



This is “Estimating and Managing Costs”, chapter 9 from the book [Beginning Project Management \(index.html\)](#) (v. 1.0).

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## Chapter 9

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### Estimating and Managing Costs

An important part of a project manager's job is managing money. All types of organizations must manage their money well in order to fulfill their mission, including not-for-profit and government organizations. The tools and methods used to manage money on a project vary depending on the phase and complexity of the project. This chapter describes the methods used to estimate the cost of a project, create a budget, and manage the cost of activities while the project is being executed.

## 9.1 Estimating Costs

### LEARNING OBJECTIVES

1. Describe methods of estimating costs.
2. Identify the effects of project phase and complexity on the choice of estimating method.
3. Describe the method of combining cost estimates with a schedule to create a budget.

### Estimating Costs to Compare and Select Projects

During the conceptual phase when project selection occurs, economic factors are an important consideration when choosing between competing projects. To compare the simple paybacks or internal rates of return between projects, an estimate of the cost of each project is made. The estimates must be accurate enough so that the comparisons are meaningful, but the amount of time and resources used to make the estimates should be appropriate to the size and complexity of the project. The methods used to estimate the cost of the project during the selection phase are generally faster and consume fewer resources than those used to create detailed estimates in later phases. They rely more on the **expert judgment**<sup>1</sup> of experienced managers who can make accurate estimates with less detailed information. Estimates in the earliest stages of project selection are usually made using estimates based from previous projects that can be adjusted—**scaled**<sup>2</sup>—to match the size and complexity of the current project or by applying standardized formulas.

#### Analogous Estimate

An estimate that is based on other project estimates is an **analogous estimate**<sup>3</sup>. If a similar project cost a certain amount, then it is reasonable to assume that the current project will cost about the same. Few projects are exactly the same size and complexity, so the estimate must be adjusted upward or downward to account for the difference. The selection of projects that are similar and the amount of adjustment needed is up to the judgment of the person who makes the estimate. Normally, this judgment is based on many years of experience estimating projects, including incorrect estimates that were learning experiences for the expert.

1. Decisions based on incomplete information made by people who have extensive personal experience.
2. Multiplied by an adjustment factor to make the new estimate proportional to the original.
3. Budget estimate based on a similar project.

### Analogous Estimate for John's Move

In the John's move example, John asked a friend for advice about the cost of his move. His friend replied, "I moved from an apartment a little smaller than yours last year and the distance was about the same. I did it with a fourteen-foot truck. It cost about \$575 for the truck rental, pads, hand truck, rope, boxes, and gas." Because of the similarity of the projects, John's initial estimate of the cost of the move was less than \$700 and he decided that the cost would be affordable and the project could go forward.

Less experienced managers who are required to make analogous estimates can look through the documentation that is available from previous projects. If those projects were evaluated using the Darnall-Preston Complexity Index (DPCI), the manager can quickly identify projects that have similar profiles to the project under consideration even if those projects were managed by other people. Comparing the original estimates with the final project costs on several previous projects with the same DPCI ratings gives a less experienced manager the perspective that it would take many years to acquire by trial and error. It also provides references the manager can use to justify the estimate.

### Parametric Estimate

If the project consists of activities that are common to many other projects, average costs are available per unit. For example, if you ask a construction company how much it would cost to build a standard office building, they will ask for the size of the building in square feet and the city in which the building will be built. From these two factors—size and location—the company's estimator can predict the cost of the building. Factors like size and location are **parameters**<sup>4</sup>—measurable factors that can be used in an equation to calculate a result. The estimator knows the average cost per square foot of a typical office building and adjustments for local labor costs. Other parameters such as quality of finishes are used to further refine the estimate. Estimates that are calculated by multiplying measured parameters by cost-per-unit values are **parametric estimates**<sup>5</sup>.

4. Measurable factors that can be used in an equation to calculate a result.

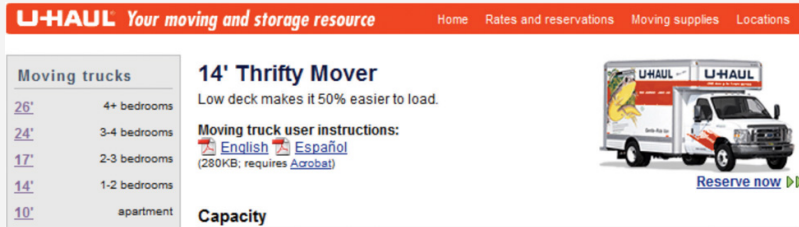
5. Estimates that are calculated by multiplying measured parameters by cost-per-unit values.

## Parametric Estimate for John’s Move

To estimate the size of the truck needed for John’s move, the parameter used by a truck rental company is the number of bedrooms, as shown below.

