why "honest" errors occur—that projects look easier, faster, and cheaper to senior managers than to those who must do the work that nonexpert estimators tend to overlook details required to do a complete job—that everyone seems to assume that Murphy's law has been repealed for their personal project. But these things should be learned by experience. Why do experienced managers err on their budget and schedule estimates?

Ambrose Bierce, in *The Devil's Dictionary*, defined "experience" as "The wisdom that enables us to recognize as an undesirable old acquaintance the folly that we have already embraced." It is axiomatic that we should learn through experience. It is a truism that we do not. Nowhere is this more evident than in project management, and yet it is not difficult to improve one's estimation/forecasting skills.

Recall that there are two generic types of estimation error. First, there is random error in which overestimates and underestimates are equally likely. These are errors that tend to cancel each other. If we sum these errors over many estimates, their sum will approach zero. Second, there is bias, which is systematic error. For biased estimates, the chance of over- and underestimates are *not* equally likely, and their sum, either positive or negative will increase as the number of estimates increases. A measure for bias, the "tracking signal" (TS), is given in Row 4 of Figure 7-5. Using the ubiquitous Excel® we can construct a spreadsheet that captures the essence of a person's performance as an estimator. Two simple statistical measures are used: the mean absolute deviation (MAD), and the tracking signal (TS). The printout† of such a spreadsheet is shown in Figure 7-5. Appendix A of this book (on the book's website) includes information on probability, statistics, and forecasting.

Figure 7-5 assumes that for each period (Column A) someone has made an estimate of a variable (Column B), and that the actual value of that variable is, sooner or later, known (Column C). (It should be noted that Column A need not be time periods. This column simply counts the number of estimates made and links estimates with their respective actuals.) Column D calculates the difference between the actual value, A(t), and the estimate or forecast for that period, F(t). Column E contains the absolute value of that difference. We can now calculate a statistic known as the *mean absolute deviation* (MAD).

As the information in Row 3 of the spreadsheet shows,

$$\text{MAD} = \sum(|\text{A}(t) - \text{F}(t)|)/n$$

where n is the number of differences. The MAD is therefore the arithmetic average of the absolute values of the differences—the mean absolute deviation.

Students of statistics may note that the MAD has certain logical similarities to the standard deviation. Assuming that the forecast errors are normally distributed, the MAD is approximately 80 percent of a standard deviation (see Chase et al., 1989). Thus, if the MAD is a sizable fraction of the variable being estimated, the average error is large and the forecast or estimate is not very accurate, but this does not mean that it is biased.

Now, consider Column D. The sum of the entries in this column for any number of periods is the sum of the forecast errors, often referred to as the "running sum of the forecast errors" (RSFE). As we noted, if the estimator's errors are truly random, and unbiased, their sum should approach zero. In Figure 7-5, RSFE = 133, so the forecast is quite biased.

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* Occasionally, particular sections will be shaded, meaning that they can be skipped without loss of continuity.

† Any of the common spreadsheet programs can easily handle all of the calculations shown in this chapter and will accept formulas and calculations from any of the others.

	A	B	C	D	E	F	G
1	This is a template for improving one's estimating skills						
2							
3	MAD = SUM (|A(t) – F (t)|)/n The Average Absolute Error						
4	Tracking Signal = SUM(A(t) – F(t))/MAD A Measure of Bias						
5							Tracking
6	Period	Estimate	Actual	A(t) – F(t)	|A(t) – F(t)|	MAD	Signal
7	======	========	========	========	========	========	========
8							
9	1	155	163	8	8		
10	2	242	240	–2	2	5.00	1.20
11	3	46	67	21	21	10.33	2.61
12	4	69	78	9	9	10.00	3.60
13	5	75	71	–4	4	8.80	3.64
14	6	344	423	79	79	20.50	5.41
15	7	56	49	–7	7	18.57	5.60
16	8	128	157	29	29	19.88	6.69
17							
18	Key Formulae		Total =	133	159		
19	Cell D9	= (C9–B9) copy to D10:D16					
20	Cell E9	= ABS(C9–B9) copy to E10:E16					
21	Cell F10	= (Sum($E$9:E10))/A10 copy to F11:F16					
22	Cell G10	= (Sum($D$9:D10))/F10 copy to G11:G16					

Figure 7-5 Excel® template for cost estimation.

The tracking signal is a special measure of the estimator's bias. It is easily found:

$$TS = RSFE/MAD$$

Note that it calculates the number of MADs in the RSFE (see column G in Figure 7-5, and recall the similarity between MAD and standard deviation). If the RSFE is small, approaching zero, the TS will also approach zero. As the RSFE grows, the TS will grow, indicating bias. Division of the RSFE by the MAD creates a sort of "index number," the TS, a ratio that is independent of the size of the variables being considered. We cannot say just how much bias is acceptable in an estimator/forecaster. We feel that a TS $\geq$ 3 is too high unless the estimator is a rank beginner. Certainly, an experienced estimator should have a much lower TS. (It should be obvious that the TS may be either negative or positive. Our comment actually refers to the absolute value of the TS.)

Perhaps more important than worrying about an acceptable limit on the size of the tracking signal is the practice of tracking it and analyzing why the estimator's bias, if there is one, exists. If the estimator can identify the source of the bias, then the forecasting process should be corrected, with a concomitant improvement in the forecasts. If not, but the bias seems to continue, the estimator can simply correct the forecasts by the amount of the known bias. It has often been said that manufacturing managers do this when automatically cutting the Sales Department's upcoming quarterly sales forecasts by 20 percent.

Similarly, the estimator should consider how to reduce the MAD, the random error. Such analysis is the embodiment of "learning by experience." The Excel® template makes the analysis simple to conduct, and should result in decreasing the size of both the MAD and the TS.

Some estimators would like to speed up the process of improving their estimation skills by grouping forecasts of different resources to generate more data points when calculating their MADs and TSs. Use of the tracking signal requires that the input data, estimates (forecasts) and actuals, be collected and processed separately for each variable being estimated. Cost estimates and actuals for different resources, for instance, would be used to find the MAD and TS for each individual resource. The reason for this inconvenience is that resources come in different units and the traditional caution about adding apples and oranges applies. (Even if all resources are measured in dollars, we still have scale problems when we mix resource costs of very different sizes.) Fortunately, there is a way around the problem.

Instead of defining the estimation error as the *difference* between actual and forecast, we can define it as the *ratio* of actual to forecast. Therefore, the new error for the first forecast (Period 1) in Figure 7-5 is not eight units, but rather is

