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BECOMING A MASTER MANAGER

A Competing Values Approach

WILEY

and equipment that will be needed). Alternatively, monitoring tracks progress to see whether the project is proceeding as planned. Is the schedule being adhered to? Are milestones being met? How likely is the project to be completed within, or even under, the projected budget? In the next two sections, we will present several key planning and monitoring tools. It should, however, be noted that the monitoring tools will be useful only if the planning has been conducted carefully, with sufficient attention to detail.

PLANNING TOOLS

Project planning is not simply deciding on an outcome to be achieved. Project planning should make clear the path the project is expected to take as well as the destination. Consequently, the planning process should focus attention not only on the goals and objectives of the project but also on such issues as the technical and managerial approach, resource availability, the project schedule, contingency planning and re-planning assumptions, project policies and procedures, performance standards, and methods of tracking, reporting, and auditing (Badiru, 1993). It is thus evident that planning is far more complex than scheduling. Indeed, while scheduling is considered a key element of coordination, it is actually the last step of the planning process and depends on the existence of a precise statement of goals and objectives, accompanied by a detailed description of the scope of work. Below we present some of the key planning tools available to the project manager, with the order of presentation based on the order in which they are likely to be used.

Today, many of these tools can be found in project management software programs such as Microsoft Office's Standard Project 2007 and Enterprise Project Management (EPM) Solution. These types of products incorporate the basic planning tools discussed below and simplify planning, monitoring, and coordinating processes by integrating all data relevant to the project. For example, data associated with the statement of work and work breakdown structure (discussed below) related to specific tasks, working times, schedules, deadlines, people, materials, machines, and so on can be entered into computerized templates. During the data entry process, the software can also provide prompts to help establish the order in which work needs to be completed if two tasks are dependent. As data on tasks, times, and schedule are entered, the computer can generate PERT and Gantt charts, as well as other types of reports.

Because not every organization requires a full-blown project management software system, a variety of other programs have been developed to address users with different needs. One example is LiquidPlanner, a web-based program available by subscription from http://www.liquidplanner.com. The program's "to-do list" feature is used to enter information traditionally found in the statement of work. Milestones and a time-tracking feature are available to help monitor progress. LiquidPlanner's distinguishing capability is its capacity for automatically adjusting the workflow plan as the project unfolds. Such project management software and features are constantly appearing. Doing a search for project management apps, for example, will reveal literally dozens of solutions. Thus, we do not attempt to provide instruction on how any particular program works. Rather, we focus on explaining the fundamental concepts upon which those programs are based.

STATEMENT OF WORK

The statement of work (SOW) is a written description of the scope of work required to complete the project. It should include a statement regarding the objectives of the project, brief descriptions of the services to be performed and the products and documents to be delivered, an explanation of funding constraints, specifications, and an overall schedule. Specifications should be included for all aspects of the project. They will be used to provide standards for determining the cost of the project. The overall schedule should be more general, including only start and end dates and key milestones.

The statement of work may also include brief descriptions of the tasks necessary for project completion as well as a description, where appropriate, of how individual tasks will be integrated into the whole. Alternatively, this information may be included in the work breakdown structure.

WORK BREAKDOWN STRUCTURE

The work breakdown structure (WBS) shows the total project divided into components that can be measured in terms of time and cost. It may be presented in tabular or graphical form, or both (see Figures M2.2A and M2.2B). Whether in tabular or graphical form, the WBS divides

PROJECT: ORGANIZING THE OFFICE PICNIC

	TASK	ESTIIMATED TIIME (DAYS)	RESPONSIIBLE PERSON
TASK 1:	Do invitations and determine number of guests	5	Sam
	Activity 1.1: Get material from last year's picnic		
	Activity 1.2: Edit last year's invitation	.5	Sam
	Activity 1.3: Set up invitation log	.5	Sam
	•		
	•		
	•		
	Activity 1.X: Do final estimate on number of guests	.5	Sam
TASK 2:	Plan and purchase food		
	Activity 2.1: Plan snack food	.5	Marty
	Activity 2.2: Plan main meal	2	Pat
	Activity 2.3: Plan beverages	.5	Chris
	•		
	•		
	•		
	Activity 2.X: Purchase beverages	.5	Chris
TASK 3:	Plan picnic activities		
	Activity 3.1: Do informal poll of activities enjoyed at last year's picnic	5	Linda
	Activity 3.2: Find out where sports equipment is held	.5	Marty
	•		
	•		
	•		
	Activity 3.X: Buy new equipment, as necessary	1	Linda
TASK 4:	Plan and purchase supplies		
	Activity 4.1: Plan food supplies (plates, cups, plasticware, etc.)	.5	Marty
	Activity 4.2: Plan decorations	.5	Chris
	•		
	•		
	•		
	Activity 4.X: Pick up decorations from Picnic Store	.5	Marty