Figure 9.1

Number of Bedrooms Used for Parametric Cost Estimate



The moving company assumes that the number of bedrooms is the important parameter in determining how big a truck is needed for a move. For John’s move, he has a one-bedroom apartment, so he chooses the fourteen-foot truck. Once the size is determined, other parameters, such as distance and days, are used to estimate the cost of the truck rental.

## Estimating Costs to Initiate Projects

Once the project is selected, more accurate estimates are often needed to raise funds and agree on contracts with vendors in the initiation phase.

## Estimate During the Initiation Phase of John’s Move

John recalled that his friend also told him how tiring it was to do all the packing, loading, and driving himself, and some items were damaged when the load shifted inside the truck during the trip. John decides to call in favors from two friends, Dion and Carlita, to help him pack in Chicago and to hire some of the skilled labor like that needed to load the truck properly.

## Vendor Bid Analysis

If services or products will be provided by vendors, the cost of those services can be determined by issuing a **request for proposal (RFP)**<sup>6</sup>. The RFP describes the work, service, or product to be provided by the vendor and the quality level required. The RFP is sent to a list of vendors who are **qualified**<sup>7</sup>—meet standards of reliability and capability—to perform this type of work. They respond with a proposal for completing the work described in the RFP, including an estimate of the cost. Some government organizations are required to use the qualified vendor with the lowest bid. Other organizations are not bound to take the lowest bid but are usually required to justify their reasons for not doing so.

### Using RFPs to Make Estimates on John's Move

John wants to find out how much it would cost to hire a skilled crew to load and secure the furniture in the truck and then have another crew from the same company meet him in Atlanta to unload the truck and help him unpack. He is not sure if any companies offer this option, so he decides to ask three moving companies for bids. He also decides to ask for bids on a standard move that includes all phases of packing, loading, transportation, and unloading as a comparison to see if his cost-saving plan is worth the extra effort.

The project management team can review the responses by several vendors to the RFP to determine if their estimate of the cost of that aspect of the project is close to the estimate made during the project selection stage. If the estimates by the vendors are much higher than expected, and if the project cannot be completed for the cost that was used to select the project, the selection decision might have to be reconsidered. Reconsidering the selection of the project should take into consideration the economic ratings of the competing projects that were not chosen and who the project champions are for the projects that would be affected.

Some vendors may suggest an alternative way to meet the objective of the RFP in a more cost-effective manner that does not match the specifics of the RFP. Such alternatives can reduce costs if they are acceptable.

### Bottom-Up Estimating

The most accurate and time-consuming estimating method is to identify the cost of each item in each activity of the schedule, including labor and materials. If you view

6. Requires a bidder to offer solutions and ideas on how to perform the scope of work and a price for performing that work.

7. Meets a standard of reliability and capability.

the project schedule as a hierarchy where the general descriptions of tasks are at the top and the lower levels become more detailed, finding the price of each item at the lowest level and then summing them to determine the cost of higher levels is called **bottom-up estimating**<sup>8</sup>.

### Bottom-Up Estimate for John’s Move

After evaluating the bids by the moving companies, John decides the savings are worth his time if he can get the packing done with the help of his friends. He decides to prepare a detailed estimate of costs for packing materials and use of a rental truck. He looks up the prices for packing materials and truck rental costs on company Web sites and prepares a detailed list of items, quantities, and costs, as shown below.

Figure 9.2  
Detailed Cost Estimate

Category	Description	Quantity	Unit Price	Cost
Packing Materials	Small Boxes	10	\$1.70	\$17.00
Packing Materials	Medium Boxes	15	\$2.35	\$35.25
Packing Materials	Large Boxes	7	\$3.00	\$21.00
Packing Materials	Extra Large Boxes	7	\$3.75	\$26.25
Packing Materials	Short Hanger Boxes	3	\$7.95	\$23.85
Packing Materials	Box Tape	2	\$3.85	\$7.70
Packing Materials	Markers	2	\$1.50	\$3.00
Packing Materials	Mattress/Spring Bags	2	\$2.95	\$5.90
Packing Materials	Lift Straps per Pair	1	\$24.95	\$24.95
Packing Materials	Bubble Wrap	1	\$19.95	\$19.95
Packing Materials	Furniture Pads	4	\$7.95	\$31.80
Truck	Rental			\$400.00
Truck	Gas at 10mpg	200	\$2.25	\$45.00

This type of estimate is typically more accurate than an analogous or parametric estimate. In this example, the sum of packing materials and truck expenses is estimated to be \$661.25.

8. Summing of estimates of each detail of the activity and project.

The detail can be **rolled up**<sup>9</sup>—subtotaled—to display less detail. This process is made easier using computer software. On projects with low complexity, the cost estimates can be done on spreadsheet software.

### Rolling Up a Detailed Cost Estimate for John’s Move

For example, the subtotal feature could be used in Excel and collapsed to show the subtotals for the two categories of costs, as shown below.

