Typically, project progress reports are designed and communicated in written or oral form. A common topic format for progress reports follows:

- Progress since last report
- Current status of project
    1. Schedule
    2. Cost
    3. Scope
- Cumulative trends
- Problems and issues since last report
    1. Actions and resolution of earlier problems
    2. New variances and problems identified
- Corrective action planned

Given the structure of your information system and the nature of its outputs, we can use the system to interface and facilitate the project control process. These interfaces need to be relevant and seamless if control is to be effective.

13.2 The Project Control Process

LO 13-1

Identify the four steps for controlling a project.

Control is the process of comparing actual performance against plan to identify deviations, evaluate possible alternative courses of actions, and take appropriate corrective action. The project control steps for measuring and evaluating project performance are presented below.

1. Setting a baseline plan.
2. Measuring progress and performance.
3. Comparing plan against actual.
4. Taking action.

Each of the control steps is described in the following paragraphs.

Step 1: Setting a Baseline Plan

The baseline plan provides us with the elements for measuring performance. The baseline is derived from the cost and duration information found in the work breakdown structure (WBS) database and time-sequence data from the network and resource scheduling decisions. From the WBS the project resource schedule is used to time-phase all work, resources, and budgets into a baseline plan. See Chapter 8.

Step 2: Measuring Progress and Performance

Time and budgets are quantitative measures of performance that readily fit into the integrated information system. Qualitative measures such as meeting customer technical specifications and product function are most frequently determined by on-site inspection or actual use. This chapter is limited to quantitative measures of time and budget. Measurement of time performance is relatively easy and obvious. That is, is the critical path early, on schedule, or late; is the slack of near-critical paths decreasing to cause new critical activities? Measuring performance against budget (e.g., money, units in place, labor hours) is more difficult and is *not* simply a case of comparing actual versus budget. Earned value is necessary to provide a realistic estimate of performance against a time-phased budget. **Earned value** (EV) is defined as the budgeted cost of the work performed.

Step 3: Comparing Plan against Actual

Because plans seldom materialize as expected, it becomes imperative to measure deviations from plan to determine if action is necessary. Periodic monitoring and measuring the status of the project allow for comparisons of actual versus expected plans. It is crucial that the timing of status reports be frequent enough to allow for early detection of variations from plan and early correction of causes. Usually status reports should take place every one to four weeks to be useful and allow for proactive correction.

Step 4: Taking Action

If deviations from plans are significant, corrective action will be needed to bring the project back in line with the original or revised plan. In some cases, conditions or scope can change, which, in turn, will require a change in the baseline plan to recognize new information.

The remainder of this chapter describes and illustrates monitoring systems, tools, and components to support managing and controlling projects. Several of the tools you developed in the planning and scheduling chapters now serve as input to your information system for monitoring performance. Monitoring time performance is discussed first, followed by cost performance.

13.3 Monitoring Time Performance

A major goal of progress reporting is to catch any negative variances from plan as early as possible to determine if corrective action is necessary. Fortunately, monitoring schedule performance is relatively easy. The project network schedule, derived from the WBS/OBS, serves as the baseline to compare against actual performance.

Gantt charts (bar charts), control charts, and milestone schedules are the typical tools used for communicating project schedule status. As suggested in Chapter 6, the Gantt chart is the most favored, used, and understandable. This kind of chart is commonly referred to as a tracking Gantt chart. Adding actual and revised time estimates to the Gantt chart gives a quick overview of project status on the report date.

Tracking Gantt Chart

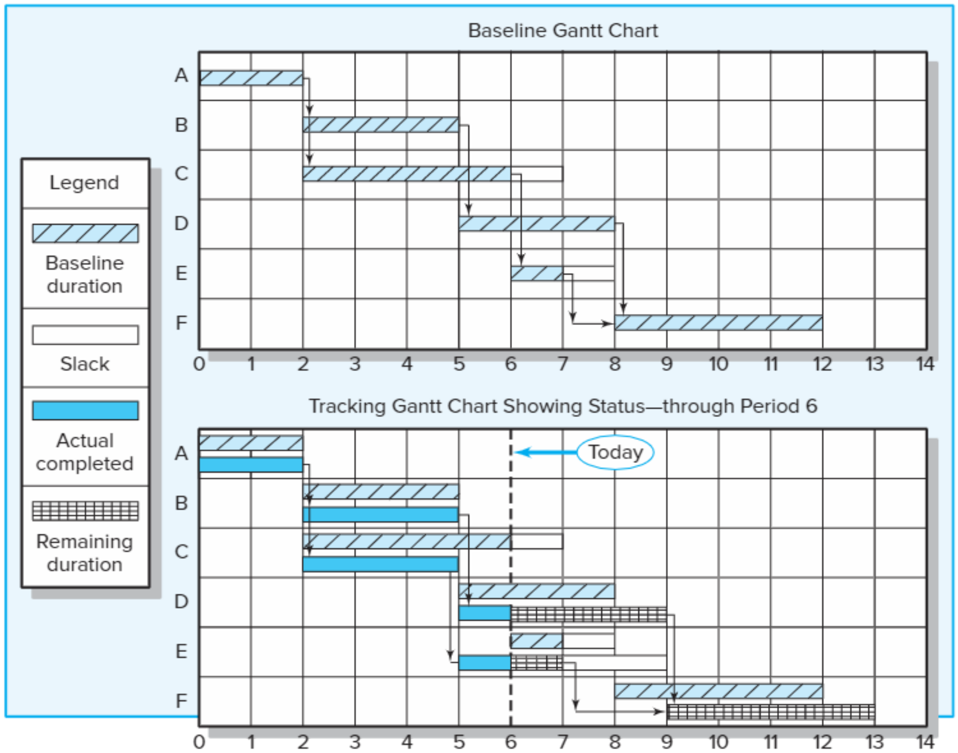
LO 13-2

Utilize a tracking Gantt to monitor time performance.