$$A(t)/F(t) = 163/155 = 1.052$$

<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th></tr>
<tr><td>1</td><td colspan="7">This is a template for improving one's estimating skills</td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td colspan="7">MAR = SUM {|(A(t) / F (t)) – 1|} /n</td></tr>
<tr><td>4</td><td colspan="7">Tracking Signal = SUM{(A(t) / F (t)) – 1}/MAR</td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Tracking</td></tr>
<tr><td>6</td><td>Period</td><td>Estimate</td><td>Actual</td><td>(A(t)/F(t)) – 1</td><td>|(A(t)/F(t)) – 1|</td><td>MAR</td><td>Signal</td></tr>
<tr><td>7</td><td>=====</td><td>=======</td><td>=======</td><td>========</td><td>==========</td><td>=====</td><td>======</td></tr>
<tr><td>8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>1</td><td>155</td><td>163</td><td>0.052</td><td>0.052</td><td></td><td></td></tr>
<tr><td>10</td><td>2</td><td>242</td><td>240</td><td>–0.008</td><td>0.008</td><td>0.030</td><td>1.448</td></tr>
<tr><td>11</td><td>3</td><td>46</td><td>67</td><td>0.457</td><td>0.457</td><td>0.172</td><td>2.904</td></tr>
<tr><td>12</td><td>4</td><td>69</td><td>78</td><td>0.130</td><td>0.130</td><td>0.162</td><td>3.898</td></tr>
<tr><td>13</td><td>5</td><td>75</td><td>71</td><td>–0.053</td><td>0.053</td><td>0.140</td><td>4.120</td></tr>
<tr><td>14</td><td>6</td><td>344</td><td>423</td><td>0.230</td><td>0.230</td><td>0.155</td><td>5.205</td></tr>
<tr><td>15</td><td>7</td><td>56</td><td>49</td><td>–0.125</td><td>0.125</td><td>0.151</td><td>4.523</td></tr>
<tr><td>16</td><td>8</td><td>128</td><td>157</td><td>0.227</td><td>0.227</td><td>0.160</td><td>5.670</td></tr>
<tr><td>17</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td>Key Formulae</td><td></td><td>Total =</td><td>0.908</td><td>1.281</td><td></td><td></td></tr>
<tr><td>19</td><td>Cell D9</td><td colspan="6">= (C9–B9)–1 copy to D10:D16</td></tr>
<tr><td>20</td><td>Cell E9</td><td colspan="6">= ABS((C9–B9)–1) copy to E10:E16</td></tr>
<tr><td>21</td><td>Cell F10</td><td colspan="6">= (Sum($E$9:E10))/A10 copy to F11:F16</td></tr>
<tr><td>22</td><td>Cell G10</td><td colspan="6">= (Sum($D$9:D10))/F10 copy to G11:G16</td></tr>
</table>

Figure 7-6 Estimation template using ratios.

or a 5.2 percent error. In order to produce measures similar in nature and concept to the MAD and TS, we will subtract 1 from the ratio. Thus, when the actual is greater than the forecast, the measure (i.e., the error ratio minus 1) will be positive, and if the actual is *less* than the forecast, the measure will be negative. Figure 7-6 shows the calculations of $\{A(t)/F(t) - 1\}$ for the data used in Figure 7-5. Column E shows the absolute value of column D, and column F lists the MAR (mean absolute ratio). The tracking signal is calculated as usual by dividing the "running sum of the forecast ratios" (RSFR) by the MAR,

$$TS = RSFR/MAR$$

Notice that this calculation does not suffer from unit or scale effects because the ratio of actual to forecast is a dimensionless number and we are finding the percent error rather than the "real" error.

One caution remains. While this technique will allow one to aggregate dissimilar data and, thereby, measure the degree of random error and bias faster than when using differences, care must be exercised to aggregate only data for which there is good reason to believe that the amount of bias and uncertainty is roughly the same for all resource estimates.

At the beginning of this discussion, we made the assumption that estimation errors were "honest." That assumption is not necessary. If a manager suspects that costs are purposely being under- or overestimated, it is usually not difficult to collect appropriate data and calculate the tracking signal for an individual estimator—or even for an entire project team. If it is known that such information is being collected, one likely result is that the most purposeful bias will be sharply reduced.

It may occur to the reader that we have not applied simulation analysis, similar to that illustrated in Chapter 2, to deal with budgetary uncertainty. It should be obvious that such an application is appropriate. For example, in addition to optimistic, pessimistic, and most likely cost estimates, a number of other variables are uncertain—the inflation rate for various cost elements, the learning rate, the amount of resource usage for individual tasks, and the timing of expenditures, to mention a few. As we have noted above, we are saving this application for a detailed description for the scheduling problem in Chapter 8. Its application to budgeting is quite similar.

A final note: In the next chapter, we discuss a method for managing schedule and budget risk. We also describe some software used for risk management. Most of the useful methods require that the forecaster specify the mode and range of the variable being forecast. These models tacitly assume that the data supplied represent unbiased estimates. As we noted previously, if the input estimates are biased, the output will incorporate that error and the danger is not "Garbage in, garbage out" but "Garbage in, gospel out."

SUMMARY

This chapter initiated the subject of project implementation by focusing on the project budget, which authorizes the project manager to obtain the resources needed to begin work. Different methods of budgeting were described along with their impacts on project management. Then, a number of issues concerning cost estimation were discussed, particularly the effect of learning on the cost of repetitive tasks and how to use the concept of the learning curve. Finally, methods for improving cost estimation skills were described.

Specific points made in the chapter were these:

- The intent of a budget is to communicate organizational policy concerning the organization's goals and priorities.
- There are a number of common budgeting methods: top-down, bottom-up, the program budget.
- A form identifying the level of resource need, when it will be needed, who the contact is, and its availability is especially helpful in estimating costs.

- It is common for organizations to fund projects whose returns cover direct but not full costs in order to achieve long-run strategic goals of the organization.
- If projects include repetitive tasks with significant human input, the learning phenomenon should be taken into consideration when preparing cost estimates.
- The learning curve is based on the observation that the amount of time required to produce one unit decreases a constant percentage every time the cumulative output doubles.
- A method for determining whether or not cost estimates are biased is described. The method can be used to improve any estimation/forecasting process.
- Other major factors, in addition to learning, that should be considered when making project cost estimates are inflation, differential changes in the cost factors, waste and spoilage, personnel replacement costs, and contingencies for unexpected difficulties.

In the next chapter, we address the subject of task scheduling, a topic of major importance in project management. More research and investigation have probably been conducted on the subject of scheduling than any other element of project management.

GLOSSARY

Bottom-up Budgeting A budgeting method that begins with those who will be doing the tasks estimating the resources needed. The advantage is more accurate estimates.

Cost Categories

Direct (or Variable) Cost These costs vary with output; e.g., labor costs, material costs, and sometimes the cost of capital equipment such as machinery that performs a specific function on each unit of output.

General & Administrative Cost (G&A) The cost of administration; e.g., Accounting, Human Resources, and Legal not charged as an Indirect Cost and not included in Overhead Cost. Sometimes the G&A is not reported as a separate item but is included in overhead cost. G&A is usually charged as a fixed percent of a direct cost such as labor.

Indirect (or Fixed) Cost These costs are associated with output, but do not vary with each unit of output; e.g., the cost of capital equipment not charged per piece of output, advertising, distribution, or sales. Costs are charged as a lump sum or as a fixed percent of some direct cost such as labor.

Overhead Cost Costs incurred by the firm, but not associated with any specific product or class of products; e.g., cost of building and ground maintenance, utilities, cost of plant security, cost of health insurance and pension plans. Typically charged as a fixed percent of some direct cost such as labor.

Learning Rate The percentage of the previous worker hours per unit required for doubling the output.

Program Budgeting Budgeting by project task/activity and then aggregating income and expenditures by project or program, often in addition to aggregation by organizational unit or category.

Top-Down Budgeting A budgeting method that begins with top managers' estimates of the resources needed for a project. Its primary advantage is that the aggregate budget is typically quite accurate because no element has been left out. Individual elements, however, may be quite inaccurate.

Variances The pattern of deviations in costs and usage used for exception reporting to management.

QUESTIONS

Material Review Questions

1. What are the advantages of top-down budgeting? Of bottom-up budgeting? What is the most important task for top management to do in bottom-up budgeting?
2. In preparing a budget, what indirect costs should be considered?
3. Describe the purpose and use of a tracking signal.
4. Describe the top-down budgeting process.
5. What is a variance?
6. Describe the learning curve phenomenon.
7. How might you determine if cost estimates are biased?
8. What is "program budgeting"?
9. What is the difference between activity- and category-oriented budgets?