Figure 9.3  
Sum of Detailed Costs by Type

1	2	3	A	B	C	D	E
1	Type	Description	Quantity	Unit Price	Cost		
13	<b>Packing Materials Total</b>						\$216.65
16	<b>Truck Total</b>						\$445.00
17	<b>Grand Total</b>						\$661.65
18							

On larger projects, software that manages schedules can also manage costs and display costs by activity and by category.

### Activity-Based Estimates

An activity can have costs from more than one vendor plus costs for labor and materials from internal sources. Detailed estimates from all sources can be reorganized so those costs that are associated with a particular activity can be grouped by adding the activity code to the detailed estimate, as shown in Figure 9.4 "Detailed Costs Associated with Activities".

9. Subtotaled.



Figure 9.4 Detailed Costs Associated with Activities

Category	Description	Activity	Quantity	Unit Price	Cost
Packing Materials	Small Boxes	2.1	10	\$1.70	\$17.00
Packing Materials	Medium Boxes	2.1	15	\$2.35	\$35.25
Packing Materials	Large Boxes	2.1	7	\$3.00	\$21.00
Packing Materials	Extra Large Boxes	2.1	7	\$3.75	\$26.25
Packing Materials	Short Hanger Boxes	2.1	3	\$7.95	\$23.85
Packing Materials	Box Tape	2.1	2	\$3.85	\$7.70
Packing Materials	Markers	2.1	2	\$1.50	\$3.00
Packing Materials	Mattress/Spring Bags	2.1	2	\$2.95	\$5.90
Packing Materials	Lift Straps per Pair	2.1	1	\$24.95	\$24.95
Packing Materials	Bubble Wrap	2.1	1	\$19.95	\$19.95
Packing Materials	Furniture Pads	2.1	4	\$7.95	\$31.80
Truck	Rental	2.2			\$400.00
Truck	Gas at 10mpg	2.2	200	\$2.25	\$45.00

The detailed cost estimates can be sorted by activity and then subtotaled by activity to determine the cost for each activity.

### Establishing a Budget

Once the cost of each activity is estimated, it is possible to determine how much money is needed for each group of tasks and for the whole project.

### Cost of Tasks

The cost of each group of activities of the project can be estimated by summing the costs of the components of each activity in the group. This process of subtotaling costs by category or activity is called **cost aggregation**<sup>10</sup>.

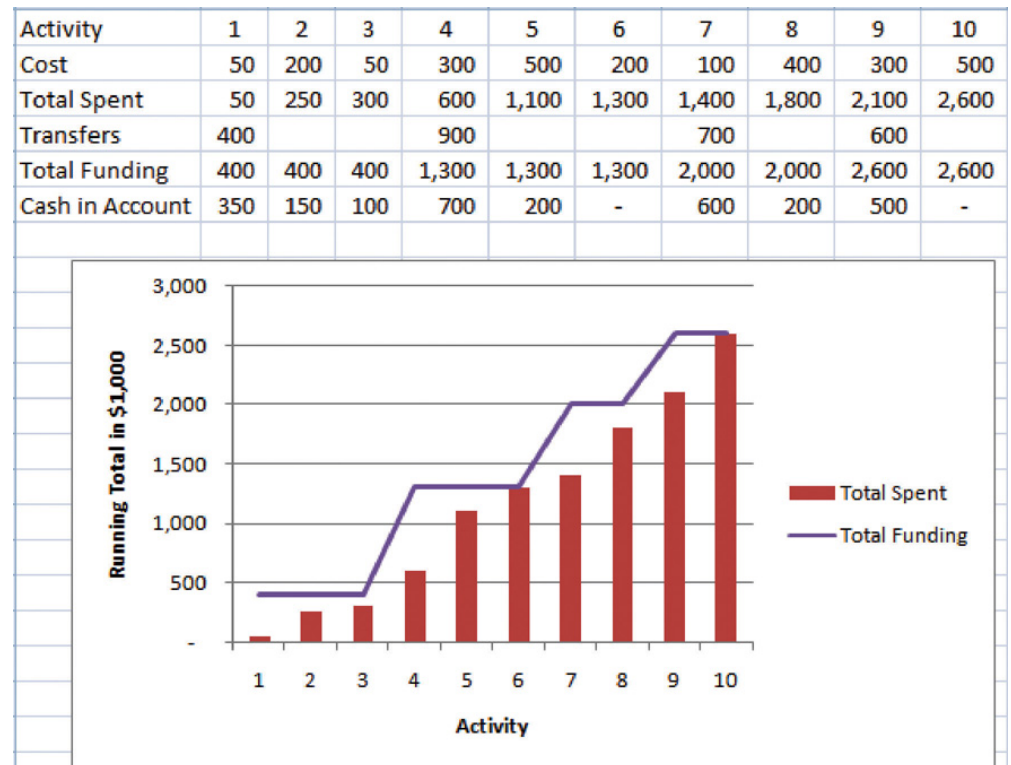
### Budget Timeline

Because the costs are associated with activities and each activity has a start date and a duration, it is possible to calculate how much money needs to be spent by any