FIGURE M2.2A ***Work breakdown structure: tabular form.***

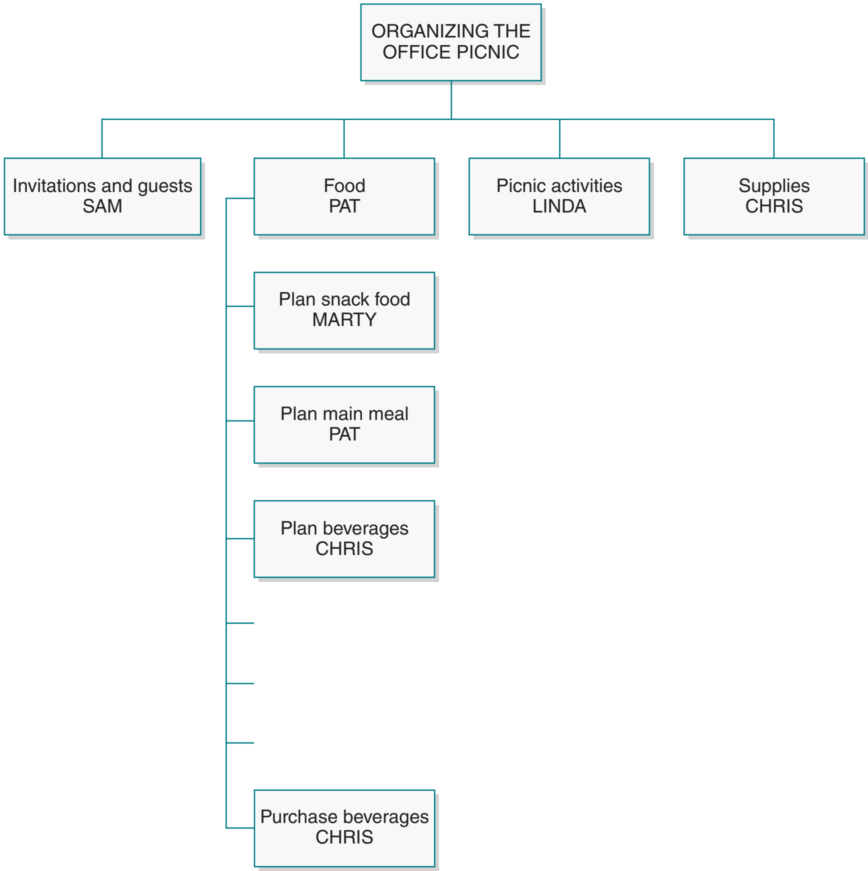

FIGURE M2.2B ***Work breakdown structure: graphical form.***

the project into a series of hierarchical levels; in graphical form, it resembles an organization chart of tasks (rather than positions). The complexity of the project and the degree of control desired during project monitoring will determine the number of levels. Badiru (1993) suggests starting with three levels, with level 1 being the final or total project, level 2 being the major tasks or subsections of the project, and level 3 containing definable tasks or subcomponents of level 2. Again, if the project is very complex, the WBS should include additional levels, until the final level specifies discrete activities that can be examined in terms of the time and cost required to complete the activity.

At the final level, the work breakdown structure should include at least two pieces of information that are needed for coordination of effort: the estimated time to complete the activity and the name of an individual who is responsible for seeing that the activity is completed. Often a third piece of information, the estimated cost of completing the activity, is also included. This allows for better integration of cost and schedule information needed to monitor the project. When cost information is included, people refer to the work breakdown structure as a *costed WBS.* Time and cost estimates should be developed by the persons most knowledgeable about those specific activities. Thus, if project team members come from different functional areas, the project manager should likely consult with managers from those different functional areas before making time and cost estimates.

