

# Cost Management

## SEVEN

Do you create a budget for your projects? Do you have practical experience managing and controlling project costs? The questions on the exam are written to test whether you have such experience. If these efforts are not part of how you manage your real-world projects, make sure you read this chapter carefully and fully understand the concepts discussed.

Many people are nervous about questions relating to earned value. This chapter should help ease your mind. There have typically been 15 to 20 questions on earned value on the exam. Not all these questions have required earned value calculations. Some questions may only require you to interpret earned value terminology and analysis results. With a little study, earned value questions should be easy.

On the exam, there is a strong connection between cost management and schedule management. Some topics (including planning, estimating, and monitoring and controlling) covered here in the Cost Management chapter also apply to the Schedule Management chapter. The Schedule Management chapter included information on estimating techniques that can be used for both schedule and cost estimating. Earned value analysis is discussed later in this chapter, and is another example of a technique that can be used for both cost and schedule.

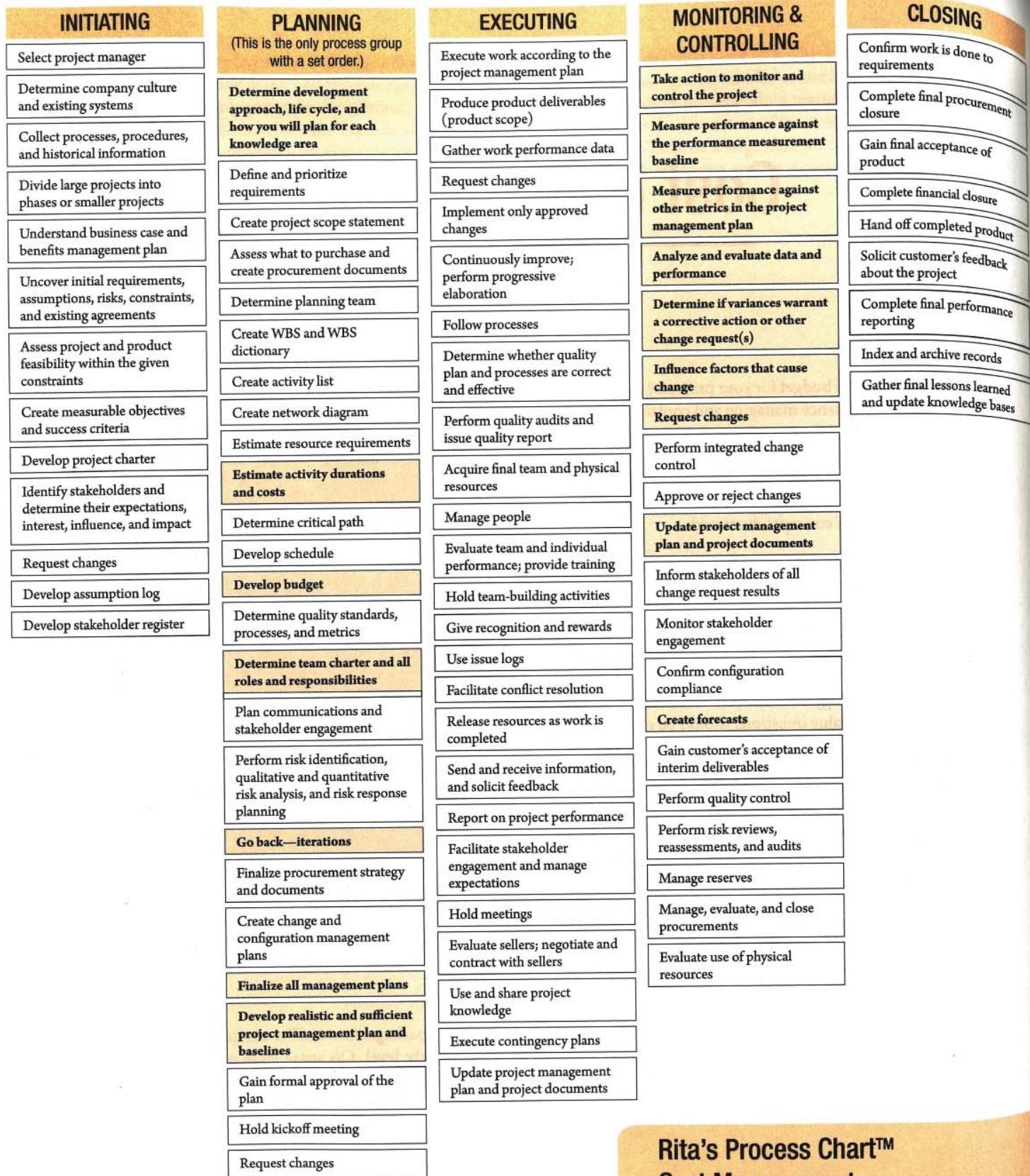
The Schedule Management chapter describes the decomposition of work packages into smaller components, or activities. For many projects, cost estimates are created at the activity level. On some large projects, however, it might be more practical to estimate and control costs at a higher level, called a control account. (See the Scope Management chapter for more on control accounts.)