10. Sum of component costs.

particular date during the project. The money needed to pay for a project is usually transferred to the project account shortly before it is needed. These transfers must be timed so that the money is there to pay for each activity without causing a delay in the start of the activity. If the money is transferred too far in advance, the organization will lose the opportunity to use the money somewhere else, or they will have to pay unnecessary interest charges if the money is borrowed. A schedule of money transfers is created that should match the need to pay for the activities. The process of matching the schedule of transfers with the schedule of activity payments is called **reconciliation**<sup>11</sup>. Refer to [Figure 9.5 "Fund Transfers and Expenditures"](#) that shows the costs of ten major activities in a project. Funds are transferred into the project account four times. Notice that during most of the project, there were more funds available than were spent except at activity 6 when all the available funds were spent.

Figure 9.5 Fund Transfers and Expenditures



In the project budget profile shown in [Figure 9.5 "Fund Transfers and Expenditures"](#), there is no margin for error if the total of the first six activities exceeds the amount of funding at that point in the project.

11. Matching funds provided with funds spent.

Contractual agreements with vendors often require partial payment of their costs during the project. Those contracts can be managed more conveniently if the unit

of measure for partial completion is the same as that used for cost budgeting. For example, if a contractor is pouring concrete for a large project, their contract may call for partial payment after 25 percent of the total volume of concrete is poured as determined by cubic yards of concrete.

### KEY TAKEAWAYS

- Analogous estimating scales an estimate from a similar project to match the current project. Parametric estimating multiplies a standard cost-per-unit value by the number of units in the project. Bids from contractors can be compared to estimate costs. Bottom-up estimating determines the cost of each detail and aggregates them to determine activity cost estimates.
- During the project selection and approval stage, rough estimates are used that are usually obtained using analogous and parametric methods. Vendor bid analysis and detailed bottom-up estimates are used in the initiation phase to estimate project costs.
- Detailed estimates are associated with activities and aggregated during the planning phase to create an activity-based budget. Funding transfers are arranged to reconcile money spent to money from funding sources in a timely manner.

### EXERCISES

1. An estimate that is obtained by scaling up an estimate from a similar project is a(n) \_\_\_\_\_ estimate.
2. An estimate that uses standard costs per unit such as price per square foot or price per cubic yard is a \_\_\_\_\_ estimate.
3. Matching the transfer of funds into the project account with the money spent is called \_\_\_\_\_.

#### Estimates

Consider a project in which you have been involved that used an estimating technique to provide numbers for the conceptual plan. Briefly describe the type of project and identify the estimating method used.

## 9.2 Managing the Budget

### LEARNING OBJECTIVES

1. Describe methods to manage cash flow.
2. Describe the terms and relationships of budget factors used in earned value analysis.
3. Calculate and interpret budget and schedule variances.
4. Calculate and interpret the schedule performance index and the cost performance index.
5. Calculate and interpret estimates to complete the project.
6. Calculate the revised final budget.

Projects seldom go according to plan in every detail. It is necessary for the project manager to be able to identify when costs are varying from the budget and to manage those variations.

### Managing Cash Flow

If the total amount spent on a project is equal to or less than the amount budgeted, the project can still be in trouble if the funding for the project is not available when it is needed. There is a natural tension between the financial people in an organization, who do not want to pay for the use of money that is just sitting in a checking account, and the project manager, who wants to be sure that there is enough money available to pay for project expenses. The financial people prefer to keep the company's money working in other investments until the last moment before transferring it to the project account. The contractors and vendors have similar concerns, and they want to get paid as soon as possible so they can put the money to work in their own organizations. The project manager would like to have as much cash available as possible to use if activities exceed budget expectations.

### Contingency Reserves

Most projects have something unexpected occur that increases costs above the original estimates. If estimates are rarely exceeded, the estimating method should be reviewed because the estimates are too high. It is not possible to predict which activities cost more than expected, but it is reasonable to assume that some of them will be. Estimating the likelihood of such events is part of risk analysis, which is discussed in more detail in a later chapter.

Instead of overestimating each cost, money is budgeted for dealing with unplanned but statistically predictable cost increases. Funds allocated for this purpose are called **contingency reserves**<sup>12</sup>. Project Management Institute, Inc., *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, 4th ed. (Newtown Square, PA: Project Management Institute, Inc., 2008), 173. Because it is likely that this money will be spent, it is part of the total budget for the project. If this fund is adequate to meet the unplanned expenses, then the project will complete within the budget.

### Management Reserves

If something occurs during the project that requires a change in the project scope, money may be needed to deal with the situation before a change in scope can be negotiated with the project sponsor or client. It could be an opportunity as well as a challenge. Money can be made available to the project to be used at the discretion of the manager to meet needs that would change the scope of the project. These funds are called **management reserves**<sup>13</sup>. Unlike contingency reserves, they are not likely to be spent and are not part of the project's budget baseline, but they can be included in the total project budget. Project Management Institute, Inc., *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, 4th ed. (Newtown Square, PA: Project Management Institute, Inc., 2008), 177.