Figure 13.1 presents a baseline Gantt chart and a **tracking Gantt** chart for a project at the end of period 6. The solid bar below the original schedule bar represents the actual start and finish times for completed activities or any portion of an activity completed (see activities A, B, C, D, and E). For example, the actual start time for activity C is period 2; the actual finish time is period 5; the actual duration is three time units, rather than four scheduled time periods. Activities in process show the actual start time; the extended bar represents the expected remaining duration (see activities D and E). The remaining duration for activities D and E are shown with the hatched bar. Activity F, which has not started, shows a revised estimated actual start (9) and finish time (13).

Note how activities can have durations that differ from the original schedule, as in activities C, D, and E. Either the activity is complete and the actual is known, or new information suggests the estimate of time be revised and reflected in the status report.

FIGURE 13.1
Baseline and Tracking Gantt Charts



Activity D's revised duration results in an expected delay in the start of activity F. The project is now estimated to be completed one period later than planned. Although sometimes the Gantt chart does not show dependencies, when it is used with a network, the dependencies are easily identified if tracing is needed.

Control Chart

This chart is another tool used to monitor past project schedule performance and current performance and to estimate future schedule trends. Figure 13.2 depicts a project **control chart**. The chart is used to plot the difference between the scheduled time on the critical path at the report date with the actual point on the critical path. Although Figure 13.2 shows the project was behind early in the project, the plot suggests corrective action brought the project back on track. If the trend is sustained, the project will come in ahead of schedule. Because the activity scheduled times represent average durations, four observations trending in one direction indicate there is a very high probability that there is an identifiable cause. The cause should be located and action taken if necessary. Control chart trends are very useful for giving warning of potential problems so appropriate action can be taken if necessary.

Milestone Schedules

Milestone schedules are often used to keep more distal stakeholders informed on the progress of a project. Such stakeholders, whether it is senior management, the owner, or regulatory agencies often neither need or desire a detailed accounting of project progress. Instead, their interests can be satisfied by reporting progress towards major project milestones. Remember from Chapter 4, milestones are significant project

SNAPSHOT FROM PRACTICE 13.1 Guidelines for Setting Milestones

In medieval times mounds of stones were used to mark distance traveled along a path or road. Travelers would use these rock formations to gauge their progress and adjust their plans. In modern times, milestones are distinct events along the project timeline that are used to gauge progress and adjust plans. Milestones are building blocks for the project's schedule and often create positive momentum to propel the project along to completion. To be effective milestones need to be concrete, specific, measurable events.

© Erik Larson

Here are some guidelines for setting milestones gleaned from conversations with veteran project managers:

Avoid the temptation to overuse milestones as a motivational tool by labeling every task a milestone. Only important deliverables or achievements should be used as milestones.

Timing of milestones is important. Milestones that are placed too far apart will not generate momentum. Conversely, milestones placed too close together quickly lose their distinctiveness. As a rule of thumb, space milestones at intervals no longer than every two weeks for projects of several months in duration.

Critical merge and burst activities are often useful milestones since they indicate significant work has been or is about to be accomplished. Here it is important to remember that milestones are events not tasks, and the start of a merge activity (i.e., patent application submitted) or the completion of a burst activity (i.e., building permit approved) should be used.

Rates of completion can be used on projects involving repetition and not sequential advancement. For example, on a training project, milestones could be set as percentages of employees fully trained and certified, e.g., 25%, 50%, 75%, and 100%.

Completing a high anxiety, high risk task is always worthy of milestone consideration.

software includes the original framework; many systems have added industry-specific variations to more precisely track progress and costs. This chapter presents the "generic" core of an integrated cost/schedule information system.[1]

The earned value system starts with the time-phased costs that provide the project budget *baseline,* which is called the planned budgeted value of the work scheduled (PV). Given this time-phased baseline, comparisons are made with actual and planned schedule and costs using earned value. The earned value approach provides the missing links not found in conventional cost-budget systems. At any point in time, a status report can be developed for the project.

The earned value cost/schedule system uses several acronyms and equations for analysis. Table 13.1 presents a glossary of these acronyms. You will need this glossary as a reference. In recent years acronyms have been shortened to be more phonetically friendly. This movement is reflected in material from the Project Management Institute, in project management software, and by most practitioners. This text edition follows the recent trend. The acronyms found in brackets represent the older acronyms, which are often found in software programs. To the uninitiated, the terms used in practice appear horrendous and intimidating. However, once a few basic terms are understood, the intimidation index will evaporate.

[1]See Fleming and Koppelman (2010) for a more complete earned value description.

TABLE 13.1
Glossary of Terms

EV	Earned value for a task is simply the percent complete times its original budget. Stated differently, EV is the percent of the original budget that has been earned by actual work completed. [The older acronym for this value was BCWP—budgeted cost of the work performed.]
PV	The planned time-phased baseline of the value of the work scheduled. An approved cost estimate of the resources scheduled in a time-phased cumulative baseline [BCWS—budgeted cost of the work scheduled].
AC	Actual cost of the work completed. The sum of the costs incurred in accomplishing work [ACWP—actual cost of the work performed].
CV	Cost variance is the difference between the earned value and the actual costs for the work completed to date where CV = EV − AC.
SV	Schedule variance is the difference between the earned value and the baseline line to date where SV = EV − PV.
BAC	Budgeted cost at completion. The total budgeted cost of the baseline or project cost accounts.
EAC	Estimated cost at completion.
ETC	Estimated cost to complete remaining work.
VAC	Cost variance at completion. VAC indicates expected actual over- or underrun cost at completion.

Following five careful steps ensures that the cost/schedule system is integrated. These steps are outlined here. Steps 1, 2, and 3 are accomplished in the planning stage. Steps 4 and 5 are sequentially accomplished during the execution stage of the project.