Class Discussion Questions

10. Discuss ways in which to keep budget planning from becoming a game.

11. List some of the pitfalls in cost estimating. What steps can a manager take to correct cost overruns?

12. Why do consulting firms frequently subsidize some projects? Is this ethical?

13. What steps can be taken to make controlling costs easier? Can these steps also be used to control other project parameters, such as performance?

14. Which budgeting method is likely to be used with which type of organizational structure?

15. What are some potential problems with the top-down and bottom-up budgeting processes? What are some ways of dealing with these potential problems?

16. How is the budget planning process like a game?

17. Would any of the conflict resolution methods described in the previous chapter be useful in the budget planning process? Which?

18. How does the fact that capital costs vary with different factors complicate the budgeting process?

19. Why is learning curve analysis important to project management?

20. Why is it "ethically necessary to be honest" in negotiations between a superior and subordinate?

21. The chapter describes the problems of budgeting for S-shaped and exponential life-cycle projects. What might be the budgeting characteristics of a project with a straight line life cycle?

Questions for Project Management in Practice

Pathfinder Mission to Mars—On a Shoestring

22. How did a change in philosophy make such a drastic difference in project cost?

23. Why was the mission scope so limited? Why even spend the money to go to Mars with such limited objectives?

24. Describe their "de-scope," "lien list," and "cash reserve" approaches.

25. Recent design-to-cost interplanetary projects have also had some spectacular failures. Is this the natural result of this new philosophy?

Completing the Limerick Nuclear Facility Under Budget

26. What "trick" did the construction firm use to come in ahead of schedule and under budget?

27. What extra expenses did the contractor incur in order to finish ahead of schedule? How can one tell whether they are spending too much to finish early, thereby saving not only time but also overhead costs?

Managing Costs at Massachusetts' Neighborhood Health Plan

28. Wouldn't higher eligibility requirements for subscribers cut NHP's health care costs? Why did this exacerbate NHP's situation?

29. Explain the trade-off between hospital utilization and contract rates.

30. How did changing from a line item pay plan to an episode plan allow comparisons and save costs?

PROBLEMS

1. Using the cost estimation template and Actuals in Figure 7-5, compare the model in the figure with the following estimates derived from a multiplicative model. Base your comparison on the mean bias, the MAD, and the tracking signal. Comment.

Period:	1	2	3	4	5	6	7	8
Estimated:	179	217	91	51	76	438	64	170

2. Repeat Problem 1 but using the template in Figure 7-6 based on the MAR instead.

3. Conduct a discounted cash flow calculation to determine the NPV of the following project, assuming a required rate of return of 0.2. The project will cost \$75,000 but will result in cash inflows of \$20,000, \$25,000, \$30,000, and \$50,000 in each of the next four years.

4. In Problem 3, assume that the inflows are uncertain but normally distributed with standard deviations of \$1000, \$1500, \$2000, and \$3500, respectively. Find the mean forecast NPV using Crystal Ball®. What is the probability the actual NPV will be positive?

5. A production lot of 25 units required 103.6 hours of effort. Accounting records show that the first unit took 7 hours. What was the learning rate?

6. If unit 1 requires 200 hours to produce and the labor records for an Air Force contract of 50 units indicates an average labor content of 63.1 hours per unit, what was the learning rate? What total additional number of labor-hours would be required for a follow-on Air Force contract of 50 units? What would be the average labor content of this second contract? Of both contracts combined? If labor costs the vendor $10/hour on this second contract and the price to the Air Force is fixed at $550 each, what can you say about the profitability of the first and second contracts, and hence the bidding process in general?
7. Your firm designs PowerPoint slides for computer training classes, and you have just received a request to bid on a contract to produce the slides for an eight-session class. From previous experience, you know that your firm follows an 85 percent learning rate. For this contract it appears the effort will be substantial, running 50 hours for the first session. Your firm bills at the rate of $100/hour and the overhead is expected to run a fixed $600 per session. The customer will pay you a flat fixed rate per session. If your nominal profit margin is 20 percent, what will be the total bid price, the per session price, and at what session will you break even?
8. A light manufacturing firm has set up a project for developing a new machine for one of its production lines. The most likely estimated cost of the project itself is $1,000,000, but the most optimistic estimate is $900,000 while the pessimists predict a project cost of $1,200,000. The real problem is that even if the project costs are within those limits, if the project itself plus its implementation costs exceed $1,425,000, the project will not meet the firm's NPV hurdle. There are four cost categories involved in adding the prospective new machine to the production line: (1) engineering labor cost, (2) nonengineering labor cost, (3) assorted material cost, and (4) production line downtime cost.

    The engineering labor requirement has been estimated to be 600 hours, plus or minus 15 percent at a cost of $80 per hour. The nonengineering labor requirement is estimated to be 1500 hours, but could be as low as 1200 hours or as high as 2200 hours at a cost of $35 per hour. Assorted material may run as high as $155,000 or as low as $100,000, but is most likely to be about $135,000. The best guess of time lost on the production line is 110 hours, possibly as low as 105 hours and as high as 120 hours. The line contributes about $500 per hour to the firm's profit and overhead. What is the probability that the new machine project will meet the firm's NPV hurdle?

INCIDENTS FOR DISCUSSION

Preferred Sensor Company

Sean Cole has been appointed project manager of the Preferred Sensor Company's new sensor manufacturing process project. Sensors are extremely price-sensitive, and Preferred has done a great deal of quantitative work so it can accurately forecast changes in sales volume relative to changes in pricing.

The company president, "Dude" Sensor, has considerable faith in the firm's sensitivity model and insists that all projects that affect the manufacturing cost of sensors be run against the sensitivity model in order to generate data to calculate the return on investment. The net result is that project managers, like Sean, are under a great deal of pressure to submit realistic budgets so go/no-go project decisions can be made quickly. Dude has canceled several projects that appeared marginal during their feasibility stages and recently fired a project manager for overestimating project costs on a new model sensor. The project was killed very early in the design stage and six months later a competitor introduced a similar sensor that proved to be highly successful.

Sean's dilemma is how to go about constructing a budget that accurately reflects the cost of the proposed new manufacturing process. Sean is an experienced executive and feels comfortable with his ability to come close to estimating the cost of the project. However, the recent firing of his colleague has made him a bit gun-shy. Only one stage out of the traditional four-stage sensor manufacturing process is being changed, so he has detailed cost information about a good percentage of the process. Unfortunately, the tasks involved in the process stage being modified are unclear at this point. Sean also believes that the new modification will cause some minor changes in the other three stages, but these changes have not been clearly identified. The stage being addressed by the project represents almost 50 percent of the manufacturing cost.

Questions: Under these circumstances, would Sean be wise to pursue a top-down or a bottom-up budgeting approach? Why? What factors are most relevant here?

General Ship Company

General Ship Company has been building nuclear destroyers for the Navy for the last 20 years. It has recently completed the design of a new class of nuclear destroyer and will be preparing a detailed budget to be followed during construction of the first destroyer.

The total budget for this first destroyer is $90 million. The controller feels the initial project cost estimate prepared by the planning department was too low because the waste and spoilage allowance was underestimated. Thus, she is concerned that there may be a large cost overrun on the project and wants to work closely with the project manager to control the costs.

Question: How would you monitor the costs of this project?

CONTINUING INTEGRATIVE CLASS PROJECT

Although probably a minor task for this project, create a program budget using both top-down and bottom-up budgeting. Reconcile any differences by discussion between the PM, subgroup leaders, and the student(s) responsible for the task.

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The following case and the answers to the questions at the end describe the stringent criteria this disguised but well-known firm uses to select among projects that offer major profit opportunities for the firm. In addition, the firm intentionally ties the criteria to their strategic goals so that each adopted project moves the organization farther in the competitive direction they have chosen by adding to their core competencies. The case also illustrates how the firm integrates their marketing, operations, engineering, and finance functions to forge a competitive advantage for the firm in the marketplace.