### Evaluating the Budget During the Project

A project manager must regularly compare the amount of money spent with the budgeted amount and report this information to managers and stakeholders. It is necessary to establish an understanding of how this progress will be measured and reported.

#### Reporting Budget Progress on John's Move

In the John's move example, he estimated that the move would cost about \$1,500 and take about sixteen days. Eight days into the project, John has spent \$300. John tells his friends that the project is going well because he is halfway through the project but has only spent a fifth of his budget. John's friend Carlita points out that his report is not sufficient because he did not compare the amount spent to the budgeted amount for the activities that should be done by the eighth day.

12. Money held to pay for predictable but unspecified extra costs.

13. Money that is available for changing the scope of the project.

As John's friend points out, a budget report must compare the amount spent with the amount that is expected to be spent by that point in the project. Basic measures such as percentage of activities completed, percentage of measurement units completed, and percentage of budget spent are adequate for less complex projects, but more sophisticated techniques are used for projects with higher complexity.

### Earned Value Management

A method that is widely used for medium- and high-complexity projects is the **earned value management (EVM)**<sup>14</sup> method. EVM is a method of comparing the budgeted and actual costs of a project periodically during the project. It combines the scheduled activities with detailed cost estimates of each activity. It allows for partial completion of an activity if some of the detailed costs associated with the activity have been paid but others have not. The earned value analysis method compares the anticipated cost of work that is scheduled to be done at a given point in time against what has been done and how much it actually cost.

### The Budgeted Cost of Work and Planned Value

The **budgeted cost of work scheduled (BCWS)**<sup>15</sup> comprises the detailed cost estimates for each activity in the project. The amount of work that should have been done by a particular date is the **planned value (PV)**<sup>16</sup>. These terms are used interchangeably by some sources, but the planned value term is used in formulas to refer to the sum of the budgeted cost of work up to a particular point in the project, so we will make that distinction in the definitions in this text for clarity.

#### Planned Value on Day Six of John's Move

On day six of the project, John should have taken his friends to lunch and purchased the packing materials. The portion of the BCWS that should have been done by that date (the planned value) is listed in [Figure 9.6 "Planned Value for Lunch and Packing Materials"](#). This is the planned value for day six of the project.

14. Method of comparing the budgeted and actual costs of a project during the project.

15. All the items in the cost estimate. See budget at completion (BAC).

16. Sum of the items in the budgeted cost of work scheduled that should have been spent by a particular day.

Figure 9.6 *Planned Value for Lunch and Packing Materials*

Description	Quantity	Cost
Lunch	3	\$45.00
Small Boxes	10	\$17.00
Medium Boxes	15	\$35.25
Large Boxes	7	\$21.00
Extra Large Boxes	7	\$26.25
Short Hanger Boxes	3	\$23.85
Box Tape	2	\$7.70
Markers	2	\$3.00
Mattress/Spring Bags	2	\$5.90
Lift Straps per Pair	1	\$24.95
Bubble Wrap	1	\$19.95
Furniture Pads	4	\$31.80
<b>Total</b>		<b>\$261.65</b>

### Budgeted Cost of Work Performed and Earned Value

The **budgeted cost of work performed (BCWP)**<sup>17</sup> is the budgeted cost of work scheduled that has been done. If you sum the BCWP values up to that point in the project schedule, you have the **earned value (EV)**<sup>18</sup>.

### Actual Cost

The amount spent on an item is often more or less than the estimated amount that was budgeted for that item. The **actual cost (AC)**<sup>19</sup> is the sum of the amounts actually spent on the items.

17. The budgeted cost of work scheduled that has been done.

18. Sum of budgeted expenses up to a particular point in the schedule.

19. Sum of money spent so far.

### Comparing PV, EV, and AC in John’s Move on Day Six

Dion and Carlita were both trying to lose weight and just wanted a nice salad. Consequently, the lunch cost less than expected. John makes a stop at a store that sells moving supplies at discount rates. They do not have all the items he needs, but the prices are lower than those quoted by the moving company. They have a very good price on lifting straps so he decides to buy an extra pair. He returns with some of the items on his list, but this phase of the job is not complete by the end of day six. John bought half of the small boxes, all of five other items, twice as many lifting straps, and none of four other items. John is only six days into his project, and his costs and performance are starting to vary from the plan. Earned value analysis gives us a method for reporting that progress. Refer to the figure below.