### QUICKTEST

- Cost management process
- Earned value analysis
  - PV
  - EV
  - AC
  - CPI
  - SPI
  - BAC
  - EAC
  - ETC
  - VAC
  - CV
  - SV
  - TCPI
- Cost baseline
- Cost budget
- Performance measurement baseline
- Three-point estimating
- Analogous estimating
- Bottom-up estimating
- Parametric estimating
- Inputs to estimating costs
- Cost management plan
- Rough order of magnitude (ROM) estimate
- Definitive estimate
- Budget estimate
- Reserve analysis
- Contingency reserves
- Management reserves
- Cost risk
- Variable/fixed costs
- Direct/indirect costs
- Life cycle costing
- Value analysis
- Control thresholds
- Progress reporting
- Cost of quality
- Return on investment (ROI)
- Discounted cash flow

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**Rita's Process Chart™**  
**Cost Management**  
Where are we in the project management process?

The following should help you understand how each part of cost management fits into the overall project management process:

The Cost Management Process	Done During
Plan Cost Management	Planning process group
Estimate Costs	Planning process group
Determine Budget	Planning process group
Control Costs	Monitoring and controlling process group

Although they are not currently found in the *PMBOK® Guide*, you should be familiar with the following cost management concepts.

**Life Cycle Costing<sup>1</sup>** This concept involves looking at costs over the entire life of the product, not just the cost of the project to create the product. For example, assume you plan the project to produce the product at a lower level of quality and save \$9,000. After the project is completed, the maintenance costs are \$100,000 over the life of the product, instead of the \$20,000 in maintenance it could have cost had you built the product to a higher quality standard. Your \$9,000 project “savings” cost the company \$80,000 (or \$71,000 in additional cost). This is the concept of life cycle costing—looking at the cost of the whole life of the product, not just the cost of the project. You may encounter questions on the exam requiring you to consider life cycle cost when selecting the cost option with the least negative impact.

**Value Analysis<sup>2</sup>** This concept is sometimes referred to as value engineering. Its focus is on finding a less costly way to do the same work. In other words, this technique is used to answer the question, “How can we decrease cost on the project while maintaining the same scope?” Value analysis refers to finding ways to provide required features at the lowest overall cost without loss of performance.

**Cost Risk<sup>3</sup>** In the Integration Management chapter (and other chapters), we have discussed how some topics cross the boundaries between knowledge areas. The concept of cost risk involves cost, risk, and procurement management. This term means just what its name implies—cost-related risk. Because such topics cross knowledge areas, so do the questions on the exam about the topics. See the following sample question.

**Question** Who has the cost risk in a fixed-price contract—the buyer or the seller?

**Answer** The seller

## Plan Cost Management PAGE 235

**Process** Plan Cost Management  
**Process Group** Planning  
**Knowledge Area** Cost Management

The Plan Cost Management process involves identifying how you’re going to plan (including estimating and budgeting), manage, and monitor and control project costs, including the cost of resources. This process answers the questions, “How will I go about planning cost for the project?” and “How will I effectively manage the project to the cost baseline, control costs, and manage cost variances?”

The project charter includes a high-level cost constraint as well as other requirements regarding cost management on the project. Organizational process assets used in this process include cost data and lessons learned from previous projects as well as organizational standards and policies for estimating and budgeting.

In some organizations, the Plan Cost Management process can involve determining whether the project will be paid for with the organization's existing funds or will be funded through equity or debt. It can also include decisions about how to finance project resources—such as choosing whether to purchase or lease equipment.

Net present value, return on investment, payback period, and internal rate of return are calculations that may be used to make such determinations. Do you remember these techniques from the Integration Management chapter? If not, you may want to return to that chapter now and review them. In integration, they were used as project selection measures, and they are also useful in planning cost management. As we get detailed estimates and develop the budget, we will use them to evaluate whether the project is still feasible within the charter and whether the measurable project objectives can be achieved.

Another useful calculation here is discounted cash flow. This technique is used in project selection to estimate the attractiveness of an investment by predicting how much money will be received in the future and then discounting it to its current value. In cost management planning, it is used to evaluate the potential revenue to be earned from specific project work.

Can you see how decisions about funding and financing resources might affect project risks and other project constraints? These decisions will influence how you plan the project across all knowledge areas and how work will be completed. If you haven't had to deal with these concerns on your own projects, it's easy to miss questions on the exam about how cost-related decisions could impact the rest of the project. As you read through this chapter, don't just focus on memorizing the formulas for earned value management. Make sure you truly understand what project management efforts you should be doing when it comes to cost management and what those efforts mean to the project.

**Cost Management Plan** PAGE 238 The output of this process is the cost management plan, which could also be called the "budget management plan" or "budget plan." The cost management plan is similar to other management plans (a PMI-ism). It can be formal or informal, but it is part of the project management plan. Once again, you can see that such a plan requires thinking in advance about how you will plan, manage, and monitor and control project costs. This is a concept many project managers miss.

The cost management plan may include the following:

- Specifications for how estimates should be stated (in what currency)
- The levels of accuracy and precision needed for estimates
- Approved estimating techniques
- Reporting formats to be used
- Rules for measuring cost performance
- Guidance regarding whether costs will include indirect costs (costs not directly attributable to any one project, such as overhead costs) in addition to direct costs (those costs directly attributable to the project)
- Guidelines for the establishment of a cost baseline for measuring against as part of project monitoring and controlling (the cost baseline will ultimately be established in Determine Budget)
- Control thresholds
- Cost change control procedures
- Information on control accounts or other ways to monitor spending on the project

- Funding decisions
- Methods for documenting costs
- Guidelines for dealing with potential fluctuations in resource costs and exchange rates
- Roles and responsibilities for various cost activities

Notice the inclusion of control thresholds. The creation of the cost management plan (like any other management plan in project management) requires thinking ahead about how you will control costs. If an actual cost comes in higher than expected, will you need to take action? What if it's a two-dollar difference? Control thresholds are the amount of variation allowed before you need to take action. You determine these thresholds in planning while creating the cost management plan.