C A S E

AUTOMOTIVE BUILDERS, INC.: THE STANHOPE PROJECT

Jack Meredith

It was a cold, gray October day as Jim Wickes pulled his car into ABI's corporate offices parking lot in suburban Detroit. The leaves, in yellows and browns, swirled around his feet as he walked into the wind toward the lobby. "Good morning, Mr. Wickes," said his secretary as he came into the office. "That proposal on the Stanhope project just arrived a minute ago. It's on your desk." "Good morning, Debbie. Thanks. I've been anxious to see it."

This was the day Jim had scheduled to review the 1986 supplemental capital request and he didn't want any interruptions as he scrutinized the details of the flexible manufacturing project planned for Stanhope, Iowa. The Stanhope proposal, compiled by Ann Williamson, PM and managerial "champion" of this effort, looked like just the type of project to fit ABI's new strategic plan, but there was a large element of risk in the project. Before recommending the project to Steve White, executive vice president of ABI, Jim wanted to review all the details one more time.

History of ABI

ABI started operations as the Farm Equipment Company just after the First World War. Employing new technology to produce diesel engine parts for tractors, the firm flourished with the growth of farming and became a multimillion dollar company by 1940.

During the Second World War, the firm switched to producing tank and truck parts in volume for the military. At the war's end, the firm converted its equipment to the production of automotive parts for the expanding automobile industry. To reflect this major change in their product line, the company was renamed Automotive Builders, Inc. (ABI), though they remained a major supplier to the farm equipment market.

A Major Capital Project

The farm equipment industry in the 1970s had been doing well, but there were some disturbing trends. Japanese manufacturers had entered the industry and were beginning to take a significant share of the domestic market. More significantly, domestic labor costs were significantly higher than overseas and resulted in price disadvantages that couldn't be ignored any longer. Perhaps most important of all, quality differences between American and Japanese farm equipment, including tractors, were becoming quite noticeable.

To improve the quality and costs of their incoming materials, many of the domestic tractor manufacturers were beginning to single-source a number of their tractor components. This allowed them better control over both quality and cost, and made it easier to coordinate delivery schedules at the same time.

In this vein, one of the major tractor engine manufacturers, code-named "Big Red" within ABI, let its suppliers know that it was interested in negotiating a contract for a possible 100 percent sourcing of 17 versions of special piston heads destined for a new line of high-efficiency tractor engines expected to replace the current conventional engines in both new and existing tractors. These were all six-cylinder diesel engines and thus would require six pistons each.

This put ABI in an interesting situation. If they failed to bid on this contract, they would be inviting competition into their very successful and profitable diesel engine parts business. Thus, to protect their existing successful business, and to pursue more such business, ABI seemed required to bid on this contract. Should ABI be successful in their bid, this would result in 100 percent sourcing in both the original equipment market (OEM) as well as the replacement market with its high margins.

Furthermore, the high investment required to produce these special pistons at ABI's costs would virtually rule out future competition.

ABI had two plants producing diesel engine components for other manufacturers and believed they had a competitive edge in engineering of this type. These plants, however, could not accommodate the volume Big Red expected for the new engine. Big Red insisted at their negotiations that a 100 percent supplier be able to meet peak capacity at their assembly plant for this new line.

As Jim reviewed the proposal, he decided to refer back to the memos that restated their business strategy and started them thinking about a new Iowa plant located in the heart of the farm equipment industry for this project. In addition, Steve White had asked the following basic, yet rather difficult questions about the proposal at their last meeting and Jim wanted to be sure he had them clearly in mind as he reviewed the files.

- ABI is already achieving an excellent return on investment (ROI). Won't this investment simply tend to dilute it?
- Will the cost in new equipment be returned by an equivalent reduction in labor? Where's the payoff?
- What asset protection is there? This proposal requires an investment in new facilities before knowing whether a long-term contract will be procured to reimburse us for our investment.
- Does this proposal maximize ROI, sales potential, or total profit?

To address these questions adequately, Jim decided to recheck the expected after-tax profits and average rate of return (based on sales of 70,000 engines per year) when he reached the financial portion of the proposals. These figures should give a clear indication of the "quality" of the investment. There were, however, other aspects of capital resource allocation to consider besides the financial elements. One of these was the new business strategy of the firm, as recently articulated by ABI's executive committee.

The Business Strategy

A number of elements of ABI's business strategy were directly relevant to this proposal. Jim took out a note pad to jot down each of them and assign them a priority as follows:

1. Bid only on good margin products that have the potential for maintaining their margins over a long term.
2. Pursue oly new products whose design or production process is of a proprietary nature and that exist in areas where our technical abilities enable us to maintain a long-term position.
3. Employ, if at all possible, the most advanced technology in new projects that is either within our experience or requires the next step up in experience.
4. Foster the "project champion" approach to innovation and creativity. The idea is to encourage entrepreneurship by approving projects to which individual managers are committed and that they have adopted as personal "causes" based on their belief that the idea, product, or process is in our best interest.
5. Maintain small plants of no more than 480 employees. These have been found to be the most efficient, and they enjoy the best labor relations.

With these in mind, Jim reopened the proposal and started reading critical sections.

Demand Forecasts and Scenarios

For this proposal, three scenarios were analyzed in terms of future demand and financial impacts. The baseline "Scenario I" assumed that the new line would be successful. "Scenario II" assumed that the Japanese would soon follow and compete successfully with Big Red in this line. "Scenario III" assumed that the new line was a failure. The sales volume forecasts under these three scenarios are shown in Table 1.

There was, however, little confidence in any of these forecasts. In the preceding few years Japan had become a formidable competitor, not only in price but also in more difficult areas of competition, such as quality and reliability. Furthermore, the economic situation in 1986 was taking a severe toll on American farmers and economic forecasts indicated there was no relief in sight. Thus, as stated in the proposal:

> The U.S. farm market will be a difficult battleground for world farm equipment manufacturers and any forecast of a particular engine's potential in this market must be considered as particularly risky. How much risk do we want to accept? Every effort should be made to minimize our exposure on this investment and maximize our flexibility.

Manufacturing Plan

The proposal stressed two primary aspects of the manufacturing process. First, a learning curve was employed

Table 1. Demand Forecasts (000s engines)*

Year	*Baseline I*	*Scenario II*	*Scenario III*
1987	69	69	69
1988	73	72	72
1989	90	81	77
1990	113	95	68
1991	125	87	62
1992	145	74	47

*Each engine requires six pistons.

in calculating production during the 1000-unit ramp-up implementation period in order to not be overly optimistic. A learning rate of 80 percent was assumed. Second, an advanced technology process using a flexible manufacturing system, based largely on turning centers, was recommended since it came in at $1 million less than conventional equipment and met the strategy guidelines of using sophisticated technology when appropriate.

Since ABI had closely monitored Big Red's progress in the engine market, the request for bids had been foreseen. In preparation for this, Jim had authorized a special manufacturing-process study to determine more efficient and effective ways of producing piston heads. The study considered product design, process selection, quality considerations, productivity, and manufacturing system planning. Three piston manufacturing methods were considered in the study: (1) batch manufacture via computer numerically controlled (CNC) equipment; (2) a flexible manufacturing system (FMS); and (3) a high-volume, low-unit-cost transfer machine.

The resulting recommendation was to install a carefully designed FMS, if it appeared that additional flexibility might be required in the future for other versions, or even other manufacturers. Though such a system would be expensive, the volume of production over the FMS's longer lifetime would offset that expense. Four preferred machine builders were contacted for equipment specifications and bids. It was ABI's plan to work closely with the selected vendor in designing and installing the equipment, thus building quality and reliability into both the product and the process and learning about the equipment at the same time.