1. Define the work using a WBS. This step involves developing documents that include the following information (see Chapters 4 and 5):
   a. Scope.
   b. Work packages.
   c. Deliverables.
   d. Organization units.
   e. Resources.
   f. Budgets for each work package.
2. Develop work and resource schedule.
   a. Schedule resources to activities (see Chapter 8).
   b. Time-phase work packages into a network.
3. Develop a time-phase budget using work packages included in an activity. The cumulative values of these budgets will become the baseline and will be called the planned budgeted cost of the work scheduled (PV). The sum should equal the budgeted amounts for all the work packages in the cost accounts (see Chapter 8).
4. At the work package level, collect the actual costs for the work performed. These costs will be called the actual cost of the work completed (AC). Collect percent complete and multiply this times the original budget amount for the value of the work actually completed. These values will be called earned value (EV).
5. Compute the **schedule variance** (SV = EV − PV) and **cost variance** (CV = EV − AC). Prepare hierarchical status reports for each level of management—from work package manager to customer or project manager. The reports should also include project rollups by organization unit and deliverables. In addition, actual time performance should be checked against the project network schedule.

Figure 13.3 presents a schematic overview of the integrated information system, which includes the techniques and systems presented in earlier chapters. Those who have tenaciously labored through the early chapters can smile! Steps 1 and 2 are

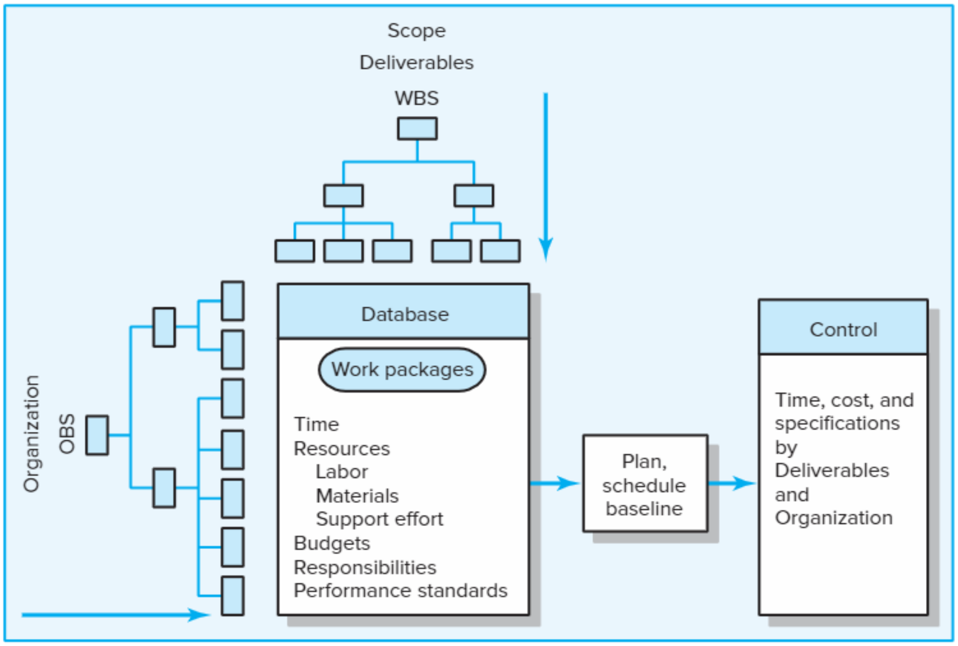


FIGURE 13.3 **Project Management Information System Overview**

already carefully developed. Observe that control data can be traced backward to specific deliverables and organization unit responsible.

The major reasons for creating a baseline are to monitor and report progress and to estimate cash flow. Therefore, it is crucial to integrate the baseline with the performance measurement system. Costs are placed (time-phased) in the baseline exactly as managers expect them to be "earned." This approach facilitates tracking costs to their point of origin. In practice, the integration is accomplished by using the same rules in assigning costs to the baseline as those used to measure progress using earned value. You may find several rules in practice, but percent complete is the workhorse most commonly used. Someone familiar with each task estimates what percent of the task has been completed or how much of the task remains.

Percent Complete Rule

This rule is the heart of any earned value system. The best method for assigning costs to the baseline under this rule is to establish frequent checkpoints over the duration of the work package and assign completion percentages in dollar terms. For example, units completed could be used to assign baseline costs and later to measure progress. Units might be lines of code, hours, drawings completed, cubic yards of concrete in place, workdays, prototypes complete, etc. This approach to percent complete adds "objectivity" to the subjective observation approaches often used. When measuring percent complete in the monitoring phase of the project, it is common to limit the amount earned to 80 or 90 percent until the work package is 100 percent complete.

What Costs Are Included in Baselines?

The baseline (PV) is the sum of the cost accounts, and each cost account is the sum of the work packages in the cost account. Three direct costs are typically included in baselines—labor, equipment, and materials. The reason: these are direct costs the project manager can control. Overhead costs and profit are typically added later by accounting processes. Most work packages should be discrete, of short time span, and have measurable outputs. If materials and/or equipment are a significant portion of the cost of work packages, they can be budgeted in separate work packages and cost accounts.

Methods of Variance Analysis

LO 13-4

Calculate and interpret cost and schedule variance.

Generally the method for measuring accomplishments centers on two key computations:

1. Comparing earned value with the expected schedule value.
2. Comparing earned value with the actual costs.

These comparisons can be made at the project level or down to the cost account level. Project status can be determined for the latest period, all periods to date, and estimated to the end of the project.