## Estimate Costs PAGE 240

**Process** Estimate Costs  
**Process Group** Planning  
**Knowledge Area** Cost Management

This process involves coming up with cost estimates for all project activities and resources required to complete them. These estimates will be combined into one time-phased spending plan in the next process: Determine Budget.

In the Schedule Management chapter, we included some Tricks of the Trade® titled, “Things to Know about Estimating for the Exam.” As noted in that chapter, those concepts apply to both cost and schedule estimating. Take some time now to review that list. It is helpful to have those concepts fresh in your mind before continuing to read about the Estimate Costs process.

So what costs should you estimate? To put it simply, you need to estimate the costs of all the efforts to complete the project. This includes costs directly associated with the project, such as labor, equipment, materials, and training for the project, as well as the following:

- Costs of quality efforts
- Costs of risk efforts
- Costs of the project manager’s time
- Costs of project management activities
- Expenses for physical office spaces used directly for the project
- Overhead costs, such as management salaries and general office expenses

In addition, when the project involves a procurement, the buyer estimates the amount of profit they are paying the seller when purchasing goods or services. The seller estimates the amount of profit to build into the cost of providing the goods or services.

**Types of Cost** There are several ways to look at costs when creating an estimate. In the past, the exam has only asked a few questions regarding types of cost. The following information should help you answer such questions.

A cost can be either variable or fixed:

- **Variable costs** These costs change with the amount of production or the amount of work. Examples include the cost of material, supplies, and wages.
- **Fixed costs** These costs do not change as production changes. Examples include the cost of setup, rent, utilities, etc.

A cost can be either direct or indirect:

- **Direct costs** These costs are directly attributable to the work on the project. Examples are team wages, team travel and recognition expenses, and costs of material used on the project.
- **Indirect costs** Indirect costs are overhead items or costs incurred for the benefit of more than one project. Examples include taxes, fringe benefits, and janitorial services.

**Inputs to Estimating Costs** PAGE 241 These inputs help you create estimates more quickly and accurately. For example, imagine having access to a repository containing all the previous WBSs for projects similar to yours, along with the estimates and actual costs for each activity. Can you see how that might be helpful in creating more accurate estimates on your own project? Having highly accurate estimates will help you better control the project later and, therefore, save you effort. So, read through the following list of inputs, and think through how each might help you estimate costs:

- **Cost management plan** This plan, developed in the Plan Cost Management process, documents the methods you'll use to estimate costs, as well as the levels of accuracy and precision required for estimates.
- **Quality management plan** This plan outlines all the activities the team must perform (as well as any required resources) in order to achieve the expected level of quality. These quality activities have cost associated with them.
- **Scope baseline** To create a cost estimate, you need to know the details of what project and product scope you are estimating; this includes knowing what is out of scope and what cost-related constraints have been placed on the project scope. This information can be found by looking at all the components of the scope baseline (the project scope statement, WBS, and WBS dictionary).
- **Lessons learned register** Lessons learned from estimates made in earlier phases of the current project (if you are using rolling wave planning) should have been documented in the project's lessons learned register. Also, historical lessons learned regarding estimates from previous similar projects should be available. You can use these lessons to help you create more accurate estimates for the remaining parts of your project.
- **Project schedule** The project schedule includes a list of activities, the resources needed to complete the work, and information about when the work will occur. There are two reasons you need a schedule before you can come up with a budget. First, the timing of when you buy something may affect its cost. For example, the price of material or a piece of equipment may vary due to factors such as availability, seasonal pricing fluctuations, or new model releases. If you know something will be more expensive at the time it is scheduled to be purchased, you may consider changing the schedule to be able to purchase the material or equipment at a different time, for a lower price. As another example, the cost of human resources may be impacted by their availability. If a lower-priced resource is not available, you may have to pay more for a higher-priced one. Second, you need to develop a time-phased spending plan to monitor and control project expenditures (a budget) so you know how much money will be spent during specific periods of time (weeks, months, etc.) This is the process of iterative planning, as shown in Rita's Process Chart™.
- **Resource requirements** The resource management plan lists the human resources (including the quantity of resources needed and their skills) required on the project, as well as all the other resources (such as materials and equipment) necessary to complete each activity. Of course, these resources have costs associated with them. The project manager should have access to the rates paid to everyone who works on the project. Recognition and rewards given to team members can increase productivity and save money, but they are still a cost item and need to be estimated. The resource management plan is discussed in more detail in the Resource Management chapter.

- **Risk register** The risk management process can save time and money, but there are costs associated with the efforts to deal proactively with risks (both opportunities and threats). Risks are an input to this process because they influence how costs are estimated. They can also be an output because our choices related to estimating costs have associated risks. Again, planning is iterative.
- **Policies and historical records related to estimating, templates, processes, procedures, lessons learned, and historical information (organizational process assets)** As noted earlier, records from past projects can be highly beneficial in creating estimates for a current project. Organizational policies and standardized templates, such as preferred estimation methods and forms to document estimates, can also make this effort faster and easier.
- **Company culture and existing systems that the project will have to deal with or can use (enterprise environmental factors)** For cost estimating, this includes marketplace conditions, commercial cost databases, exchange rates, and inflation. You also might review the sources from which supplies might be procured and at what costs as part of estimating.
- **Project management costs** It is important to understand that part of the expense of a project comes from the costs of project management activities. Although project management efforts save money on projects overall, they also result in costs, and should be included in the project cost estimates. These include not only costs associated with the efforts of the project manager but also those associated with status reports, change analysis, etc.

