Manufacturing and Service Operations Planning

Spring 2019

Project Management in Practice

receive quarterly results for the purpose of correcting problems in the following quarter. The results took 4 months to reach them, however, completely negating the value of the budgeting-reporting system.

In this chapter, we will first examine some different methods of budgeting and cost estimating, as used for projects. Then we will consider some ways to improve the cost estimation process, including some technical approaches such as learning curves and tracking signals. We will also discuss some ways to misuse the budget that are, unfortunately, common. Last, we discuss the problem of budget uncertainty and the role of risk management when planning budgets.


Risk

4.1 METHODS OF BUDGETING

Budgeting is simply the process of forecasting what resources the project will require, what quantities of each will be needed, when they will be needed, and how much they will cost. Tables 4-1 and 4-2 depict the direct costs involved in making a short documentary film. Table 4-1 shows the cost per unit of usage (cost/hour) of seven different personnel categories and one facility. Note that the facility does not charge by the hour, but has a flat rate charge. Table 4-2 shows the resource categories and amounts used for each activity required to make the DVD. The resource costs shown become part of the budget for producing the documentary film. As you will see below, overhead charges may be added to these direct charges.

Most businesses and professions employ experienced estimators who can forecast resource usage with amazingly small errors. For instance, a bricklayer can usually estimate within 1 or 2 percent the number of bricks required to construct a brick wall of given dimensions. In many fields, the methods of cost estimation are well documented based on the experience of estimators gathered over many years. The cost of a building, or house, is usually estimated by the square feet of floor area multiplied by an appropriate dollar value per square foot and then adjusted for any unusual factors.

Budgeting a project such as the development of a control system for a new computer, however, is often more difficult than budgeting more routine activities—and even more difficult than regular departmental budgeting which can always be estimated as: "Same as last year plus X percent." But project budgeters do not usually have tradition

Table 4-1 Resource Cost per Unit for Producing a Short Documentary Film

Producing a DVD Resource Cost						
ID	*Resource Name*	*Max. Units*	*Std. Rate*	*Ovt. Rate*	*Cost/Use*	*Accrue At*
1	Scriptwriter	1	$75.00/hr	$100.00/hr	$0.00	Prorated
2	Producer	1	$100.00/hr	$150.00/hr	$0.00	Prorated
3	Client	0.2	$0.00/hr	$0.00/hr	$0.00	Prorated
4	Secretary	1	$25.00/hr	$40.00/hr	$0.00	Prorated
5	Editor	1	$50.00/hr	$85.00/hr	$0.00	Prorated
6	Production staff	1	$40.00/hr	$70.00/hr	$0.00	Prorated
7	Editing staff	1	$40.00/hr	$70.00/hr	$0.00	Prorated
8	Editing room	1	$0.00/hr	$0.00/hr	$250.00	Start

Table 4-2 Budget by Resource for Producing a Short Documentary Film

Producing a DVD Budget by Resource				
ID	***Task Name***	***Resource Work Hours***	***Cost***	***Task Duration***
1	**Project approval**	0 hr	$0.00	0 days
2	**Scriptwriting**	112 hr	$8,400.00	14 days
	Scriptwriter	112 hr	$8,400.00	
3	**Schedule shoots**	240 hr	$5,400.00	15 days
4	**Begin scheduling**	0 hr	$0.00	0 days
5	**Propose shoots**	120 hr	$7,000	5 days
	Scriptwriter	40 hr	$3,000.00	
	Producer	40 hr	$4,000.00	
	Client	40 hr	$0.00	
6	**Hire secretary**	40 hr	$4,000.00	5 days
	Producer	40 hr	$4,000.00	
7	**Schedule shoots**	80 hr	$2,000.00	10 days
	Secretary	80 hr	$2,000.00	
8	**Scheduling comp**	0 hr	$0.00	0 days
9	**Script approval**	80 hr	$4,000.00	5 days
	Producer	40 hr	$4,000.00	
	Client	40 hr	$0.00	
10	**Revise script**	80 hr	$7,000.00	5 days
	Scriptwriter	40 hr	$3,000.00	
	Producer	40 hr	$4,000.00	
11	**Shooting**	160 hr	$7,200.00	10 days
	Editor	80 hr	$4,000.00	
	Production staff	80 hr	$3,200.00	
12	**Editing**	168 hr	$5,290.00	7 days
	Editor	56 hr	$2,800.00	
	Editing staff	56 hr	$2,240.00	
	Editing room	56 hr	$250.00	
13	**Final approval**	160 hr	$6,250.00	5 days
	Producer	40 hr	$4,000.00	
	Client	40 hr	$0.00	
	Editor	40 hr	$2,000.00	
	Editing room	40 hr	$250.00	
14	**Deliver DVD to client**	0 hr	$0.00	0 days

to guide them. Projects are, after all, unique activities. Of course, there may be somewhat similar past projects that can serve as a model, but these are rough guides at best. Forecasting a budget for a multiyear project such as a large product line or service development project is even more hazardous because the unknowns can escalate quickly with changes in technology, materials, prices, and even the findings of the project up to that point.