Assessing the current status of a project using the earned value cost/schedule system requires three data elements—planned cost of the work scheduled (PV), budgeted cost of the work completed (EV), and actual cost of the work completed (AC). From these data the schedule variance (SV) and cost variance (CV) are computed each reporting period. *A positive variance indicates a desirable condition, while a negative variance suggests problems or changes that have taken place.*

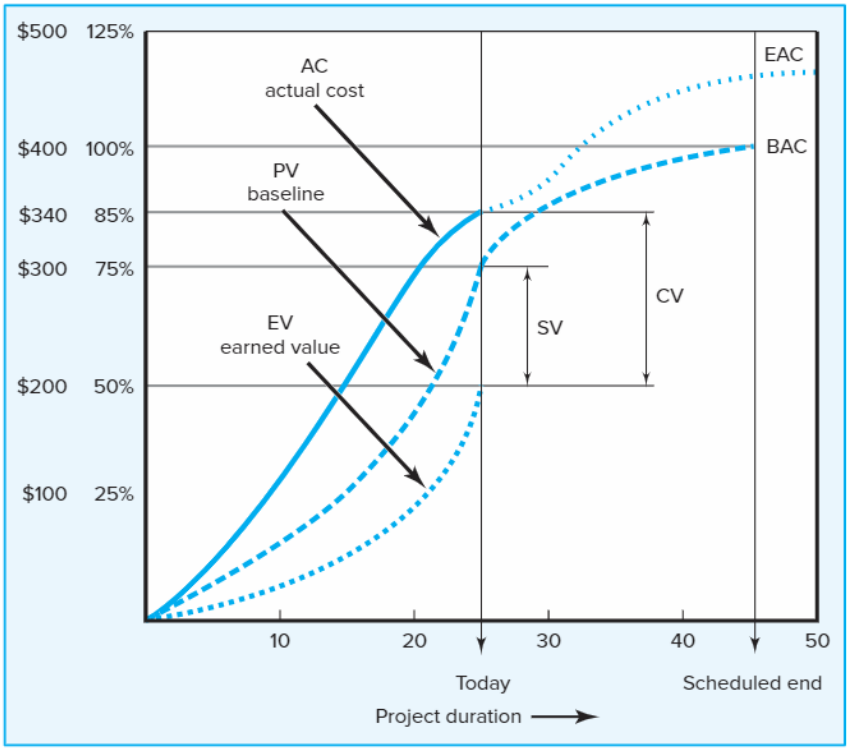
Cost variance tells us if the work accomplished costs more or less than was planned at any point over the life of the project. If labor and materials have not been separated, cost variance should be reviewed carefully to isolate the cause to either labor or materials—or to both.

Schedule variance presents an overall assessment of *all* work packages in the project scheduled to date. It is important to note schedule variance contains *no* critical path information. Critical and non-critical activities are combined in the calculation. Schedule variance measures progress in dollars rather than time units. Therefore, it is unlikely that any translation of dollars to time will yield accurate information telling if any milestone or critical path is early, on time, or late (even if the project occurs exactly as planned). *The only accurate method for determining the true time progress of the project is to compare the project network schedule against the actual network schedule to measure if the project is on time* (refer to Figure 13.1). However, SV is very useful in assessing the direction all the work in the project is taking—after 20 or more percent of the project has been completed.

Figure 13.4 presents a sample cost/schedule graph with variances identified for a project at the current status report date. Note the graph also focuses on what remains to be accomplished and any favorable or unfavorable trends. The "today" label marks the report date (time period 25) of where the project has been and where it is going. Because our system is hierarchical, graphs of the same form can be developed for different levels of management. In Figure 13.4 the top line represents the actual costs (AC) incurred for the project work to date. The middle line is the baseline (PV) and ends at the scheduled project duration (45). The bottom line is the budgeted value of the work actually completed to date (EV) or the earned value. The dotted line extending the actual costs from the report date to the new estimated completion date represents revised estimates of *expected* actual costs; that is, additional information suggests the costs at completion of the project will differ from what was planned. Note that the project duration has been extended and the **variance at completion (VAC)** is negative (BAC – EAC).

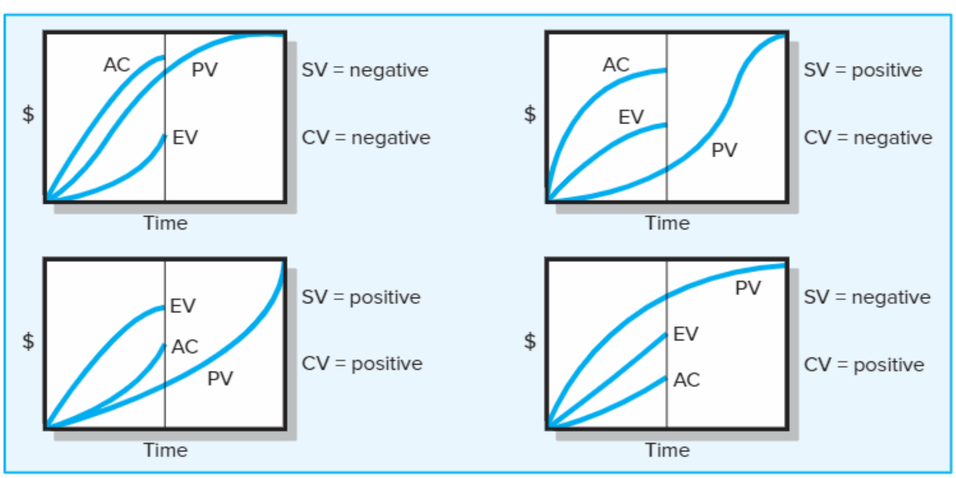
Another interpretation of the graph uses percentages. At the end of period 25, 75 percent of the work was scheduled to be accomplished. At the end of period 25, the

FIGURE 13.4
Cost/Schedule Graph



value of the work accomplished is 50 percent. The actual cost of the work completed to date is $340, or 85 percent of the total project budget. The graph suggests the project will have about an 18 percent cost overrun and be five time units late. The current status of the project shows the cost variance (CV) to be over budget by $140 (EV – AC = 200 – 340 = –140). The schedule variance (SV) is negative $100 (EV – PV = 200 – 300 = –100), which suggests the project is behind schedule. Before moving to an example, consult Figure 13.5 to practice interpreting the outcomes of cost/schedule graphs. Remember, PV is your baseline and anchor point.