PROGRAM EVALUATION AND REVIEW TECHNIQUE AND CRITICAL PATH METHOD

The WBS provides information on the estimated time of completion for each individual activity, but it does not indicate the order in which the activities can or will take place. It does not indicate whether Activity A must be completed before Activity B can proceed, or whether the two can proceed concurrently. When a project is fairly simple, these interrelationships are not difficult to discern, and a schedule can be constructed directly from the WBS by laying out the activities in the order in which they are to be carried out (see the section on Gantt charts, later in this competency). Alternatively, when a project is complex, it is almost impossible to construct a schedule before the interrelationships among the various activities are made explicit. Network diagrams are graphical tools for making these interrelationships explicit.

In the late 1950s, *Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM)* were developed to help with project planning. PERT was introduced by the Special Projects Office of the United States Navy in 1958 as an aid in planning (and controlling) its Polaris Weapon System, a project that involved approximately 3,000 contractors. At virtually the same time, a similar technique, CPM, was introduced by the DuPont Company. The methods are very similar and essentially show the flow of activities from start to finish. Over the years, the two methods have essentially merged and people often refer to PERT/CPM diagrams and/or analysis. As project management computer software has become more sophisticated, other similar approaches have been developed that provide more accurate time estimates, but PERT and CPM are still traditionally used to introduce the basic network diagramming concepts (Dodin, 2006).

PERT/CPM diagrams allow the project manager to see the flow of tasks associated with a project by showing the interrelationships between activities. These diagrams allow the project manager to estimate the time necessary to complete the overall project given the interdependencies among tasks and to identify those critical points where a delay in task completion can have a major effect on overall project completion. In performing the PERT/CPM analysis, one assumes that all tasks or activities can be clearly identified and sequenced and that the time necessary for completing each task or activity can be estimated.

Figure M2.3 shows a simple PERT/CPM diagram. In the diagram, arrows designate activities. The circles at the beginning and end of the arrows are referred to as nodes; they designate starting and ending points for activities. These points in time, called events, consume no time in and of themselves. An activity is referred to as Activity *i,j* or Activity *i-j,* where *i* is the start node and *j* is the end node. Because of the way the diagram is constructed, the PERT/CPM diagram is sometimes referred to as an arrow or activity-on-arrow network diagram. Alternatively, activity-in-node network diagrams, as the name implies, place the activities within the node (usually drawn in boxes) and use the arrows simply to show the necessary ordering of activities. In activity-on-arrow diagrams, the numbers along the arrows indicate the expected time for the activity to be completed. Although these numbers may come directly from the WBS, it is customary to calculate an expected time for activity completion (t_e), using a weighted average of an optimistic time (t_o), a pessimistic time (t_p), and the most likely time (t_m) using the following equation:

$$t_e = (t_o + 4t_m + t_p)/6$$

Note that Activity 3,6 has an expected time of zero weeks. This type of activity, called a dummy activity, is used to indicate that Activity 6,7 cannot begin until Activity 1,3 is complete.

The *critical path* is that chain of activities that takes the **LONGEST** time to proceed through the network. It indicates the least possible time in which the overall project can be

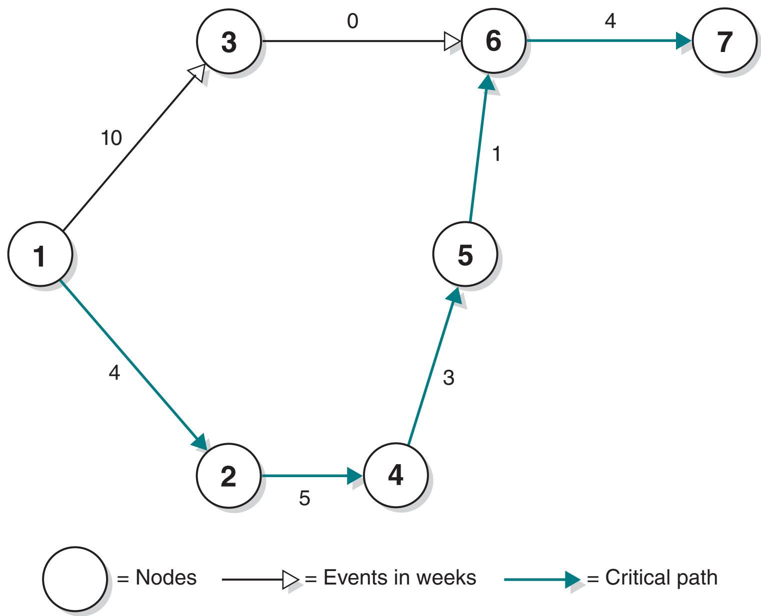

FIGURE M2.3 ***PERT network with critical path.***

completed, and it is the path that needs to be watched most carefully to ensure that the project stays "on track."