To add further flexibility for the expensive machinery, all design features that would facilitate retool or changeover to other products were incorporated. For example, the machining centers would also be capable of machining other metals, such as aluminum or nodular iron, and would be fitted with variable feed and speed motors, feed-force monitors, pressure-controlled clamping of workpieces, and air-leveling pallets. Also, fully interchangeable chucks, spindles, pallets, tooling, and risers would be purchased to minimize the spare parts inventories.

Plant Operation and Organization

As stated in the proposal, many innovative practices were to be employed at the new plant:

- Machine operators will be trained to do almost all of their own machine maintenance.
- All employees will conduct their own statistical process control and piston heads will be subject to 100 percent inspection.
- There will only be four skill classes in the plant. Every employee in each of those classes will be trained to do any work within that class.
- There will not be any time clocks in the plant.

The organizational structure for the 11 salaried workers in the new plant is shown in Figure 1, and the complete labor summary is illustrated in Figure 2, including the shift breakdown. As can be seen, the plant will be relatively small, with 65 employees in the ratio of 1:5 salaried to hourly. The eight-month acquisition of the employees during the ramp-up is illustrated in Figure 3, with full employment occurring by March 1987.

Financial Considerations

Financial aspects of new proposals at ABI were considered from a number of perspectives, in part because of the interdependent nature of many proposals. The results of not investing in a proposal are normally compared with the results of investing and the differences noted. Variations on the investment assumptions are also tested, including errors in the forecast sales volumes, learning rates, productivities, selling prices, and cancellations of both current and future orders for existing and potential business.

For the Stanhope proposal, the site investment required is $3,012,000. The details of this investment are shown in Table 2. The total investment required amounts to $7,108,000 (plus required working capital of $1,380,000). The equipment is depreciated over an eight-year life. ABI, under the revised tax laws, is in the

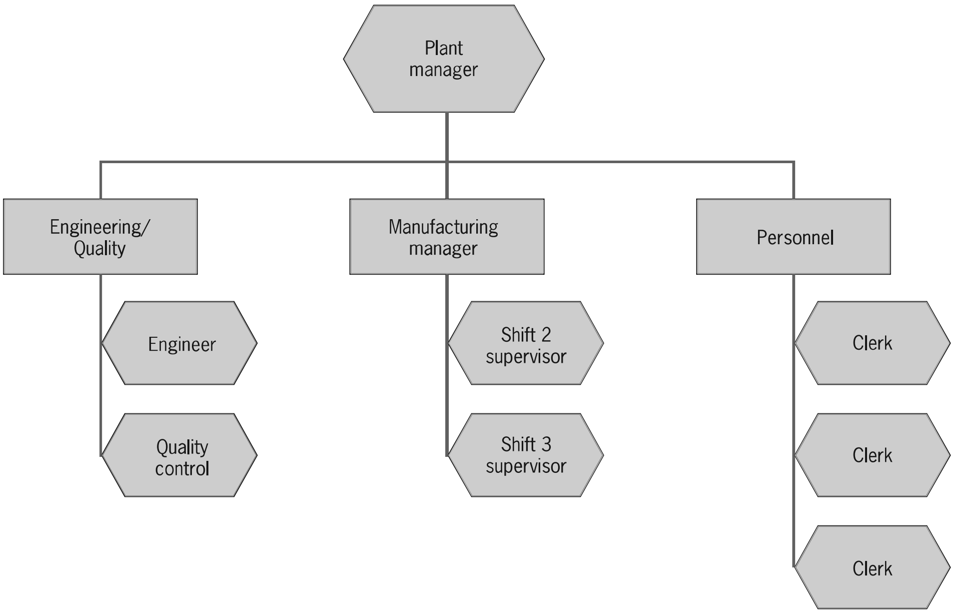

Figure 1 Stanhope organization.

34 percent tax bracket. The price of the piston heads has been tentatively set at $25.45 apiece. ABI's expected costs are shown in Table 3.

Some Concerns

Jim had spoken with some of his colleagues about the FMS concept after the preliminary financial results had been tabulated. Their concerns were what now interested him. For example, he remembered one manager asking: "Suppose Big Red's sales only reach 70 percent of our projections in the 1989–90 time period, or say, perhaps as much as 150 percent; how would this affect the project? Does the FMS still apply or would you consider some other form of manufacturing equipment, possibly conventional or CNC with potential aftermarket application in the former case or a transfer machine in the latter case?"

Another manager wrote down his thoughts as a memo to forward to Jim. He had two major concerns:

- "Scenario II" analysis assumes the loss of substantial volume to competition. This seems rather unlikely.
- After-tax margins seem unreasonably high. Can we get such margins on a sole-source contract?

Salaried Labor	Number of Staff
Plant manager	1
Manufacturing managers (3 shifts)	3
Quality control manager	1
Engineering	2
Personnel manager	1
Clerical	3
	11

Hourly Labor	Days	Afternoons	Night
Direct	14	14	10
Inspection	1	1	1
Maintenance	2	1	1
Tooling	2	2	1
Rec./shp./mtl.	2	1	1
Total	21	19	14

Summary	
Salary	11
Hourly	54
Total	65

Figure 2 Stanhope labor summary.

Jim wondered what these changes in their assumptions would do to the ROI of the proposal and its overall profitability.

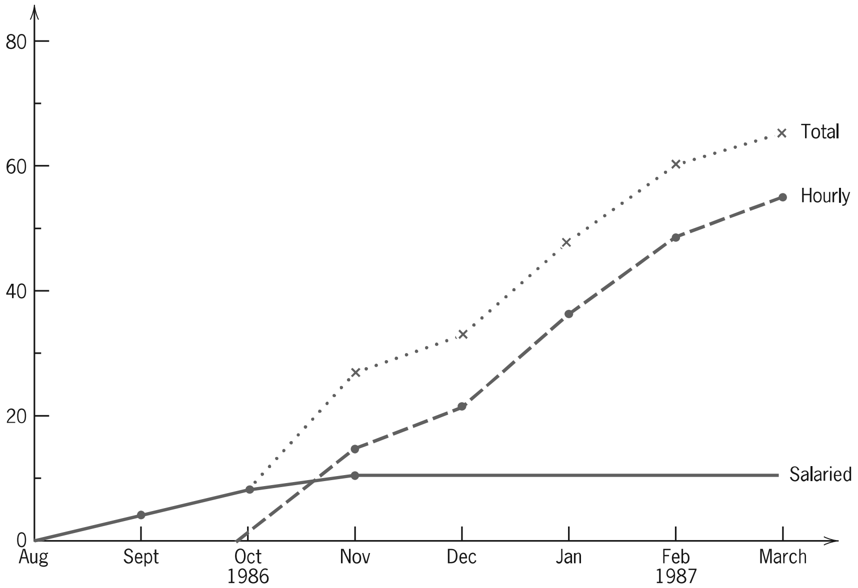

Figure 3 Stanhope labor buildup.

Table 2. Stanhope Site Capital Costs

Land and Site Preparation	
land	$246,000
access roads/parking lot	124,000
landscaping	22,000
Building Costs	
building (67,000 sq ft)	1,560,000
air conditioning	226,000
power	205,000
employee services	177,000
legal fees and permits	26,000
Auxiliary Equipment	
ABI company sign	25,000
containers, racks, etc.	33,000
flume	148,000
coolant disposal	97,000
furnishings	51,000
forklift trucks	72,000
Total	3,012,000

Table 3. Piston Head Cost Summary

Material	$8.47
Labor	1.06
Variable overhead	2.23
Fixed overhead	2.44
Freight	0.31
Total Factory Cost	14.51
General & administrative	1.43
Scrap	0.82
Testing	0.39
Total Cost	17.15

Conclusion

Jim had concerns about the project also. He wondered how realistic the demand forecasts were, given the weak economy and what the Japanese might do. If the demand didn't materialize, ABI might be sorry they had invested in such an expensive piece of equipment as an FMS.