Organizational tradition also impacts project budgeting. Every firm has its own rules about how overhead and other indirect costs are charged against projects. Every firm has its ethical codes. Most firms must comply with the Sarbanes-Oxley Act (SOX) and the Health Insurance Portability and Accountability Act (HIPAA). Most firms have their own accounting idiosyncrasies, and the PM cannot expect the accounting department to make special allowances for his or her individual project. Although accounting will charge normal expenditures against a particular activity's account number, as identified in the WBS, unexpected overhead charges, indirect expenses, and usage or price variances may suddenly appear when the PM least expects it, and probably at the worst possible time. (Price variances due to procurement, and the entire procurement process, are discussed in Chapter 12 of PMBOK, 2013.) There is no alternative—the PM must simply become completely familiar with the organization's accounting system, as painful as that may be.


PMBOK Guide

In the process of gaining this familiarity, the PM will discover that cost may be viewed from three different perspectives (Hamburger, 1986). The PM recognizes a cost once a commitment is made to pay someone for resources or services, for example when a machine is ordered. The accountant recognizes an expense when an invoice is received—not, as most people believe, when the invoice is paid. The controller perceives an expense when the check for the invoice is mailed. The PM is concerned with commitments made against the project budget. The accountant is concerned with costs when they are actually incurred. The controller is concerned with managing the organization's cash flows. Because the PM must manage the project, it is advisable for the PM to set up a system that will allow him or her to track the project's commitments.

Another aspect of accounting that will become important to the unaware PM is that accountants live in a linear world. When a project activity has an $8,000 charge and runs over a four-month period, the accounting department (or worse, their software) sometimes simply spreads the $8,000 evenly over the time period, resulting in a $2,000 allocation per month. If expenditures for this activity are planned to be $5,000, $1,000, $1,000, and $1,000, the PM should not be surprised when the organization's controller storms into the project office after the first month screaming about the unanticipated and unacceptable cash flow demands of the project!

Next, we look at two different approaches for gathering the data for budgeting a project: top-down and bottom-up.

Top-Down Budgeting

The top-down approach to budgeting is based on the collective judgments and experiences of top and middle managers concerning similar past projects. These managers estimate the overall project cost by estimating the costs of the major tasks, which estimates are then given to the next lower level of managers to split up among the tasks under their control, and so on, until all the work is budgeted.

The advantage of this approach is that overall budget costs can be estimated with fair accuracy, though individual elements may be in substantial error.

Another advantage is that errors in funding small tasks need not be individually identified because the overall budget allows for such exceptions. Similarly, the good chance that some small but important task was overlooked does not usually cause a serious budgetary problem. The experience and judgment of top management are presumed to include all such elements in the overall estimate. In the next section, we will note that the assumptions on which these advantages are based are not always true.

Bottom-Up Budgeting

In bottom-up budgeting, the WBS identifies the elemental tasks, whose resource requirements are estimated by those responsible for executing them (e.g., programmer-hours in a software project). This can result in much more accurate estimates, but it often does not do so for reasons we will soon discuss. The resources, such as labor and materials, are then converted to costs and aggregated to different levels of the project, eventually resulting in an overall direct cost for the project. The PM then adds, according to organizational policy, indirect costs such as general and administrative, a reserve for contingencies, and a profit figure to arrive at a final project budget.

Bottom-up budgets are usually more accurate in the detailed tasks, but risk the chance of overlooking some small but costly tasks. Such an approach, however, is common in organizations with a participative management philosophy and leads to better morale, greater acceptance of the resulting budget, and heightened commitment by the project team. It is also a good managerial training technique for aspiring project and general managers.

Unfortunately, true bottom-up budgeting is rare. Upper level managers are reluctant to let the workers develop the budget, fearing the natural tendency to overstate costs, and fearing complaints if the budget must later be reduced to meet organizational resource limitations. Moreover, the budget is upper management's primary tool for control of the project, and they are reluctant to let others set the control limits. Again, we will see that the budget is not a sufficient tool for controlling a project. Top-down budgeting allows the budget to be controlled by people who play little role in designing and doing the work required by the project. It should be obvious that this will cause problems—and it does.