To identify the critical path, it is necessary to understand the concept of *slack* or *float*. In Figure M2.3, the critical path, 1-2-4-5-6-7, takes 17 weeks from start to finish. Note, however, that there is another path, 1-3-6-7, which takes only 14 weeks from start to finish. This means that Activity 1,3 could begin 3 weeks later than Activity 1,2 and the project would still be completed on time, assuming, of course, that the time estimates are fairly accurate. We then say that Activity 1,3 has a total float or slack of 3 weeks. While this is easy to see in Figure M2.3, it requires more effort when the diagram is more complex.

The first step in identifying the critical path is to identify the earliest start and finish times. Start at the first node of the diagram; this has an earliest start time of zero. For the other nodes, the earliest start time equals the earliest finish time of the previous activity. For all activities, the earliest finish time is the sum of the earliest start time plus the estimated time of the activity.

Next, take the largest finish time for the last node and calculate the latest start and finish times by starting at the last node and subtracting the estimated time for completion of that activity from the latest finish time of the previous activity. To identify the critical path, make a list of latest finish times and earliest start times. Time available is then calculated as the difference between the earliest start time and the latest finish time. If available time is equal to the estimated time for completing the activity, there is no float, and that activity is on the critical path. Table M2.1 shows the calculations.

As indicated above, the critical path is important because it is the path that must be most closely monitored. It is the path for which there is no slack, and activities must begin and end on time in order for the project schedule to be met. Activities that are not on the critical path can begin anytime between the earliest and latest start dates. The determination is usually made in accordance with the availability of resources, primarily human resources.

TABLE M2.1 Identifying the Critical Path

Activity	*Latest Finish Time (–)*	*Earliest Start Time (–)*	*Time Estimate*	*(=) Float*
1,2	4	0	0	0*
1,3	13	0	10	3
2,4	9	4	5	0*
3,6#	13	10	0	3
4,5	12	9	3	0*
5,6	13	12	1	0*
6,7	17	13	4	0*

*Critical path
#Dummy activity—has no time duration

Because projects typically require trade-offs among cost, time, and quality, project managers often need to estimate different approaches to the project. Project-crashing analysis can be used to help estimate the trade-offs associated with expediting a particular project by reviewing the costs associated with reducing the amount of time to complete the tasks on the critical path by adding additional resources.

RESOURCE LEVELING

The ultimate purpose of project management is to obtain the most efficient use of resources while still achieving project objectives (being effective). Efficient use of resources can be a problem, however, if there are wide swings in resource needs. Even on carefully planned projects, there may be times when team members feel they can't get enough done as well as times when team members find they do not have enough to do (House, 1988).

Resource leveling is "the process of scheduling work on noncritical activities so that resource requirement on peak days will be reduced" (Kimmons, 1990, p. 79). *Resources* here refer to all project resources that are limited within a specified time period, including personnel, equipment, and materials; resource leveling is most often used to allocate personnel to different project activities. One approach to maximizing the use of people is to use the information from the WBS, together with the information regarding the amount of float, to schedule activities that are not on the critical path.

To determine the optimal use of resources, the project manager needs to begin by assuming that all activities will begin at their earliest start dates. Based on this assumption, the project manager can then draw a graph showing the required personnel, by job type (title), over time. This graph will show peaks, times when there is a great amount of work to be done, and valleys, times when there is less work to be done. Using the PERT/CPM diagram and the table that gives the float associated with each activity, the project manager can then level the resources by moving the start dates for some of the activities that have float to a later time (but prior to the latest start date). The process continues until the changes in personnel requirements from one time period to the next are minimized, that is, until the peaks and valleys are evened. Of course, this type of manual resource leveling is extremely difficult on large, complex projects. Fortunately, in 1986, the resource-leveling paradigm was revolutionized when Primavera Software, Inc. developed an automatic resource leveling tool (Nosbisch & Winter, 2006). Since that time, other automatic resource leveling tools have greatly improved the ability of project managers to deploy resources more efficiently.

GANTT CHARTS

The most popular tool for visually displaying project activities across time is the Gantt chart, developed by Henry L. Gantt in the early part of the twentieth century. These charts are essentially bar charts that allow you to see at a glance how the different activities fit into the overall schedule.