Figure 9.7  
Planned Value, Earned Value, and Actual Cost

Project Earned Value Analysis—Day 6						
Description	Budgeted Cost of Work Scheduled (BCWS)		Budgeted Cost of Work Performed (BCWP)		Actual Cost (AC)	
	Quantity	Cost	Quantity	Cost	Quantity	Cost
Lunch	3	\$45.00	3	\$45.00	3	\$35.00
Small Boxes	10	\$7.00	5	\$8.50	5	\$9.50
Medium Boxes	15	\$35.25	15	\$35.25	15	\$28.00
Large Boxes	7	\$21.00				
Extra Large Boxes	7	\$26.25				
Short Hanger Boxes	3	\$23.85				
Box Tape	2	\$7.70	2	\$7.70	2	\$5.50
Markers	2	\$3.00	2	\$3.00	2	\$2.00
Mattress/Spring Bags	2	\$5.90	2	\$5.90	2	\$7.50
Lift Straps per Pair	1	\$24.95	1	\$24.95	2	\$38.50
Bubble Wrap	1	\$19.95				
Furniture Pads	4	\$31.80	4	\$31.80	4	\$28.50
<b>PV</b>		<b>\$261.65</b>	<b>EV</b>	<b>\$162.10</b>	<b>AC</b>	<b>\$154.50</b>



The original schedule called for spending \$261.65 (PV) by day six. The amount of work done was worth \$162.10 (EV) according to the estimates, but the actual cost was only \$154.50 (AC).

### Schedule Variance

The project manager must know if the project is on schedule and within the budget. The difference between planned and actual progress is the **variance**<sup>20</sup>. The **schedule variance (SV)**<sup>21</sup> is the difference between the earned value (EV) and the planned value (PV). Expressed as a formula,  $SV = EV - PV$ . If less value has been earned than was planned, the schedule variance is negative, which means the project is behind schedule.

### Schedule Variance on John's Move

Planning for John's move calls for spending \$261.65 by day six, which is the planned value (PV). The difference between the planned value and the earned value is the scheduled variance (SV). The formula is  $SV = EV - PV$ . In this example,  $SV = \$162.10 - \$261.65 = \$(99.55)$ . A negative SV indicates the project is behind schedule.

The difference between the earned value (EV) and the actual cost (AC) is the **cost variance (CV)**<sup>22</sup>. Expressed as a formula,  $CV = EV - AC$

### Cost Variance on John's Move

The difference between the earned value of \$162.10 and the actual cost of \$154.50 is the cost variance (CV). The formula is  $CV = EV - AC$ . In this example,  $CV = \$162.10 - \$154.50 = \$7.60$ .

A positive CV indicates the project is under budget.

20. Difference between estimated and actual.

21. Difference between the earned value (EV) and the planned value (PV).

22. Earned value minus actual cost.

### Variance Indexes for Schedule and Cost

The schedule variance and the cost variance provide the amount by which the spending is behind (or ahead of) schedule and the amount by which a project is exceeding (or less than) its budget. They do not give an idea of how these amounts compare with the total budget.

The ratio of earned value to planned value gives an indication of how much of the project is completed. This ratio is the **schedule performance index (SPI)**<sup>23</sup>. The formula is  $SPI = EV/PV$ . In the John's move example, the SPI equals 0.62 ( $SPI = \$162.10/\$261.65 = 0.62$ ) A SPI value less than one indicates the project is behind schedule.

The ratio of the earned value to the actual cost is the **cost performance index (CPI)**<sup>24</sup>. The formula is  $CPI = EV/AC$ .

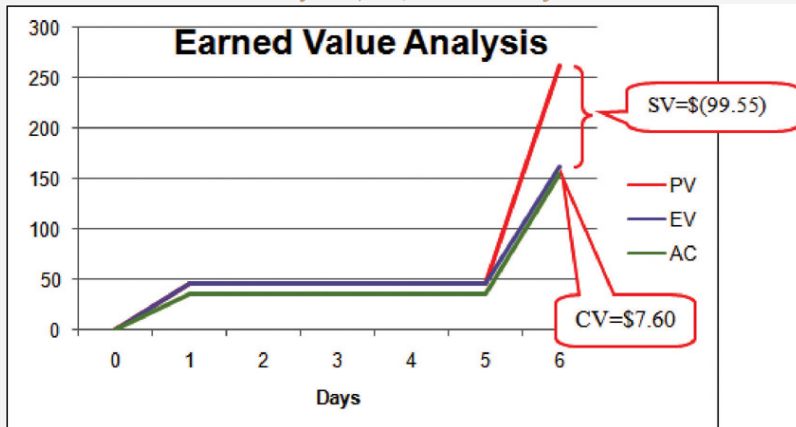
23. Ratio of earned value (EV) to planned value (PV).

24. Ratio of earned value (EV) to actual cost (AC).

### Cost Performance Index of John’s Move

In the John’s move example,  $CPI = \$162.10 / \$154.50 = 1.05$ . A value greater than 1 indicates the project is under budget.

Figure 9.8  
Schedule Variance and Cost Variance on Day Six of the John’s Move Project



The cost variance of positive \$7.60 and the CPI value of 1.05 tell John that he is getting more value for his money than planned for the tasks scheduled by day six. The schedule variance (SV) of negative \$99.55 and the schedule performance index (SPI) of 0.62 tell him that he is behind schedule in adding value to the project.