**Exercise** Test yourself! Try to recreate the list of inputs to estimating in the space below. For the answer, refer back to the previous list. Spend some time thinking about any inputs you forgot, to make sure you really understand these inputs for the exam.

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**How Is Estimating Done?** Costs can be estimated using the same techniques described in the Schedule Management chapter: one-point estimating, analogous estimating, parametric estimating, bottom-up estimating,<sup>4</sup> and three-point estimating.

**Exercise** Test yourself! See if you understand the differences between top-down (analogous) and bottom-up estimating by identifying the advantages and disadvantages of each technique. (These estimating techniques were described in the Schedule Management chapter.)

**What Are the Advantages of  
Top-Down (Analogous) Estimating?**

**What Are the Disadvantages of  
Top-Down (Analogous) Estimating?**

**What Are the Advantages of  
Bottom-Up Estimating?**

**What Are the Disadvantages of  
Bottom-Up Estimating?**

**What Are the Advantages of Bottom-Up Estimating?**

**What Are the Disadvantages of Bottom-Up Estimating?**

**Answer** There are many possible answers to these questions. The purpose of this exercise is to get you thinking about the differences so you can answer any questions on the topic of estimating, no matter how they may be worded. When taking the exam, look at the context of the question to determine whether it is referring to early, high-level estimating or more detailed, bottom-up estimating.

**Advantages of Top-Down (Analogous) Estimating**

- Quick
- Activities do not need to be identified
- Less costly to create
- Cost constraints created by management in project initiating give the project manager data to evaluate high-level project feasibility
- Overall project costs will be capped for a project analogous estimate

**Disadvantages of Top-Down (Analogous) Estimating**

- Less accurate
- Estimates are prepared with a limited amount of detailed information and understanding of the project or key deliverables
- Requires considerable experience to do well
- There may be infighting to gain the biggest piece of the budget without being able to justify the need
- Extremely difficult for projects with uncertainty or where there is no history of similar projects for the subject matter expert to reference
- Does not take into account the differences between projects

**Advantages of Bottom-Up Estimating**

- More accurate, as it uses analogous, three-point, or parametric estimating at the activity level
- Gains buy-in from the team because the team creates estimates they can live with
- Based on a detailed analysis of the project and the deliverables
- Provides a basis for monitoring and controlling, performance measurement, and management

**Disadvantages of Bottom-Up Estimating**

- Takes time and money to use this estimating technique
- Tendency for the team to pad estimates unless they understand the use of reserves
- Requires that the project be defined and well understood before estimating begins
- Requires time to break the project down into smaller pieces

**Accuracy of Estimates** Think about someone walking into your office and asking you to estimate the total cost of a new project. The first question you would probably ask is, “How accurate do you want me to be?” Estimates made in the early part of the project will be less accurate than those made later, when more is known about the project. Estimates should be in a range, as it is very unlikely an activity will be completed for the exact amount estimated. In the early part of the project, you typically provide wide-ranging estimates. They are top-down in nature. Over time, as you determine more information about the project during planning, you can narrow the estimate range. These top-down estimates evolve into bottom-up estimates.

**Project Management Information System** A Project Management Information System (PMIS) is made up of tools to support information documentation, storage, and retrieval on the project. It includes estimating spreadsheets and software, and integrates finance and accounting, scheduling, quality, and risk tools. These tools can significantly speed up calculations and analysis related to estimating.

**Determining Resource Cost Rates** Although many project managers do not have access to this information on their projects, the exam assumes a project manager knows the actual cost of labor when performing detailed cost estimating. Resources are not limited to internal human resources. The work of estimating resource costs might also involve estimating the work of consultants, sellers, and suppliers.

When the project includes plans to outsource pieces of work, the Estimate Costs and Plan Procurement Management processes impact each other and require iterations as planning progresses. This same relationship exists between Plan Procurement Management and the other estimating processes, such as Estimate Activity Resources and Estimate Activity Durations.

**Alternatives Analysis** In this process, alternatives analysis involves assessing the cost of various ways to accomplish the project work. This could include make-or-buy analysis or other types of analysis regarding how to accomplish the project outcomes within cost constraints or practices of the organization.

**Reserve Analysis** Proper project management requires the use of reserves to cover the schedule, cost, and other areas of risk in a project estimate. As discussed in the Schedule Management chapter, reserve analysis involves identifying which activities on the project have significant risk and determining how much time and money to set aside to account for those risks in case they occur. Contingency reserves are used for known risks, which are specifically identified risks. A management reserve is used to accommodate unknown, or unidentified, risks. See the Risk Management chapter to learn how these reserves are calculated.

**Cost of Quality** The cost of work added to the project to accommodate quality efforts should be included in the project estimate.

**Decision-Making** As is the case with schedule estimates, involving team members in estimating costs improves accuracy because they are the ones most likely to understand what’s involved in the effort. Examples of group decision-making techniques include voting, brainstorming, and the nominal group technique, all of which were described in the Scope Management chapter of this book.