FIGURE 13.5
Earned-Value Review Exercise



13.5 Developing a Status Report: A Hypothetical Example

Working through an example demonstrates how the baseline serves as the anchor from which the project can be monitored using earned value techniques.

Assumptions

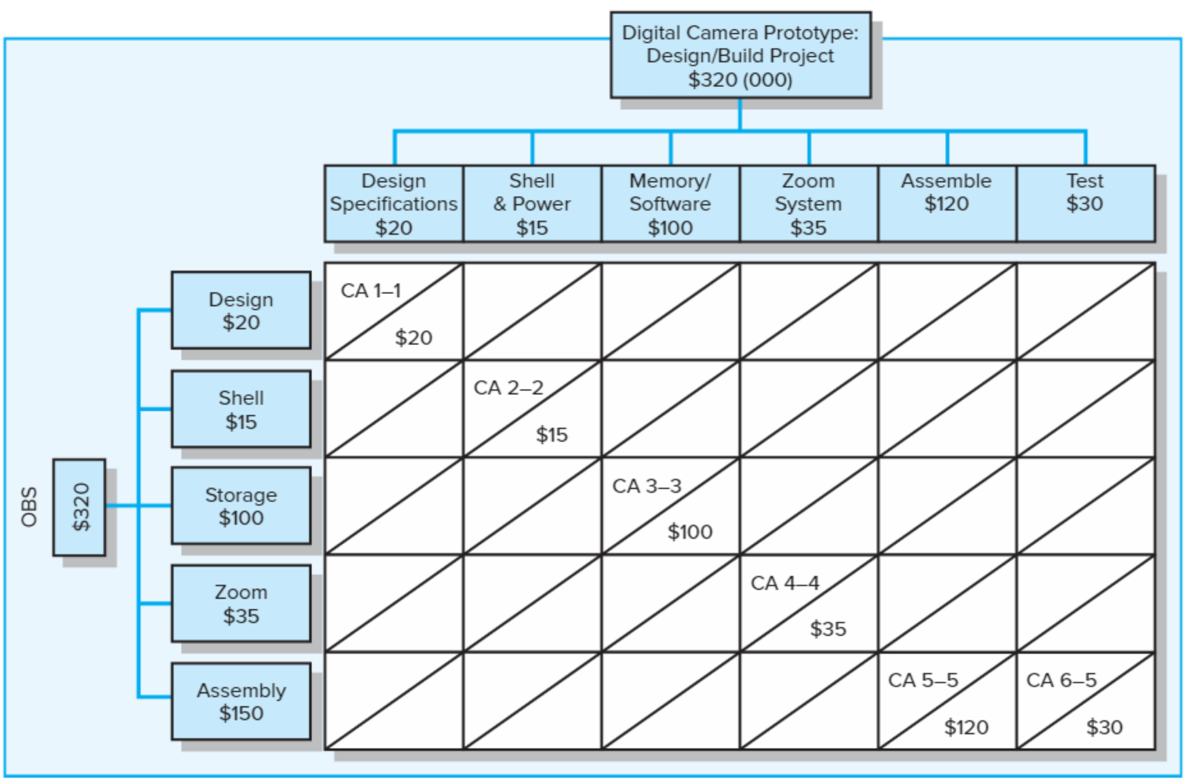
Because the process becomes geometrically complex with the addition of project detail, some simplifying assumptions are made in the example to more easily demonstrate the process:

1. Assume each cost account has only one work package, and each cost account will be represented as an activity on the network.
2. The project network early start times will serve as the basis for assigning the baseline values.
3. From the moment work on an activity task begins, some actual costs will be incurred each period until the activity is completed.

Baseline Development

Figure 13.6 (Work Breakdown Structure with Cost Accounts) depicts a simple work breakdown structure (WBS/OBS) for the Digital Camera example. There are six deliverables (Design Specifications, Shell & Power, Memory/Software, Zoom System, Assemble, and Test), and five responsible departments (Design, Shell, Storage, Zoom, and Assembly). The total for all the cost accounts (CA) is $320,000, which represents

FIGURE 13.6 Work Breakdown Structure with Cost Accounts



the total project cost. Figure 13.7, derived from the WBS, presents a planning Gantt chart for the Digital Camera project. The planned project duration is 11 time units. This project information is used to time-phase the project budget baseline. Figure 13.8 (Project Baseline Budget) presents a worksheet with an early start baseline developed with costs assigned. They are assigned "exactly" as managers plan to monitor and measure schedule and cost performance.

Development of the Status Report

A status report is analogous to a camera snapshot of a project at a specific point in time. The status report uses earned value to measure schedule and cost performance. Measuring earned value begins at the work package level. Work packages are in one of three conditions on a report date:

1. Not yet started.
2. Finished.
3. In-process or partially complete.

Earned values for the first two conditions present no difficulties. Work packages that are not yet started earn zero percent of the PV (budget). Packages that are completed earn 100 percent of their PV. In-process packages apply the percent complete rule to the PV baseline to measure earned value (EV). In our camera example we will only use the percent complete rule to measure progress.