Best Practice

We recommend that organizations employ both forms of developing budgets. They both have advantages, and the use of one does not preclude the use of the other. Making a single budget by combining the two depends on setting up a specific system to negotiate the differences. We discuss just such a system below. The only disadvantage of this approach is that it requires some extra time and trouble, a small price to pay for the advantages. A final warning is relevant. Any budgeting system will be useful only to the extent that all cost/revenue estimates are made with scrupulous honesty.

Project budgeting is a difficult task due to the lack of precedent and experience with unique project undertakings. Yet, understanding the organization's accounting system is mandatory for a PM. The two major ways of generating a project budget are top-down and bottom-up. The former is usually accurate overall but possibly includes significant error for low-level tasks. The latter is usually accurate for low-level tasks but risks overlooking some small but potentially costly tasks. Most organizations use top-down budgeting in spite of the fact that bottom-up results in better acceptance and commitment to the budget.

4.2 COST ESTIMATING

In this section, we look at the details of the process of estimating costs and some dangers of arbitrary cuts in the project budget. We also describe and illustrate the difference between activity budgeting and program budgeting.

Work Element Costing

The task of building a budget is relatively straightforward but tedious. Each work element is evaluated for its resource requirements, and its costs are then determined. For example, suppose a certain task is expected to require 16 hours of labor at $10 per hour, and the required materials cost $235. In addition, the organization charges overhead for the use of utilities, indirect labor, and so forth at a rate of 50 percent of direct labor. Then, the total task cost will be

$$\$235 + [(16\ \text{hr} \times \$10/\text{hr}) \times 1.5] = \$475$$

In some organizations, the PM adds the overhead charges to the budget. In others, the labor time and materials are just sent to the accounting department and they run the numbers, add the appropriate overhead, and total the costs. Although overhead was charged here against direct labor, more recent accounting practices such as activity-based costing may charge portions of the overhead against other cost drivers such as machine time, weight of raw materials, or total time to project completion.

Direct resource costs such as for materials and machinery needed solely for a particular project are usually charged to the project without an overhead add-on. If machinery from elsewhere in the organization is used, this may be charged to the project at a certain rate (e.g., $/hr) that will include depreciation charges, and then will be credited to the budget of the department owning and paying for the machine. On top of this, there is often a charge for GS&A (general, sales, and administrative) costs that includes upper management, staff functions, sales and marketing, plus any other costs not included in the overhead charge. GS&A may be charged as a percentage of direct costs, all direct and indirect costs, or on other bases including total time to completion.

Thus, the fully costed task will include direct costs for labor, machinery, and resources such as materials, plus overhead charges, and finally, GS&A charges. The full cost budget is then used by accounting to estimate the profit to be earned by the project. The wise PM, however, will also construct a budget of direct costs for his or her own use. This budget provides the information required to manage the project without being confounded with costs over which he or she has no control.

Note that the overhead and GS&A effect can result in a severe penalty when a project runs late, adding significant additional and possibly unexpected costs to the project. Again, we stress the importance of the PM thoroughly understanding the organization's accounting system, and especially how overhead and other such costs are charged to the project.

Of course, this process can also be reversed to the benefit of the PM by minimizing the use of drivers of high cost. Sometimes clients will even put clauses in contracts to foster such behavior. For example, when the state of Pennsylvania contracted for the construction of the Limerick nuclear power generating facility in the late 1980s, they included such an incentive fee provision in the contract. This provision stated that any savings that resulted from finishing the project early would be split between the state

and the contractor. As a result, the contractor went to extra expense and trouble to make sure the project was completed early. The project came in 8 months ahead of its 49-month due date and the state and the contractor split the $400 million savings out of the total $3.2 billion budget.

The Impact of Budget Cuts

In the previous chapter on planning, we described a process in which the PM plans Level 1 activities, setting a tentative budget and duration for each. Subordinates (and this term refers to anyone working on the project even though such individuals may not officially report to the PM and may be "above" the PM on the firm's organizational chart) then take responsibility for specifying the Level 2 activities required to produce the Level 1 task. As a part of the Level 2 specifications, tentative budgets and durations are noted for each Level 2 activity. The PM's initial budget and duration estimates are examples of top-down budgeting. The subordinate's estimates of the Level 2 task budgets and durations are bottom-up budgeting. As we promised, we now deal with combining the two budgets.