During the project, the manager can evaluate the schedule using the schedule variance (SV) and the schedule performance index (SPI) and the budget using the cost variance (CV) and the cost performance index (CPI).

### Estimated Cost to Complete the Project

Partway through the project, the manager evaluates the accuracy of the cost estimates for the activities that have taken place and uses that experience to predict how much money it will take to complete the unfinished activities of the project—the **estimate to complete (ETC)**<sup>25</sup>.

25. Estimate of the amount of money needed to complete the unfinished part of the project.

### Atypical Cost Variance

To calculate the ETC, the manager must decide if the cost variance observed in the estimates to that point are representative of the future. For example, if unusually bad weather causes increased cost during the first part of the project, it is not likely to have the same effect on the rest of the project. If the manager decides that the cost variance up to this point in the project is **atypical**<sup>26</sup>—not typical—then the estimate to complete is the difference between the original budget for the entire project—the **budget at completion (BAC)**<sup>27</sup>—and the earned value (EV) up to that point. Expressed as a formula,  $ETC = BAC - EV$

#### Estimate to Complete John's Move

In John's move, John was able to buy most of the items at a discount house that did not have a complete inventory and, he chose to buy an extra pair of lift straps. He knows that the planned values for packing materials were obtained from the price list at the moving company where he will have to buy the rest of the items, so those two factors are not likely to be typical of the remaining purchases. The reduced cost of lunch is unrelated to the future costs of packing materials, truck rentals, and hotel fees. John decides that the factors that caused the variances are atypical. He calculates that the estimate to complete (ETC) is the budget at completion (\$1,534) minus the earned value at that point (\$162.10), which equals \$1,371.90. Expressed as a formula,  $ETC = \$1,534 - \$162.10 = \$1,371.90$ .

### Typical Cost Variance

If the manager decides that the cost variance is caused by factors that will affect the remaining activities, such as higher labor and material costs, then the estimate to complete (ETC) needs to be adjusted by dividing it by the cost performance index (CPI). For example, if labor costs on the first part of a project are estimated at \$80,000 (EV) and they actually cost \$85,000 (AC), the cost variance will be 0.94. (Recall that the cost variance =  $EV/AC$ ).

To calculate the estimate to complete (ETC) assuming the cost variance on known activities is typical of future cost, the formula is  $ETC = (BAC - EV)/CPI$ . If the budget at completion (BAC) of the project is \$800,000, the estimate to complete is  $(\$800,000 - \$80,000)/0.94 = \$766,000$ .

26. Opposite of typical—not typical.

27. Budget for the entire project.

### Estimate Final Project Cost

If the costs of the activities up to the present vary from the original estimates, it will affect the total estimate for the project cost. The new estimate of the project cost is the **estimate at completion (EAC)**<sup>28</sup>. To calculate the EAC, the estimate to complete (ETC) is added to the actual cost (AC) of the activities already performed. Expressed as a formula,  $EAC = AC + ETC$ .

#### Estimate at Completion for John's Move

The revised estimate at completion (EAC) for John's move at this point in the process is  $EAC = \$154.50 + \$1,371.90 = \$1,526.40$ .

Refer to [Figure 9.9 "Summary of Terms and Formulas for Earned Value Analysis"](#) for a summary of terms and formulas.

Figure 9.9 Summary of Terms and Formulas for Earned Value Analysis

Term	Acronym	Description	Formula	John's Move
Actual Cost	AC	The money actually spent on projects up to the present		\$154.50
Budget at Completion	BAC	Original budget for the project (same as BCWS)		\$1,534.00
Cost Performance Index	CPI	Ratio of earned value to actual cost	$CPI = EV / AC$	1.05
Cost Variance	CV	Difference between earned value and actual cost	$CV = EV - AC$	\$ 7.60
Earned Value	EV	Sum of estimates for work actually done up to the present		\$162.10
Estimate at Completion	EAC	Revised estimate of total project cost	$EAC = AC + ETC$	\$1,526.40
Estimate to Complete	ETC	Money to complete the project if early cost variance is atypical	$ETC = BAC - EV$	\$1,371.90
Estimate to Complete	ETC	Money to complete the project if early cost variance is typical	$ETC = (BAC - EV) / CPI$	N/A
Planned Value	PV	Sum of the estimates for work done up to the present		\$261.65
Schedule Performance Index	SPI	Ratio of earned value to planned value	$SPI = EV / PV$	.62
Schedule Variance	SV	Difference between earned value and planned value	$SV = EV - PV$	(\$99.55)