Table 13.2 presents the completed, separate status reports of the Digital Camera Prototype project for periods 1 through 7. Each period percent complete and actual

FIGURE 13.7
Digital Camera Prototype Project Baseline Gantt Chart

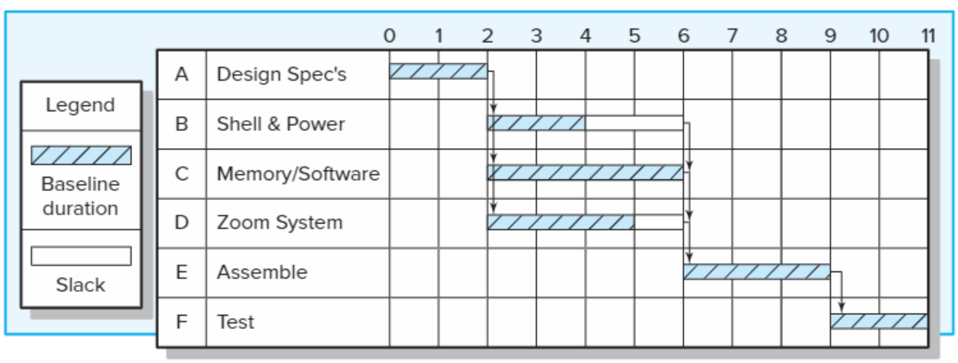


FIGURE 13.8
Digital Camera Prototype Project Baseline Budget ($000)

Schedule information						Baseline budget needs										
ACT/WP	DUR	ES	LF	SL	Total PV	Time period 1	2	3	4	5	6	7	8	9	10	11
A	2	0	2	0	20	10	10									
B	2	2	6	2	15			5	10							
C	4	2	6	0	100			20	30	30	20					
D	3	2	6	1	35			15	10	10						
E	3	6	9	0	120							30	40	50		
F	2	9	11	0	30										10	20
Total PV by period						10	10	40	50	40	20	30	40	50	10	20
Cumulative PV by period						10	20	60	110	150	170	200	240	290	300	320

TABLE 13.2
Digital Camera Prototype Status Reports: Periods 1–7

Cost Variance		CV = EV − AC				
Schedule Variance		SV = EV − PV				
Status Report: Ending Period 1						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	50%	10	10	10	0	0
Cumulative Totals		**10**	**10**	**10**	**0**	**0**
Status Report: Ending Period 2						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
Cumulative Totals		**20**	**30**	**20**	**−10**	**0**
Status Report: Ending Period 3						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
B	33%	5	10	5	−5	0
C	20%	20	30	20	−10	0
D	60%	21	20	15	+1	+6
Cumulative Totals		**66**	**90**	**60**	**−24**	**+6**
Status Report: Ending Period 4						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	50%	50	70	50	−20	0
D	80%	28	30	25	−2	+3
Comulative Totals		**113**	**150**	**110**	**−37**	**+3**
Status Report: Ending Period 5						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	60%	60	100	80	−40	−20
D	80%	28	50	35	−22	−7
Cumulative Totals		**123**	**200**	**150**	**−77**	**−27**
Status Report: Ending Period 6						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	80%	80	110	100	−30	−20
D	Finished	35	60	35	−25	0
Cumulative Totals		**150**	**220**	**170**	**−70**	**−20**
Status Report: Ending Period 7						
Task	**%Complete**	**EV**	**AC**	**PV**	**CV**	**SV**
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	90%	90	120	100	−30	−10
D	Finished	35	60	35	−25	0
E	0%	0	0	30	0	−30
F	0%	0	0	0	0	0
Cumulative Totals		**160**	**230**	**200**	**−70**	**−40**

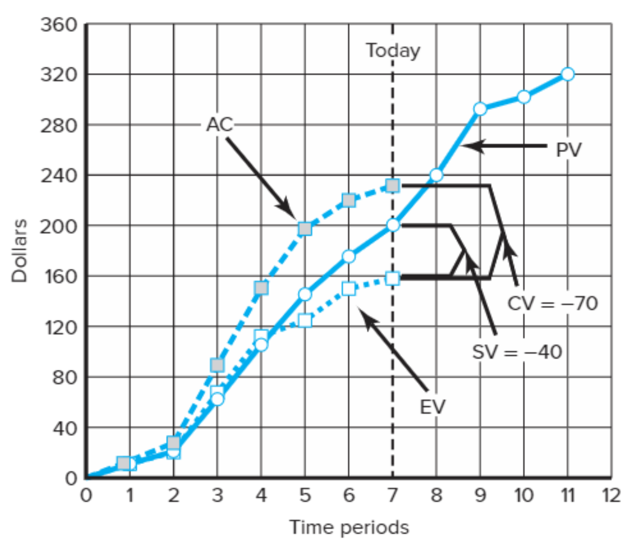
cost were gathered for each task from staff in the field. The schedule and cost variance are computed for each task and the project to date. For example, the status in period 1 shows only Task A (Design Specifications) is in process and it is 50 percent complete and actual cost for the task is 10. The planned value at the end of period 1 for Task A is 10 (see Figure 13.8). The cost and schedule variance are both zero, which indicates the project is on budget and schedule. By the end of period 3, Task A is finished. Task B (Shell & Power) is 33 percent complete and AC is 10; Task C is 20 percent complete and AC is 30; and D is 60 percent complete and AC is 20. Again, from Figure 13.8 *at the end of period 3,* we can see that the PV for Task A is 20 (10 + 10 = 20), for Task B is 5, for Task C is 20, and for Task D is 15. At the end of period 3 it is becoming clear the actual cost (AC) is exceeding the value of the work completed (EV). The cost variance (see Table 13.2) for the project at the end of period 3 is negative 24. Schedule variance is positive 6, which suggests the project may be ahead of schedule.

It is important to note that since earned values are computed from costs (or sometimes labor hours or other metrics), the relationship of costs to time is not one-for-one. For example, it is possible to have a negative SV variance when the project is actually ahead on the critical path. This would occur when delays in noncritical activities outweigh progress on the critical path. Therefore, it is important to remember, SV is in dollars and is not an accurate measure of time; however, it is a fairly good indicator of the status of the whole project in terms of being ahead or behind schedule after the project is over 20 percent complete. Only the project network, or tracking Gantt chart, and actual work completed can give an accurate assessment of schedule performance down to the work package level.