We will label the Level 1 task estimate of duration of the i^{th} task as t_i, and the respective cost estimate as r_i, the ***t*** standing for "time" and the ***r*** for "resources." In the meantime, the subordinate has estimated task costs and durations for each of the Level 2 tasks that comprise Level 1 task ***i***. We label the *aggregate* cost and duration of these Level 2 activities as r'_i and t'_i, respectively. It would be nice if r_i equaled r'_i, but the reality is rarely that neat. In general, $r_i << r'_i$ (The same is true of the time estimates, t_i and t'_i.) There are three reasons why this happens. First, jobs always look easier, faster, and cheaper to the boss than to the person who has to do them (Gagnon and Mantel, 1987). Second, bosses are usually optimistic and never admit that details have been forgotten or that anything can or will go wrong. Third, subordinates are naturally pessimistic and want to build in protection for everything that might possibly go wrong.

It is important that we make an assumption for the following discussion. We assume that both boss and subordinate are reasonably honest. What follows is a win-win negotiation, and it will fail if either party is dishonest. (We feel it is critically important to remind readers that it is never smart to view the other party in a negotiation as either stupid or ignorant. Almost without fail, such thoughts are obvious to the other party and the possibility of a win-win solution is dead.) The first step in reducing the difference between the superior's and subordinate's estimates occurs when the worker explains the reality of the task to the boss, and r_i rises. Encouraged by the fact that the boss seems to understand some of the problems, the subordinate responds to the boss's request to remove some of the protective padding. The result is that r'_i falls.

The conversation now shifts to the technology involved in the subordinate's work and the two parties search for efficiencies in the Level 2 work plan. If they find some, the two estimates get closer still, or, possibly, the need for resources may even drop below either party's estimate.

To complete our discussion, let's assume that after all improvements have been made, r'_i is still somewhat higher than r_i. Should the boss accept the subordinate's cost estimate or insist that the subordinate accept the boss's estimate? To answer this question, we must recall the discussion of project life cycles from Chapter 1. We discussed two different common forms of life cycles, and these are illustrated again, for convenience, in Figure 4-1. One curve is S-shaped, and the other is J-shaped . As it happens, the shapes of these curves hold the key to our decision.

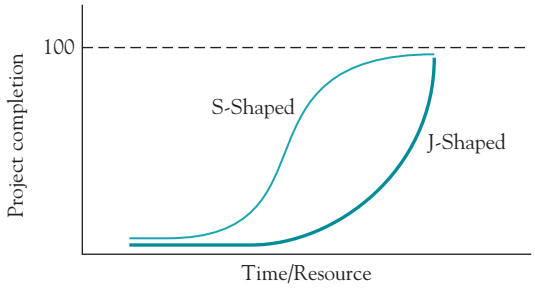

Figure 4-1 Two project life cycles (cf. Figures 1-2 and 1-3).

If the project life cycle is S-shaped, then with a somewhat reduced level of resources, a smaller than proportional cut will be made in the project's objectives or performance, likely not a big problem. If the project's life cycle is J-shaped , the impact of inadequate resources will be serious, a larger than proportional cut will be made in the project's performance. The same effect occurs during an "economy drive" when a senior manager decrees an across-the-board budget cut for all projects of, say, 5 or 10 percent. For a project with a J-shaped life cycle, the result is disaster. It is not necessary to know the actual shape of a project's life cycle with any precision. One needs merely to know the probable curvature (concave or convex to the baseline) of the last stage of the cycle for the project being considered.

The message here is that for projects with S-shaped life cycles, the top-down budgeting process is probably acceptable. For J-shaped life-cycle projects, it is dangerous for upper management not to accept the bottom-up budget estimates. At the very least, management should pay attention when the PM complains that the budget is insufficient to complete the project. An example of this problem is NASA's Space Shuttle Program, projected by NASA to cost $10–13 billion but cut by Congress to $5.2 billion. Fearing a cancellation of the entire program if they pointed out the overwhelming developmental problems they faced, NASA acquiesced to the inadequate budget. As a result, portions of the program fell 3 years behind schedule and had cost overruns of 60 percent. As the program moved into the operational flight stage, problems stemming from the inadequate budget surfaced in multiple areas, culminating in the Challenger explosion in January 1986.

Finally, in these days of increasing budget cuts and great stress on delivering project value, cuts to the organization's project portfolio must be made with care. Wheatly (2009) warns against the danger of focusing solely on ROI when making decisions about which projects will be kept and which will be terminated. We will have considerably more to say about this subject in Chapter 8.

An Aside

Here and elsewhere, we have preached the importance of managers and workers who are willing to communicate with one another frequently and honestly when developing budgets and schedules for projects. Such communication is the exception, not the rule. The fact that only a small fraction of software development projects are completed even approximately on time and on budget is so well known as to be legend, as is the record of any number of high technology industries. Sometimes the cause is scope creep, but top-down budgeting and scheduling are also prime causes. Rather than deliver another sermon on the subject, we simply reprint Rule #25 from an excellent book by Jim McCarthy, *Dynamics of Software Development* (1995).