A Gantt chart includes a timeline and a list of each of the major activities, grouped as they are in the work breakdown structure and sequenced as they are expected to occur as a result of the PERT/CPM and resource leveling analyses. The timeline for the project is shown along the horizontal axis; the list of activities along the vertical axis. For each activity, a bar shows the time commitment (see Figure M2.4). The Gantt chart is most useful when each activity time is commensurate with the units of time drawn on the horizontal axis. That is, if the horizontal axis is drawn in terms of months, most activities should take at least two months. You can also identify specific milestones, or points of accomplishment, within each task by using a circled number within the bar. In Figure M2.4 the milestones could represent first drafts of status reports due at the end of the activity. While advanced project management software can be used to create Gantt charts, they can also be created in spreadsheet programs such as Microsoft Excel by using a stacked bar chart (Baltzan & Phillips, 2008).

Specialized Gantt Charts. Once the Gantt chart is constructed, it can be used to integrate information about projected use of time with information about projected use of other resources. Two types of integrated Gantt charts are commonly used. The first shows personnel task assignments. By listing each individual along the vertical axis, followed by all of the tasks/activities to which that individual is assigned, the project manager can see at a glance which tasks/activities each person is assigned to at each time period of the project (see Figure M2.5). If the task distribution across individuals is uneven or if some individuals were mistakenly given too many work assignments during a single time period, this chart gives the project manager another chance to redistribute task assignments.