By studying the separate status reports for periods 5 through 7, you can see the project will be over budget and behind schedule. By period 7 Tasks A, B, and D are finished, but all are over budget—negative 10, 5, and 25. Task C (Memory/Software) is 90 percent complete. Task E is late and hasn't started because Task C is not yet completed. The result is that, at the end of period 7, the digital camera project is over budget $70,000, with a schedule budget over $40,000.

Figure 13.9 shows the graphed results of all the status reports through period 7. This graph represents the data from Table 13.2. The cumulative actual costs (AC) to

FIGURE 13.9
Digital Camera Prototype Summary Graph ($000)



date and the earned value budgeted costs to date (EV) are plotted against the original project baseline (PV). The cumulative AC to date is \$230; the cumulative EV to date is \$160. Given these cumulative values, the cost variance (CV = EV – AC) is negative \$70 (160 – 230 = –70). The schedule variance (SV = EV – PV) is negative \$40 (160 – 200 = –40). Again, recall that only the project network or tracking Gantt chart can give an accurate assessment of schedule performance down to the work package level.

A tracking Gantt bar chart for the Digital Camera Prototype is shown in Figure 13.10. From this figure you can see Task C (Memory/Software), which had an original duration of 4 time units, now is expected to require 6 time units. This delay of 2 time units for Task C will also delay Tasks E and F two time units and result in the project being late 2 time periods.

Figure 13.11 shows an oversimplified project rollup at the end of period 7. The rollup is by deliverables and organization units. For example, the Memory/Software deliverable has an SV of \$ –10 and a CV of –30. The responsible "Storage" department should have an explanation for these variances. Similarly, the assembly department, which is responsible for the Assemble and Test deliverables, has an SV of \$ –30 due to the delay of Task C (see Figure 13.10). Most deliverables look unfavorable on schedule and cost variance.

In more complex projects, the crosstabs of cost accounts by deliverables and organization units can be very revealing and more profound. This example contains the basics for developing a status report, baseline development, and measuring schedule and cost variance. In our example, performance analysis had only one level above the cost account level. Because all data are derived from the detailed database, it is relatively easy to determine progress status at all levels of the work and organization breakdown structures. Fortunately, this same current database can provide additional views of the current status of the project and forecast costs at the completion of the project. Approaches for deriving additional information from the database are presented next.

To the uninitiated, a caveat is in order. In practice budgets may not be expressed in total dollars for an activity. Frequently, budgets are time-phased for materials and labor separately for more effective control over costs. Another common approach used in practice is to use labor hours in place of dollars in the earned value system. Later,

FIGURE 13.10
Digital Camera Project-Tracking Gantt Chart Showing Status—Through Period 7

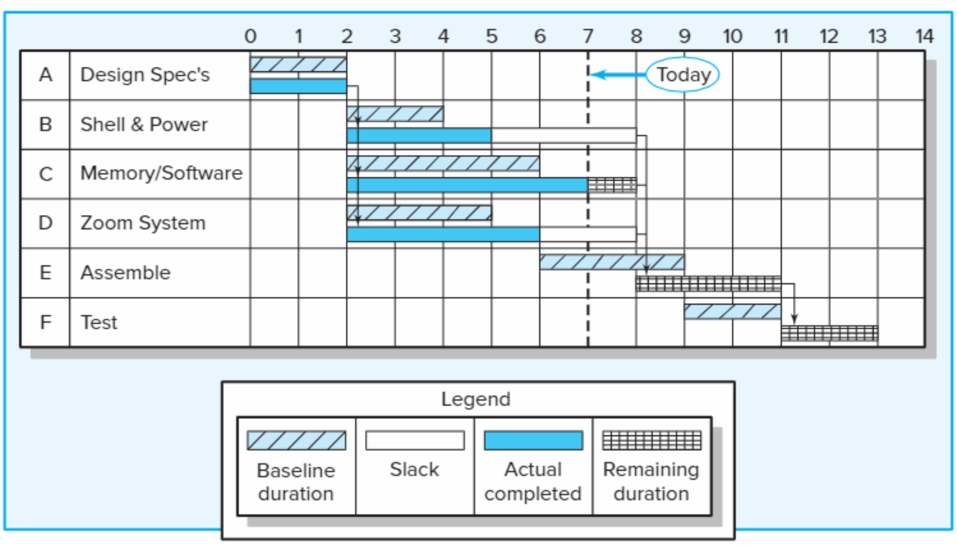
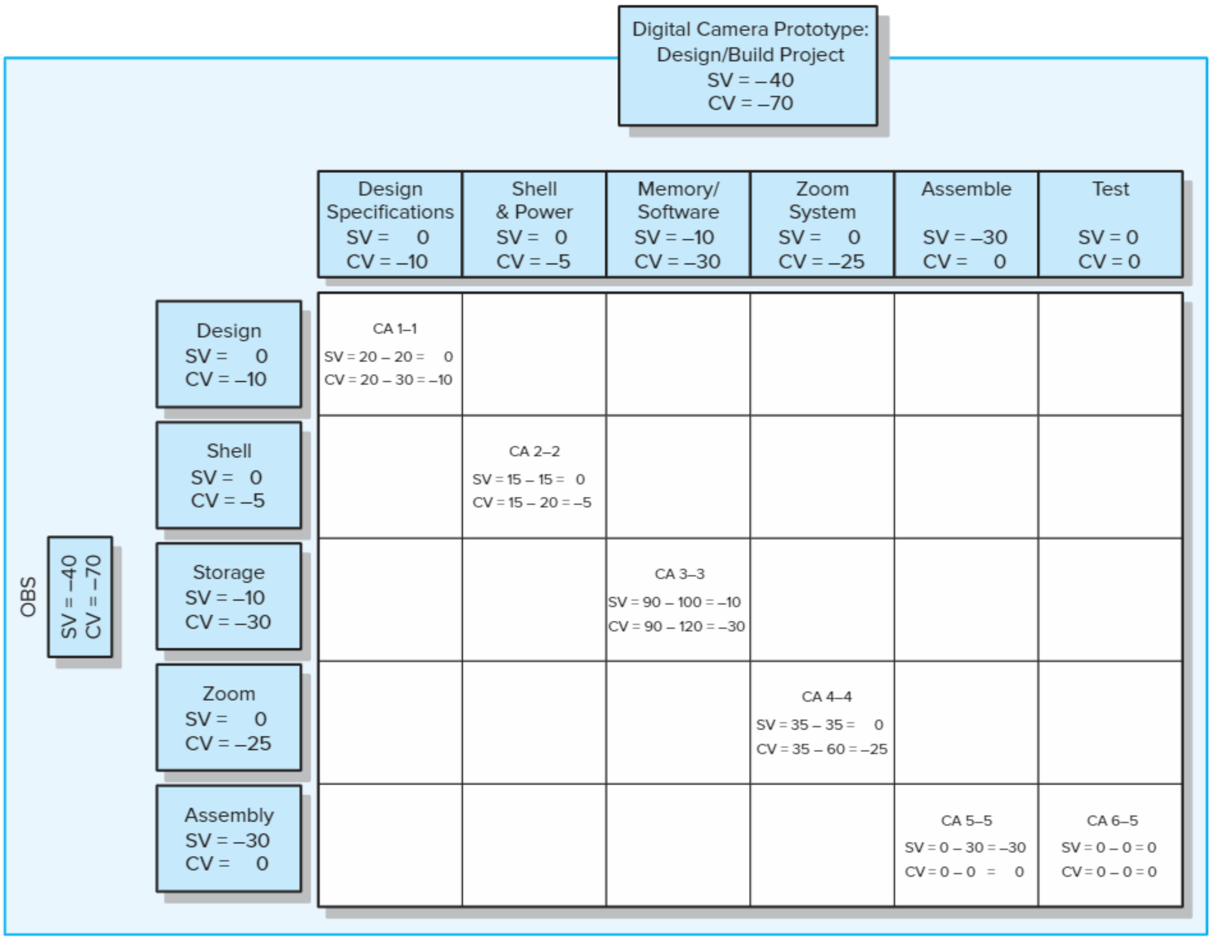