**Estimate Ranges** Organizations often have different standards for different ranges—from preliminary to conceptual to feasibility to order of magnitude to definitive estimates. Such ranges tell you how much time and effort need to go into estimating to make sure the actual cost is within the range of the estimate. The standard ranges of the order of magnitude estimate, budget estimate, and definitive estimate are shown below:

- **Rough order of magnitude (ROM) estimate<sup>5</sup>** This type of estimate is usually made during project initiating. A typical range for ROM estimates is -25 to +75 percent, but this range can vary depending on how much is known about the project when creating the estimates.
- **Budget estimate** As a best practice, it is a good idea to narrow the range of the estimate before you begin iterating the plan. A budget estimate is in the range of -10 to +25 percent.
- **Definitive estimate** As project planning progresses, the estimate will become even more refined. Some project managers use the range of +/-10 percent, while others use -5 to +10 percent.

**TRICKS OF THE TRADE**

The concept of ranges often appears on the exam. Make sure you understand that estimates become more detailed as project planning progresses. Remember that organizations have different rules for the acceptable range of estimate for an activity or the project and that what you see here may be different than your experience. It is wise to estimate in a range, based on the level of uncertainty remaining in the estimate. Even the approved baseline may be expressed as a range, for example: \$1,000,000 (-5 to +10 percent).

When completed, the Estimate Costs process results in cost estimates and an explanation of how those estimates were derived (known as the basis of estimates). It can also result in changes or updates to project documents, such as the risk register, assumption log, and lessons learned register.

**Determine Budget** PAGE 248

**Process** Determine Budget  
**Process Group** Planning  
**Knowledge Area** Cost Management

In this part of cost management, the project manager calculates the total cost of the project to determine the amount of funds the organization needs to have available for the project. The result of this calculation is the budget. The cost baseline is the portion of the budget the project manager will have control over. Meeting the cost baseline will be a measure of project success, so the budget should be in a form the project manager can use while the work is being done to control costs and, therefore, control the overall project.

To begin the Determine Budget process, the project manager should review the business case and the benefits management plan for the project. The business case includes the business need and reason the project is being done. This may be expressed in financial terms, such as expected return on investment. The benefits management plan can be used to finalize the budget and compare it to the economic benefits expected from the project.

Many of the inputs to the Estimate Costs process are used here as well: the cost management plan, the scope baseline, the project schedule, the risk register, and organizational process assets (existing policies on cost control and cost budgeting, for example). Two outputs from Estimate Costs—cost estimates and the basis of estimates—are also essential inputs to this process. You'll also need information about when and for how long resources will be needed (and at what rates—which can be found in the resource management plan), and any agreements regarding the purchase of services or products for the project.

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In estimating the total cost of a project (determining the project's budget), a project manager must perform risk management activities and include reserves in their estimates. The cost baseline includes contingency reserves; it represents the funds the project manager has authority to manage and control. The cost budget is the cost baseline plus the management reserves.

To create a budget, activity cost estimates are rolled up to work package cost estimates. Work package costs are then rolled up to control account costs and finally to project costs. This process is called cost aggregation. Contingency reserves are added to determine the cost baseline. These can be added at the project level, as described here and depicted in figure 7.1, but note it is also possible to add contingency reserves at the activity level. In the final step, the management reserves are added.