Strategically, it seemed like ABI had to make this investment to protect its profitable position in the diesel engine business; but how far should this argument be carried? Were they letting their past investments color their judgment on new ones? He was also concerned about the memo questioning the high profit margins. They did seem high in the midst of a sluggish economy.

QUESTIONS

1. How did ABI handle forecast risk?
2. Were ABI's Stanhope site costs in Table 2 derived by a top-down or bottom-up process? Why?
3. What are the answers to Steve White's questions?
4. What other factors are relevant to this issue?
5. How do the changes in assumptions mentioned by the other managers affect the proposal?
6. What position should Jim take? Why?

This article clearly describes the importance and impact of cost-related issues on a project. These issues can significantly alter the profitability and even success of a project. Costs are discussed from three viewpoints: that of the project manager, the accountant, and the controller. Not only are the amounts of expenditures and encumbrances important, but their timing is critical also. Perhaps most important is having a project cost system that accurately reports costs and variances in a way that can be useful for managerial decisions.

DIRECTED READING

THREE PERCEPTIONS OF PROJECT COST*

D. H. Hamburger

Project cost seems to be a relatively simple expression, but "cost" is more than a four letter word. Different elements of the organization perceive cost differently, as the timing of project cost identification affects their particular organizational function. The project manager charged with on-time, on-cost, on-spec execution of a project views the "on cost" component of his responsibility as a requirement to stay within the allocated budget, while satisfying a given set of specified conditions (scope of work), within a required time frame (schedule). To most project managers this simply means a commitment to project funds in accordance with a prescribed plan (time-based budget). Others in the organization are less concerned with the commitment of funds. The accounting department addresses expense recognition related to a project or an organizational profit and loss statement. The accountant's ultimate goal is reporting profitability, while positively influencing the firm's tax liability. The comptroller (finance department) is primarily concerned with the organization's cash flow. It is that person's responsibility to provide the funds for paying the bills, and putting the unused or available money to work for the company.

To be an effective project manager, one must understand each cost, and also realize that the timing of cost identification can affect both project and corporate financial performance. The project manager must be aware of the different cost perceptions and the manner in which they are reported. With this knowledge, the project manager can control more than the project's cost of goods sold (a function often viewed as the project manager's sole financial responsibility). The project manager can also influence the timing of cost to improve cash flow and the cost of financing the work, in addition to affecting revenue and expense reporting in the P&L statement.

Three Perceptions of Cost

To understand the three perceptions of cost—commitments, expenses, and cash flow—consider the purchase of a major project component. Assume that a $120,000 compressor with delivery quoted at six months was purchased. Figure 1 depicts the order execution cycle. At time 0 an order is placed. Six months later the vendor makes two shipments, a large box containing the compressor and a small envelope

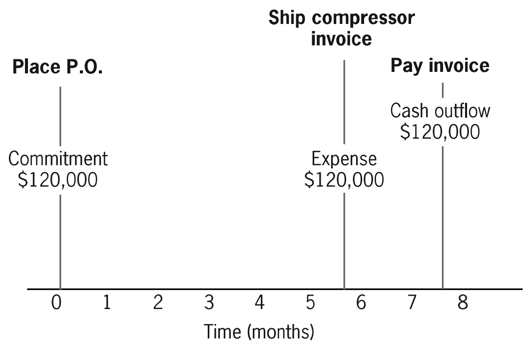

Figure 1 Three perceptions of project cost.

*Three Perceptions of Project Cost—Cost Is More Than a Four Letter Word. *Project Management Journal*, June 1986. ©1987 by the Project Management Institute. Reprinted by permission.

containing an invoice. The received invoice is processed immediately, but payment is usually delayed to comply with corporate payment policy (30, 60, 90, or more days may pass before a check is actually mailed to the vendor). In this example, payment was made 60 days after receipt of the invoice or 8 months after the order for the compressor was given to the vendor.

Commitments—The Project Manager's Concern

Placement of the purchase order represents a *commitment* to pay the vendor $120,000 following satisfactory delivery of the compressor. As far as the project manager is concerned, once this commitment is made to the vendor, the available funds in the project budget are reduced by that amount. When planning and reporting project costs the project manager deals with commitments. Unfortunately, many accounting systems are not structured to support project cost reporting needs and do not identify commitments. In fact, the value of a purchase order may not be recorded until an invoice is received. This plays havoc with the project manager's fiscal control process, as he cannot get a "handle" on the exact budget status at a particular time. In the absence of a suitable information system, a conscientious project manager will maintain personal (manual or computer) records to track his project's commitments.

Expenses—The Accountant's Concern

Preparation of the project's financial report requires identification of the project's revenues (when applicable) and all project *expenses*. In most conventional accounting systems, expenses for financial reporting purposes are recognized upon receipt of an invoice for a purchased item (not when the payment is made—a common misconception). Thus, the compressor would be treated as an expense in the sixth month.

In a conventional accounting system, revenue is recorded when the project is completed. This can create serious problems in a long-term project in which expenses are accrued during each reporting period with no attendant revenue, and the revenue is reported in the final period with little or no associated expenses shown. The project runs at an apparent loss in each of the early periods and records an inordinately large profit at the time revenue is ultimately reported—the final reporting period. This can be seriously misleading in a long-term project which runs over a multiyear period.

To avoid such confusion, most long-term project P&L statements report revenue and expenses based on a "percentage of completion" formulation. The general intent is to "take down" an equitable percentage of the total project revenue (approximately equal to the proportion of the project work completed) during each accounting period, assigning an appropriate level of expense to arrive at an acceptable period gross margin. At the end of each accounting year and at the end of the project, adjustments are made to the recorded expenses to account for the differences between actual expenses incurred and the theoretical expenses recorded in the P&L statement. This can be a complex procedure. The misinformed or uninformed project manager can place the firm in an untenable position by erroneously misrepresenting the project's P&L status; and the rare unscrupulous project manager can use an arbitrary assessment of the project's percentage of completion to manipulate the firm's P&L statement.

There are several ways by which the project's percentage of completion can be assessed to avoid these risks. A typical method, which removes subjective judgments and the potential for manipulation by relying on strict accounting procedures, is to be described. In this process a theoretical period expense is determined, which is divided by the total estimated project expense budget to compute the percentage of total budget expense for the period. This becomes the project's percentage of completion which is then used to determine the revenue to be "taken down" for the period. In this process, long delivery purchased items are not expensed on receipt of an invoice, but have the value of their purchase order prorated over the term of order execution. Figure 2 shows the $120,000 compressor in the example being expensed over the six-month delivery period at the rate of $20,000 per month.

Cash Flow—The Comptroller's Concern

The comptroller and the finance department are responsible for managing the organization's funds, and also assuring the availability of the appropriate amount of cash for payment of the project's bills. Unused funds are put to work for the organization in interest-bearing accounts or in other ventures. The finance department's primary concern is in knowing when funds will be needed for invoice payment in order to minimize the time that these funds are not being used productively. Therefore, the comptroller really

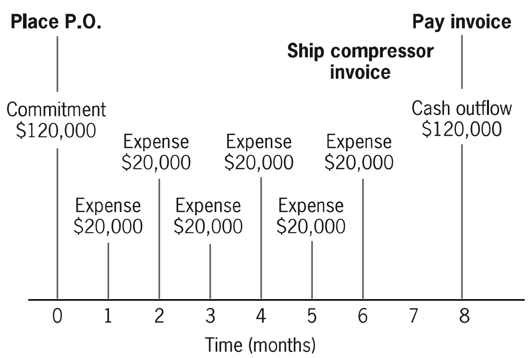

Figure 2 Percentage of completion expensing.

views project cost as a *cash outflow*. Placement of a purchase order merely identifies a future cash outflow to the comptroller, requiring no action on his part. Receipt of the invoice generates a little more interest, as the comptroller now knows that a finite amount of cash will be required for a particular payment at the end of a fixed period. Once a payment becomes due, the comptroller provides the funds, payment is made, and the actual cash outflow is recorded.