FIGURE 13.11 **Project Rollup End Period 7 ($000)**



labor hours are converted to dollars. The use of labor hours in the earned value system is the *modus operandi* for most construction work. Labor hours are easy to understand and are often the way many time and cost estimates are developed. Most earned value software easily accommodates the use of labor hours for development of cost estimates.

13.6 Indexes to Monitor Progress

LO 13-5

Calculate and interpret performance and percent indexes.

Practitioners sometimes prefer to use schedule and cost indexes over the absolute values of SV and CV, because indexes can be considered efficiency ratios. Graphed indexes over the project life cycle can be very illuminating and useful. The trends are easily identified for deliverables and the whole project.

Indexes are typically used at the cost account level and above. In practice, the database is also used to develop indexes that allow the project manager and customer to view progress from several angles. An index of 1.00 (100 percent) indicates progress is as planned. An index greater than 1.00 shows progress is better than expected. An

TABLE 13.3
Interpretation of Indexes

Index	Cost (CPI)	Schedule (SPI)
>1.00	Under cost	Ahead of schedule
=1.00	On cost	On schedule
<1.00	Over cost	Behind schedule

index less than 1.00 suggests progress is poorer than planned and deserves attention. Table 13.3 presents the interpretation of the indexes.

Performance Indexes

There are two indexes of performance efficiency. The first index measures *cost* efficiency of the work accomplished to date: (Data from Table 13.2)

Cost performance index (CPI) = EV/AC = 160/230 = .696 or .70

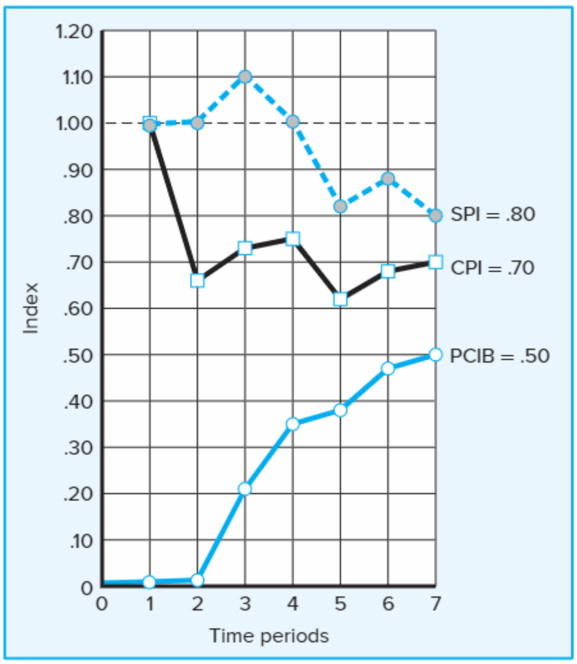
The CPI of .696 shows that $.70 worth of work planned to date has been completed for each $1.00 actually spent—an unfavorable situation indeed. The CPI is the most accepted and used index. It has been tested over time and found to be the most accurate, reliable, and stable. For example, U.S. government studies have shown that the CPI is stable from the 20 percent completion point regardless of contract type, program, or service. The CPI can provide an "early warning signal" as to cost overruns so that adjustments can be made to the budget or scope of a project.[2]

The second index is a measure of scheduling efficiency to date:

Scheduling performance index (SPI) = EV/PV = 160/200 = .80

The schedule index indicates $.80 worth of work has been accomplished for each $1.00 worth of scheduled work to date. Figure 13.12 shows the indexes plotted for our example project through period 7. This figure is another example of graphs used in practice.

FIGURE 13.12
Indexes Periods 1–7



[2] Cited by Q. W. Fleming and J. M. Koppleman, *Earned Value Project Management* (Newton Square, PA: Project Management Institute, 2010), pp. 39–42.