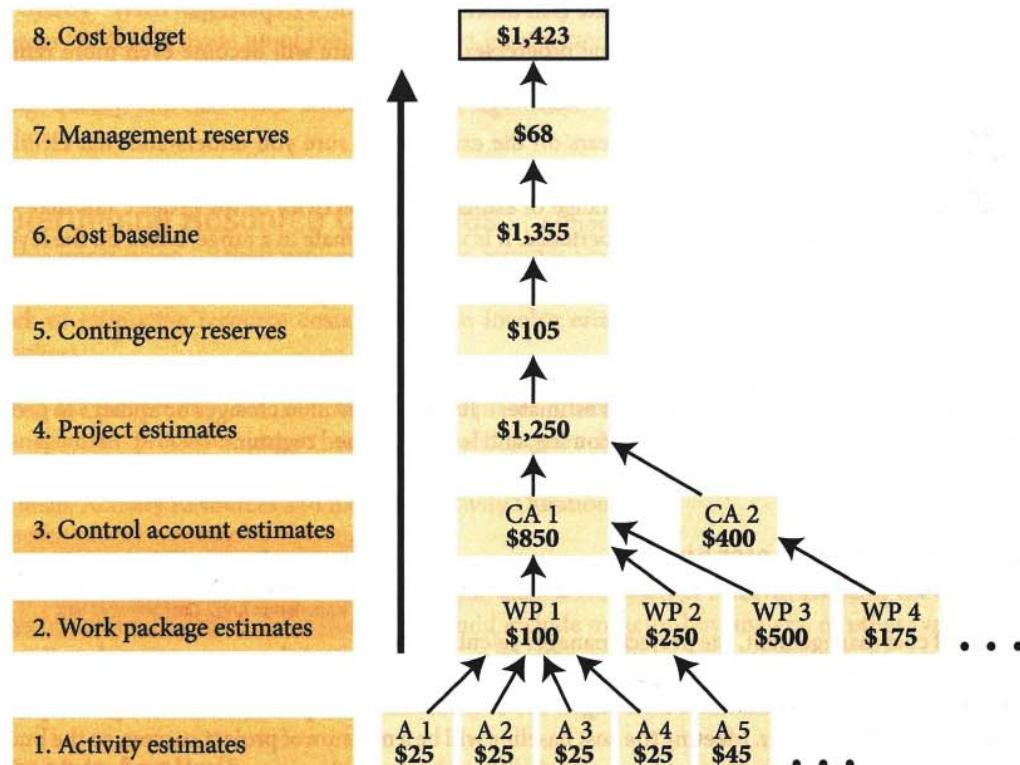


FIGURE 7.1 Creating a budget

After the cost baseline and cost budget are estimated, the project manager may compare these numbers to parametric estimates or to expert judgment; alternatively, the project manager may perform a historical information review, comparing their estimates to those of past, similar projects. For example, a general rule for a high-level parametric estimate in some industries is that design should be 15 percent of the cost of construction. Other industries estimate the cost of design to be 60 percent of the project budget. The project manager needs to investigate and justify any significant differences between the project estimates and the reference data to ensure the estimates are reasonable and as accurate as possible.

The next thing to check is cash flow (part of funding limit reconciliation<sup>6</sup>). Funding may not be available when it is needed on the project, causing changes to the other parts of the project and iterations of the project documents or project management plan. For example, if equipment costing \$500,000 is scheduled to be purchased on June 1 but the money for the purchase is not available until July 1, the activities dependent on that equipment will have to be moved to later points in the schedule. The cost baseline, therefore, is time-phased and may be shown as an S-curve.<sup>7</sup>

The project manager needs to perform another reconciliation before the proposed cost baseline and cost budget can become final: reconciling with any cost constraints in the charter. If, after all of the project manager's work, the project estimate still exceeds the constraints, the project manager must meet with management, explain why their cost requirement cannot be met, and propose options to decrease costs. Pay particular attention to that last sentence.

Such actions are a required part of project management. If a proposed budget is unrealistic, it is the project manager's job to address it early in planning. As with the schedule, project managers have a professional responsibility to reconcile the budget in this way.

Financing refers to obtaining the needed funds for a project. This means all funds, both internal and external. External funds are obtained from sources outside the performing organization, and are typically needed for major long-term projects. These funds are included in the cost baseline.

When the Determine Budget process is complete, the cost baseline, including all funding requirements, is established. As in the other processes we have discussed, the efforts involved in determining the budget may create the need for updates to project documentation including cost estimates, the risk register, and the project schedule.

## Control Costs PAGE 257

Process Control Costs  
Process Group Monitoring & Controlling  
Knowledge Area Cost Management

The Control Costs process is similar to the ongoing process of control in other knowledge areas, with a focus on cost. Complete the following exercise and imagine how this would apply to real-world projects.

**Exercise** What actions should a project manager take to control costs? (This is an important topic, so be sure to take your time to think about this question.)

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**Answer** Was one of your answers “follow the cost management plan”? That is an excellent answer! The cost management plan includes your plan for how you will control the costs of the project, which may include items such as meetings on cost, reports, measurements that will be made, and the frequency with which you will measure. The control part of the management plan is customized to the needs of the project.

If you understand the idea behind PMI-isms, you might also have answered something like “look at organizational process assets.” That is also a good answer. You need to consider policies, procedures, tools, or reporting formats related to controlling costs that are available or required by your company.

Was another one of your answers “manage changes”? This is generally correct, but make sure you understand the complexity of this effort. What about preventing unnecessary changes and influencing the things causing costs to rise? What about letting people know which changes are approved and which are not so everyone is working with the same project information? You need to make sure the project goes according to the plan; controlling all aspects of the project is essential to achieve overall project success. Think of yourself as a detective looking for anything that can get in the way of project success. This mindset will help you choose the best choice when answering questions that seem to have more than one correct answer.

Also keep in mind that control means measure. When taking the exam, assume the project manager is measuring the project, even if you do not do this on your real-world projects. Measurement helps you see if there are any variances. You can then determine if those variances require changes, including corrective or preventive actions. The cost management plan should include what you will measure, when, and what amount of variation between planned and actual will require action (your control limits). In other words, you plan what you will do to control the project before you get started. Do you do this on your projects? Assume that you do, and assume that all proper project management is being done when you take the exam unless the question tells you (directly or indirectly) that proper project management was not done.

**Progress Reporting** PAGE 264 The project manager can use information about project progress to help control the schedule and costs and to assess whether the project is on track through earned value analysis (a data analysis technique described later in this section). Some project managers use alternative means of determining progress that don’t rely on earned value analysis, such as asking team members for an estimate of percent complete for each work package or activity. On projects where work is not objectively measured, the estimates the team members are able to provide are simply guesswork. The method of asking for percent complete is time-consuming and generally a waste of time because it does not result in a realistic estimate of the project’s progress.

Another way to track progress without using earned value analysis is to accurately measure deliverable completion (evaluating how much has been done to complete the deliverable based on the work package and the cost and schedule estimates). Typically, with a WBS, 80 hours is a small enough increment of work to be able to track progress against and still have accurate data. For the exam, remember that projects planned using proper project management make use of a WBS, and the activities to produce the work package deliverable are broken down to an appropriate level for monitoring and controlling. Because such work packages are completed relatively quickly and frequently, the project manager can monitor completion of work packages as a way to show progress on deliverables within the time and cost allotted to them in the plan.