It should be noted that the compressor example is a simplistic representation of an actual procurement cycle, as vendor progress payments for portions of the work (i.e., engineering, material, and delivery) may be included in the purchase order. In this case, commitment timing will not change, but the timing of the expenses and cash outflow will be consistent with the agreed-upon terms of payment.

The example describes the procurement aspect of project cost, but other project cost types are treated similarly. In the case of project labor, little time elapses between actual work execution (a commitment), the recording of the labor hours on a time sheet (an expense), and the payment of wages (cash outflow). Therefore, the three perceptions of cost are treated as if they each occur simultaneously. Subcontracts are treated in a manner similar to equipment purchases. A commitment is recorded when the subcontract is placed and cash outflow occurs when the monthly invoice for the work is paid. Expenses are treated in a slightly different manner. Instead of prorating the subcontract sum over the performance period, the individual invoices for the actual work performed are used to determine the expense for the period covered by each invoice.

Thus the three different perceptions of cost can result in three different time-based cost curves for a given project budget. Figure 3 shows a typical relationship between commitments, expenses, and cash outflow. The commitment curve leads and the cash outflow curve lags, with the expense curve falling in the middle. The actual shape and the degree of lag/lead between the curves are a function of several factors, including: the project's labor, material, and subcontract mix; the firm's invoice payment policy; the delivery period for major equipment items; subcontract performance period and the schedule of its work; and the effect of the project schedule on when and how labor will be expended in relation to equipment procurement.

The conscientious project manager must understand these different perceptions of cost and should be prepared to plan and report on any and all approaches required by management. The project manager should also be aware of the manner in which the accounting department collects and reports "costs." Since the project manager's primary concern is in the commitments, he or she should insist on an accounting system which is compatible with the project's reporting needs. Why must a project manager resort to a manual control system when the appropriate data can be made available through an adjustment in the accounting department's data processing system?

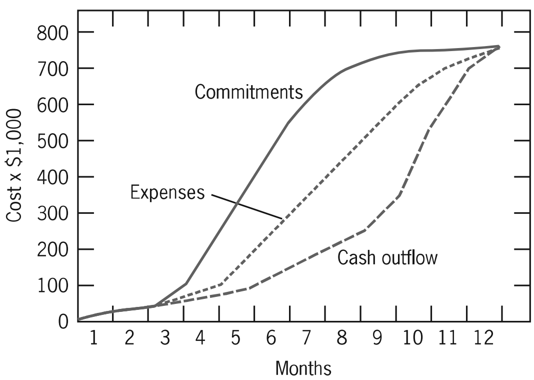

Figure 3 Three perceptions of cost.

Putting Your Understanding of Cost to Work

Most project managers believe that their total contribution to the firm's profitability is restricted by the ability to limit and control project cost, but they can do much more. Once the different perceptions of cost have been recognized, the project manager's effectiveness is greatly enhanced. The manner in which the project manager plans and executes the project can improve company profitability through influence on financing expenses, cash flow, and the reporting of revenue and expenses. To be a completely effective project manager one must be totally versed in the cost accounting practices which affect the firm's project cost reporting.

Examination of the typical project profit & loss statement (see Table 1) shows how a project sold for profit is subjected to costs other than the project's costs (cost of goods sold). The project manager also influences other areas of cost as well, addressing all aspects of the P&L to influence project profitability positively.

Specific areas of cost with examples of what a project manager can do to influence cost of goods sold, interest expense, tax expense, and profit are given next.

Table 1. Typical Project Profit & Loss Statement

Revenue (project sell price)	($1,000,000)
(less) cost of goods sold (project costs)	($ 750,000)
Gross margin	$ 250,000)
(less) selling, general & administrative expenses	($ 180,000)
Profit before interest and taxes	$ 70,000)
(less) financial expense	($ 30,000)
Profit before taxes	$ 40,000)
(less) taxes	($ 20,000)
Net profit	$ 20,000

Cost of Goods Sold (Project Cost)

- Evaluation of alternate design concepts and the use of "trade-off" studies during the development phase of a project can result in a lower project cost, without sacrificing the technical quality of the project's output. The application of value engineering principles during the initial design period will also reduce cost. A directed and controlled investment in the evaluation of alternative design concepts can result in significant savings of project cost.
- Excessive safety factors employed to ensure "on-spec" performance should be avoided. Too frequently the functional members of the project team will apply large safety factors in their effort to meet or exceed the technical specifications. The project team must realize that such excesses increase the project's cost. The functional staff should be prepared to justify an incremental investment which was made to gain additional performance insurance. Arbitrary and excessive conservatism must be avoided.
- Execution of the project work must be controlled. The functional groups should not be allowed to stretch out the project for the sake of improvement, refinement, or the investigation of the most remote potential risk. When a functional task has been completed to the project manager's satisfaction (meeting the task's objectives), cut off further spending to prevent accumulation of "miscellaneous" charges.
- The project manager is usually responsible for controlling the project's contingency budget. This budget represents money that one expects to expend during the term of the project for specific requirements not identified at the project onset. Therefore, these funds must be carefully monitored to prevent indiscriminate spending. A functional group's need for a portion of the contingency budget must be justified and disbursement of these funds should only be made after the functional group has exhibited an effort to avoid or limit its use. It is imperative that the contingency budget be held for its intended purpose. Unexpected problems will ultimately arise, at which time the funds will be needed. Use of this budget to finance a scope change is neither advantageous to the project manager nor to management. The contingency budget represents the project manager's authority in dealing with corrections to the project work. Management must be made aware of the true cost of a change so that financing the change will be based on its true value (cost-benefit relationship).
- In the procurement of equipment, material, and subcontract services, the specified requirements should be identified and the lowest priced, qualified supplier found. Adequate time for price "shopping" should be built into the project schedule. The Mercury project proved to be safe and successful even though John Glenn, perched in the Mercury capsule atop the Atlas rocket prior to America's first earth orbiting flight, expressed his now famous concern that "all this hardware was built by the low bidder." The project manager should ensure that the initial project budget is commensurate with the project's required level of reliability. The project manager should not be put in the position of having to buy project reliability with unavailable funds.
- Procurement of material and services based on partially completed drawings and specifications should be avoided. The time necessary for preparing a complete documentation package before soliciting bids should be considered in the preparation of the project schedule. Should an order be awarded based on incomplete data and the vendor then asked to alter the original scope of supply, the project will be controlled by the vendor. In executing a "fast track" project, the project manager should make certain that the budget contains an adequate contingency for the change orders which will follow release of a partially defined work scope.
- Changes should not be incorporated in the project scope without client and/or management approval and the allocation of the requisite funds. Making changes without approval will erode the existing budget and reduce project profitability; meeting the project manager's "on-cost" commitment will become extremely difficult, if not impossible.
- During periods of inflation, the project manager must effectively deal with the influence of the economy on the project budget. This is best accomplished during the planning or estimating stage of the work, and entails recognition of planning in an inflationary environment for its effect by estimating the potential cost of two distinct factors. First, a "price protection" contingency budget is needed to cover the cost increases that will occur between the time a vendor provides a firm quotation for a limited period and the actual date the order will be placed. (Vendor quotations used to prepare an estimate usually expire long before the material is actually purchased.) Second, components containing certain price-volatile materials (e.g., gold, silver, etc.) may not be quoted firm, but will be offered by the supplier as "price in effect at time of delivery." In this case an "escalation" contingency budget is needed to cover the added expense that will accrue between order placement and material delivery. Once the project manager has established these inflation related contingency budgets, the PM's role becomes one of ensuring controlled use.