28. Revised project budget based on actual cost to date plus the estimate to complete (ETC).

### KEY TAKEAWAYS

- Extra money is allocated in a contingency fund to deal with activities where costs exceed estimates. Funds are allocated in a management reserves in case a significant opportunity or challenge occurs that requires change of scope but funds are needed immediately before a scope change can typically be negotiated.
- Schedule variance is the difference between the part of the budget that has been done so far (EV) versus the part that was planned to be completed by now (PV). Similarly, the cost variance is the difference between the EV and the actual cost (AC).
- The schedule performance index (SPI) is the ratio of the earned value and the planned value. The cost performance index (CPI) is the ratio of the earned value (EV) to the actual cost (AC).
- The formula used to calculate the amount of money needed to complete the project (ETC) depends on whether or not the cost variance to this point is expected to continue (typical) or not (atypical). If the cost variance is atypical, the ETC is simply the original total budget (BAC) minus the earned value (EV). If they are typical of future cost variances, the ETC is adjusted by dividing the difference between BAC and EV by the CPI.
- The final budget is the actual cost (AC) to this point plus the estimate to complete (ETC).

## EXERCISES

1. Money that is allocated for dealing with unplanned but predictable expenses is \_\_\_\_\_ reserve.
2. The formula used to calculate the cost performance index is \_\_\_\_\_.
3. The formula used to calculate the estimate to complete for atypical cost variances is \_\_\_\_\_.
4. The sum of the budgeted amounts for the tasks that have been performed is the \_\_\_\_\_ (two words).
5. Schedule variance is the \_\_\_\_ minus the \_\_\_\_ and cost variance is the \_\_\_\_ minus the \_\_\_\_ (use acronyms).
6. Schedule performance index is \_\_\_\_ / \_\_\_\_ and the cost performance index is \_\_\_\_ / \_\_\_\_ (use acronyms).
7. The revised final budget is the \_\_\_\_ plus the \_\_\_\_ (use acronyms).

### Estimating Earned Value

Consider a project you are familiar with in which the contractor or service provider who was performing the work needed to be replaced before the job was completed. Describe how the value of the contractor's efforts up to that point was determined and how that evaluation compared to an earned value analysis.

## 9.3 Exercises

Exercises at the end of the chapter are designed to strengthen your understanding and retention of the information recently acquired in the chapter.



## SHORT ANSWER QUESTIONS

The questions in this section refer to the project budget shown below.

Figure 9.10  
Example for Short Answer Questions

	A	B	C	D	E	F	G	H
1	Week	1	2	3	4	5	6	7
2	Activity	\$60K	\$40K			\$90K		
3	BCWS	60,000	25,000	15,000	-	30,000	30,000	30,000
4	BCWP	60,000		25,000	15,000	30,000	30,000	30,000
5	AC	62,000		26,000	15,000	32,000	33,000	30,000

This project has three completed activities whose durations are indicated by the blue bars in row 2. The budgeted cost of work scheduled for each task is shown on the bar in row 2. The budgeted cost of work scheduled for each week is shown on row 3. Notice that the amounts in row 3 add up to the amounts shown on the bars. Rows 4 and 5 indicate the budgeted cost of work performed and actual cost. Notice that the second task started a week late.

1. What is the planned value (PV) at the end of week three?
2. What is the earned value (EV) at the end of week three?
3. What is the actual cost (AC) at the end of week three?
4. What is the cost variance (CV) at the end of week three?
5. What is the schedule variance (SV) at the end of week three?
6. What is the planned value (PV) at the end of week seven?
7. What is the earned value (EV) at the end of week seven?
8. What is the actual cost (AC) at the end of week seven?
9. What is the cost variance (CV) at the end of week seven?
10. What is the schedule variance (SV) at the end of week seven?
11. What is the cost performance index (CPI) at the end of week seven?
12. What is the schedule performance Index at the end of week seven?
13. If the budget at completion (BAC) for this project is \$500,000, what is the Estimate to Complete (ETC) at the end of week seven if the cost and schedule variances experienced are typical of the remainder of the activities?
14. Based on your answer to the previous question, what is the estimate at completion (EAC) for this project?

## ESSAY QUESTIONS

Write several paragraphs to provide more in-depth analysis and consideration when answering the following questions.

1. A project is about a third of the way through its scheduled activities, and an earned value management report has been prepared. The summary indicates that it has a CPI of 0.9 and an SPI of 0.8. What do these two values tell you about the project?
2. A project is about half done with a CV of \$(4,000) due to atypical costs in the first half of the project. Its project manager provides an ETC of \$50,000. Interpret this statement in your own words.
3. Give an example of an analogous estimate and a parametric estimate that are different from those described in the text.

## DISCUSSION

The exercises in this section are designed to promote exchange of information among students in the classroom or in an online discussion. The exercises are more open ended, which means that what you find might be completely different from what your classmates find, and you can all benefit by sharing what you have learned.

1. Describe an experience of your own that involved a parametric estimate. Describe the parameter and how it was used. Compare the estimate with the actual cost.
2. As an inexperienced project manager, how do you develop expert knowledge? Interview someone who would qualify as an expert in estimating costs and ask them to describe the process they went through. Ask them for advice on how to become an acknowledged expert in estimating and then share what you learn with your classmates.