**Reserve Analysis** PAGE 265 Remember the contingency reserves that get factored into the cost baseline to address known risks? Part of controlling costs involves analyzing whether those contingency reserves are still necessary or whether new reserves are required. For example, let's say a project team identifies a highly ranked risk and sets aside a contingency reserve to address that risk, should the need arise. If the risk does not occur and it is determined the risk is no longer a threat, the contingency reserve can be removed from the cost baseline (and subsequently the cost budget). Or, a risk review on a project may identify new risks, which could lead to a decision to increase the contingency reserves. Both of these examples require a change request being submitted through integrated change control. It may also be necessary to reassess the amount of management reserve that was set aside to address unknown risks. Maybe too little or too much was set aside for management reserves in the cost management plan.

Reserve analysis allows you to identify and apply lessons learned in the Control Costs process. Analysis of the management reserves may indicate too many unknown risk events are occurring, suggesting that the risk management efforts in planning were inadequate and need to be redone. Management reserves, if you recall, are separate from the cost baseline, so changes to them will change the cost budget. If an unknown risk event occurs, management reserves will pay for the workaround; a change request is required to move those management reserve funds into the cost baseline and to add any additional funds required to complete the reestimated project work within the new parameters of the project.

**Earned Value Measurement<sup>8</sup>** PAGE 261 You already know earned value, as a concept and a technique, is on the exam. Are you worried about it? Don't be. We are going to make it easier.

First, think about this: How valuable would it be to know how your project is really going? Could you sleep better at night? Would you be able to spend your time in more productive ways than worrying? These are the benefits of the methodology of earned value management. If you currently rely on hope, guesses, or a general percent complete estimate to assess how your project is faring, you probably know from experience that these methods do not tell you much, nor are they very accurate. And they may regularly result in the need to work overtime at the end of the project because of the lack of control along the way. Keep the benefits of earned value as an analysis technique in mind as you read this section, and go through it slowly if it seems confusing.

Earned value analysis is used in performance reviews to measure project performance against the scope, schedule, and cost baselines. Note that earned value analysis uses a combination of these three baselines, known as the performance measurement baseline. The measurements resulting from an earned value analysis of the project indicate whether there are any potential deviations from the performance measurement baseline. Many project managers manage their project's performance by comparing planned to actual results. With this method, however, you could easily be on time but overspend according to your plan. Using earned value analysis is better, because it integrates cost, time, and the work done (or scope), and it can be used to forecast future performance and project completion dates and costs.

Using the work performance information gathered through earned value analysis, a project manager can create reports, including cost forecasts, and other communications related to the project's progress. Earned value analysis may also result in change requests to the project.



### Terms to Know

Here are the earned value terms you need to know.

Acronym	Term	Interpretation
PV	Planned value	As of today, what is the estimated value of the work planned to be done?
EV	Earned value	As of today, what is the estimated value of the work actually accomplished?
AC	Actual cost (total cost)	As of today, what is the actual cost incurred for the work accomplished?
BAC	Budget at completion (the cost baseline)	How much did we budget for the total project effort?
EAC	Estimate at completion	What do we currently expect the total project to cost (a forecast)?
ETC	Estimate to complete	From this point on, how much more do we expect it to cost to finish the project (a forecast)?
VAC	Variance at completion	As of today, how much over or under budget do we expect to be at the end of the project?



### Formulas and Interpretations to Memorize

The exam focuses not just on calculations, but also on knowing what the numbers mean. Therefore, you should know all the formulas in the following table. Note that most exam questions relating to these formulas will refer to cumulative analysis data from the beginning of the project to the point in time when it is being measured.

Name	Formula	Interpretation
Cost variance (CV)	EV – AC	Negative is over budget; positive is under budget.
Schedule variance (SV)	EV – PV	Negative is behind schedule; positive is ahead of schedule.
Cost performance index <sup>9</sup> (CPI)	$\frac{EV}{AC}$	We are getting \$ ____ worth of work out of every \$1 spent. Funds are or are not being used efficiently. Greater than one is good; less than one is bad.
Schedule performance index (SPI)	$\frac{EV}{PV}$	We are (only) progressing at ____ percent of the rate originally planned. Greater than one is good; less than one is bad.
Estimate at completion (EAC)		As of now, how much do we expect the total project to cost? \$ _____. (See the formulas on the next page.)

**NOTE:** There are many ways to calculate EAC, depending on the assumptions made. Notice how the purpose of the formulas really is to create forecasts based on past performance of the project. Exam questions may require you to determine which EAC formula is appropriate. Pay attention to the information provided in the question. It will help you determine which formula to use.

Name	Formula	Interpretation
AC + Bottom-up ETC	$AC + \text{Bottom-up ETC}$	This formula calculates actual costs to date plus a revised estimate for all the remaining work. It is used when the original estimate was fundamentally flawed.
	$\frac{BAC}{CPI^C}$	This formula is used if no variances from the BAC have occurred or if you will continue at the same rate of spending (as calculated in your cumulative CPI or based on the trends that have led to the current CPI).
	$AC + (BAC - EV)$	This formula calculates actual costs to date plus remaining budget. It is used when current variances are thought to be atypical of the future. It is essentially AC plus the remaining value of work to perform.
	$AC + \frac{(BAC - EV)}{(CPI^C \times SPI^C)}$	This formula calculates actual to date plus the remaining budget modified by performance. It is used when current variances are thought to be typical of the future and when project schedule constraints will influence the completion of the remaining effort. So for example, it might be used when the cumulative CPI is less than one and a firm completion date must be met.
To-complete performance index (TCPPI)	$\frac{(BAC - EV)}{(BAC - AC)}$	This formula divides the value of the work remaining to be done by the money remaining to do it. It answers the question "To stay within budget, what rate do we need to meet for the remaining work?"
		Greater than one is bad; less than 1 is good.
Estimate to complete (ETC)		How much more will the project cost?
<b>NOTE:</b> You can determine ETC by either using the formula listed below or reestimating the cost of the work remaining.		
	EAC - AC	This formula calculates the total project cost as of today minus what has been spent to date.
	Reestimate	Reestimate the remaining work from the bottom up.
Variance at completion (VAC)	BAC - EAC	How much over or under budget will we be at the end of the project?