Financial Expense

- The project's financial cost (interest expense) can be minimized by the project manager through the timing of order placement. Schedule slack time can be used to defer the placement of a purchase order so that the material is not available too early and the related cash outflow is not premature. There are several risks associated with this concept. Delaying an order too long could backfire if the desired material is unavailable when needed. Allowing a reasonable margin for error in the delivery cycle, saving some of the available slack time for potential delivery problems, will reduce this risk. Waiting too long to place a purchase order could result in a price increase which can more than offset the interest savings. It is possible to "lock-up" a vendor's price without committing to a required delivery date, but this has its limitations. If vendor drawings are a project requirement, an "engineering only" order can be placed to be followed by hardware release at the appropriate time. Deferred procurement which takes advantage of available slack time should be considered in the execution of all projects, especially during periods when the cost of money is excessively high.
- Vendors are frequently used to help "finance the project" by placing purchase orders which contain extended payment terms. Financially astute vendors will build the cost of financing the project into their sell price, but only to the extent of remaining competitive. A vendor's pricing structure should be checked to determine if progress payments would result in a reduced price and a net project benefit. A discount for prompt payment should be taken if the discount exceeds the interest savings that could result from deferring payment.
- Although frequently beyond the project manager's control, properly structured progress payment terms can serve to negate most or all project financial expenses. The intent is simple. A client's progress payment terms can be structured to provide scheduled cash inflows which offset the project's actual cash outflow. In other words, maintenance of a zero net cash position throughout the period of project execution will minimize the project's financial expense. In fact, a positive net cash position resulting from favorable payment terms can actually result in a project which creates interest income rather than one that incurs an interest expense. Invoices to the client should be processed quickly, to minimize the lost interest resulting from a delay in receiving payment.
- Similarly, the project manager can influence receipt of withheld funds (retention) and the project's final payment to improve the project's rate of cash inflow. A reduction in retention should be pursued as the project nears completion. Allowing a project's schedule to indiscriminately slip delays project acceptance, thereby delaying final payment. Incurring an additional expense to resolve a questionable problem should be considered whenever the expense will result in rapid project acceptance and a favorable interest expense reduction.
- On internally funded projects, where retention, progress payments, and other client related financial considerations are not a factor, management expects to achieve payback in the shortest reasonable time. In this case, project spending is a continuous cash outflow process which cannot be reversed until the project is completed and its anticipated financial benefits begin to accrue from the completed work. Unnecessary project delays, schedule slippages, and long-term investigations extend system startup and defer the start of payback. Early completion will result in an early start of the investment payback process. Therefore, management's payback goal should be considered when planning and controlling project work, and additional expenditures in the execution of the work should be considered if a shortened schedule will adequately hasten the start of payback.

Tax Expense and Profit

- On occasion, management will demand project completion by a given date to ensure inclusion of the project's revenue and profit within a particular accounting period. This demand usually results from a need to fulfill a prior financial performance forecast. Delayed project completion by only a few days could shift the project's entire revenue and profit from one accounting period to the next. The volatile nature of this situation, large sums of revenue and profit shifting from one period to the next, results in erratic financial performance which negatively reflects on management's ability to plan and execute their efforts.
- To avoid the stigma of erratic financial performance, management has been known to suddenly redirect a carefully planned, cost-effective project team effort to a short-term, usually costly, crash exercise, directed toward a project completion date, artificially necessitated by a corporate financial reporting need. Unfortunately, a project schedule driven by influences external to the project's fundamental objectives usually results in additional cost and reduces profitability.
- In this particular case, the solution is simple if a percentage of completion accounting process can be applied. Partial revenue and margin take-down

during each of the project's accounting periods, resulting from this procedure (rather than lump sum take-down in a single period at the end of the project, as occurs using conventional accounting methods) will mitigate the undesirable wild swings in reported revenue and profit. Two specific benefits will result. First, management's revenue/profit forecast will be more accurate and less sensitive to project schedule changes. Each project's contribution to the overall forecast will be spread over several accounting periods and any individual performance change will cause the shift of a significantly smaller sum from one accounting period to the next. Second, a project nearing completion will have had 90–95 percent of its revenue/profit taken down in earlier periods, which will lessen or completely eliminate management pressure to complete the work to satisfy a financial reporting demand. Inordinate, unnecessary spending to meet such unnatural demands can thereby be avoided.

- An Investment Tax Credit,* a net reduction in corporate taxes gained from a capital investment project (a fixed percentage of the project's installed cost), can be earned when the project actually provides its intended benefit to the owner. The project manager should consider this factor in scheduling the project work, recognizing that it is not necessary to complete the entire project to obtain this tax benefit as early as possible. Failure to substantiate beneficial use within a tax year can shift this savings into the next tax year. The project manager should consider this factor in establishing the project's objectives, diligently working toward attainment by scheduling the related tasks to meet the tax deadline. Consideration should also be given to expenditures (to the extent they do not offset the potential tax savings) to reach this milestone by the desired date.
- In managing the corporate P&L statement, the need to shift revenue, expenses, and profit from one tax period to the next often exists. By managing the project schedule (expediting or delaying major component procurements or shifting expensive activities), the project manager can support this requirement. Each individual project affords a limited benefit, but this can be maximized if the project manager is given adequate notice regarding the necessary scheduling adjustments.
- Revenue/profit accrual based on percentage of completion can create a financial problem if actual expenses greatly exceed the project budget. In this case the project's percentage of completion will accumulate more quickly than justified and the project will approach a theoretical 100 percent completion before all work is done. This will "front load" revenue/profit take-down and will ultimately require a profit reversal at project completion. Some managers may find this desirable, since profits are being shifted into earlier periods, but most reputable firms do not wish to overstate profits in an early period which will have to be reversed at a later time. Therefore, the project manager should be aware of cost overruns and, when necessary, reforecast the project's "cost on completion" (increasing the projected cost and reducing the expected profit) to reduce the level of profit taken down in the early periods to a realistic level.

Conclusion

Cost is not a four letter word to be viewed with disdain by the project manager. It is a necessary element of the project management process which the project manager must comprehend despite the apparent mysteries of the accounting systems employed to report cost. The concept of cost is more than the expenses incurred in the execution of the project work: the manner in which cost is treated by the organization's functional elements can affect project performance, interest expenses, and profitability. Therefore, the conscientious project manager must develop a complete understanding of project cost and the accounting systems used to record and report costs. The project manager should also recognize the effect of the timing of project cost, and the differences between commitments, expenses, and cash flow. The project manager should insist on the accounting system modifications needed to accommodate project cost reporting and control requirements. Once an appreciation for these concepts has been gained, the project manager can apply this knowledge towards positively influencing project and organizational profitability in all areas of cost through control of the project schedule and the execution of the project's work.

Questions

1. What is the major point of the article?
2. How does the accountant view project costs?
3. How does the controller view project costs?
4. How does the project manager view project costs?
5. What other costs does the project manager need to be cognizant of? What actions should the PM take concerning these other costs?

*The proposed tax law revisions under consideration in Congress at the time this article was written include a provision which eliminates the Investment Tax Credit.