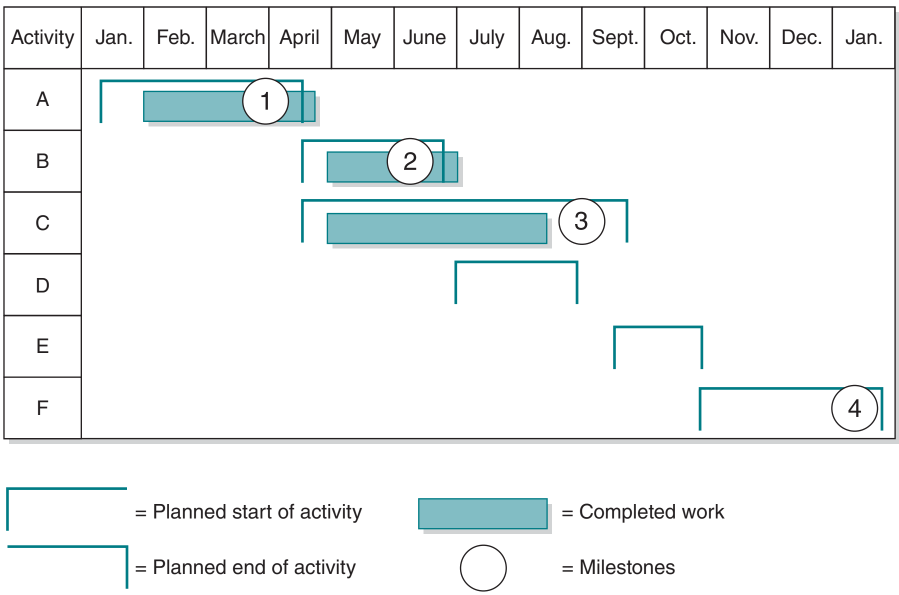

FIGURE M2.4 ***Gantt chart.***

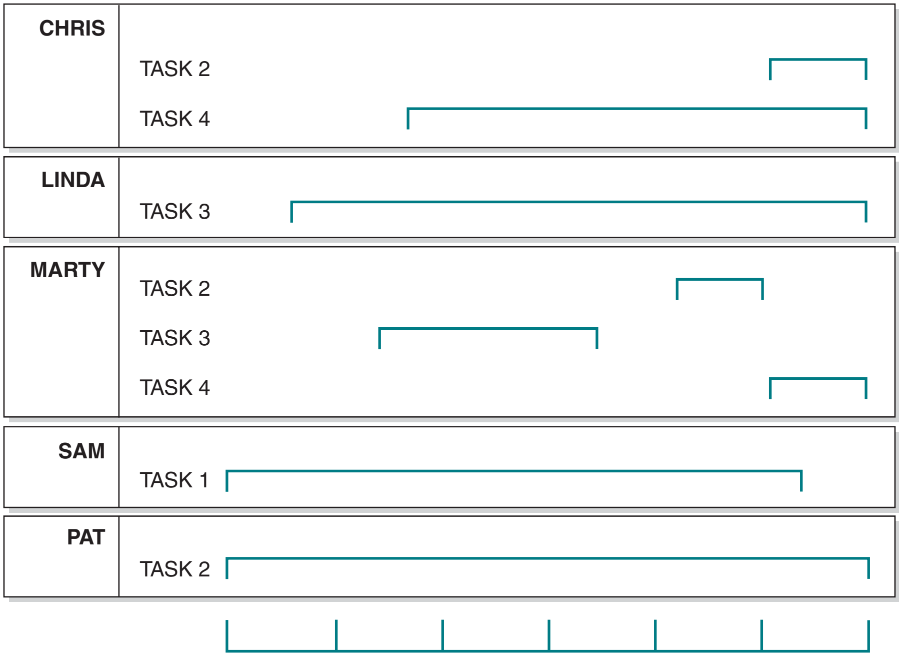

FIGURE M2.5 ***Personnel task assignments.***

The second type of integrated Gantt chart is the Bar Chart Cost Schedule (not illustrated). This Gantt chart simply shows the projected cost of each activity below the bar showing that activity in the overall Gantt chart. This allows the project manager to have some sense of how much money is projected to be spent in each time period. It also allows the project manager to calculate the cost slope by dividing the cost of the activity by the duration of that activity (in whatever unit of time is being used). Thus, for example, if Activity A costs $4,500 and is expected to take three weeks to complete, the cost slope in dollars per week is $1,500. While this piece of information is not interesting in isolation, it becomes interesting when the project manager compares it to the cost slopes of other activities because it gives a sense of the relative cost of activities per time period.

Gantt Charts as Monitoring Tools. The Gantt chart is also a useful project monitoring tool. By using different colors or different symbols, the Gantt chart can help the project manager track how closely the project is keeping to the planned schedule. When a given task runs over the allotted time, the Gantt chart can be used to determine whether or not the schedule needs to be rethought. Figure M2.4 shows that Activities A and B ran over schedule approximately one week each, whereas Activity C was completed almost one month ahead of schedule.

HUMAN RESOURCE MATRIX

One final planning tool is the human resource matrix. As with the Gantt chart used to show the personnel task assignments, this matrix can be used to see whether workload is evenly distributed across individuals. The human resource matrix lists the tasks/activities along the vertical axis and the names across the top of the matrix (see Figure M2.6). For each task/activity, one person is designated as having primary responsibility (P), and others may be designated as

TASK	CHRIS	LINDA	MARTY	PAT	SAM
1				P	
2	S		S	C	P
3		P	S	C	
4	P		S	C	

FIGURE M2.6 ***Human resource matrix.***

having secondary responsibility (S). Other designations can be also be added as needed. For example, one can label an individual as (C) if that individual needs to be consulted, or (B) if a person can provide backup, and so on. Project teams need to be able to adapt the project management tools to best meet their needs.

One advantage of this chart over the personnel task assignment chart is that it is clear whether or not time spent on the project is time in a leadership capacity. Further, it makes it clear at a glance whether someone has too many leadership (primary) assignments. Alternatively, while it tells who is assigned to which task/activity, it is not as informative as the personnel task assignment chart with respect to how much time is being spent during each time period by each person. Therefore, it is probably wise to use the two charts together for keeping track of how human resources are being utilized.

PROJECT MONITORING

As indicated in the beginning of this section, monitoring is essentially keeping track of progress over the life of the project. There are four primary resources that need to be monitored: time, money, people, and materials. Monitoring involves looking at actual expenditures of resources, comparing actual with estimated, and, where necessary, deciding what adjustments need to be made in the work plan to accommodate discrepancies between actual and estimated.

COST/SCHEDULE INTEGRATION GRAPHS

In the previous section, we gave examples of planning tools that can be used in monitoring the use of human resources and time. Here we will focus on the project budget and time. Note that the tools provided here can be used to look at the total budget or at specific components of the budget, and so they are applicable to monitoring the use of human resources and materials as well.

Cost Variances. In monitoring the budget, the project manager is concerned with two types of information. The first involves the amount of money budgeted for the work to be performed (budgeted cost of work performed—BCWP) versus the actual cost of performing the work (actual cost of work performed—ACWP). The difference between the two quantities (BCWP–ACWP), called the *cost variance*, is an indication of how close the estimated costs were to actual costs, with a positive number indicating monetary savings and a negative number indicating a budget overrun. (Again, note that these variances can be calculated for the total budget or by category of expenditure.)