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Make sure you understand and memorize the following about CV, SV, CPI, and SPI:

- EV comes first in each of these formulas. Remembering this one fact alone should help you get about half the earned value questions right.

- If it is a variance (difference), the formula is EV minus AC or PV.
- If it is an index (ratio), the formula is EV divided by AC or PV.
- If the formula relates to cost, use AC.
- If the formula relates to schedule, use PV.
- For variances interpretation: negative is bad and positive is good. Thus a -200 cost variance means you spent more than planned (over budget). A -200 schedule variance means you are behind schedule. This also applies to VAC.
- For indices interpretation: greater than one is good and less than one is bad. Remember, this only applies to CPI and SPI. The opposite is true of TCPI.

People often incorrectly answer questions requiring them to interpret earned value terms or acronyms because they fail to understand the meanings of the terms. Figure 7.2 illustrates some of the differences. Notice that planned value (PV; what the value was expected to be at this point in the project according to the plan) and actual cost (AC; what the cost has actually been on the project to this point) look backward at the project. Budget at completion (BAC), estimate to complete (ETC), and estimate at completion (EAC) look forward. BAC refers to the project's planned budget; it indicates what the end cost of the project would be if everything went according to plan. ETC and EAC forecast future performance based on what has actually occurred on the project, taking into account any variances from the plan the project has already experienced. ETC is an estimate of how much more the remainder of the project will cost to complete. EAC indicates what the total project cost is forecasted to be.

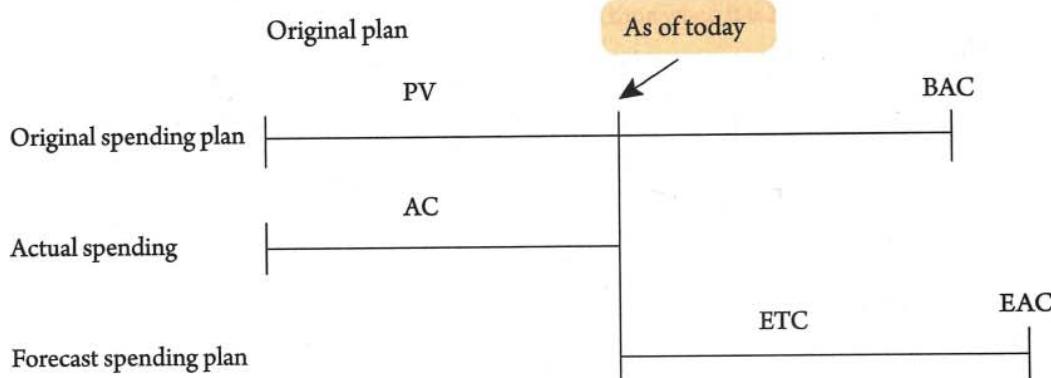


FIGURE 7.2 Understanding earned value concepts by looking backward and forward on a project

**Earned Value in Action** Earned value is an effective tool for measuring performance and determining the need to request changes. The following is a sample team meeting conversation on this subject.

*The project manager calls a team meeting and says, "We are six months into this million-dollar project, and my latest analysis shows a CPI of 1.2 and an SPI of 0.89. This means we are getting 1.2 dollars for every dollar we put into the project, but only progressing at 89 percent of the rate originally planned. Let's look for options to correct this problem."*

*The network specialist suggests that she could be removed from the project team and replaced with someone less expensive.*

The project manager replies, "Not only would it sadden me to lose you, but your suggestion would improve costs, not schedule. You are the company's best network specialist. Someone else would not be as proficient as you in completing the work."

The IT coordinator suggests either removing the purchase of new computers from the project, or telling the customer the project will be two weeks late.

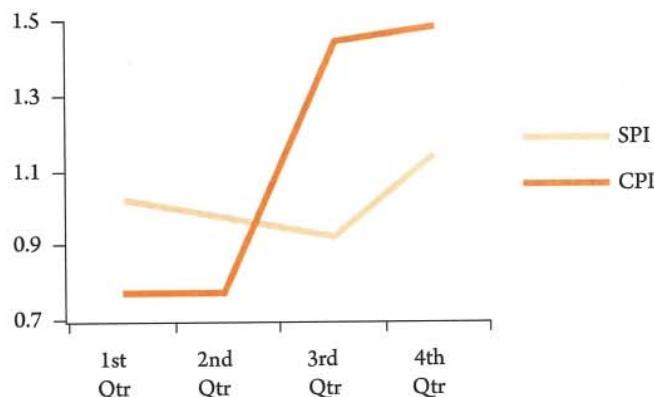
The project manager responds, "Canceling the new computers would save us money, not time. We need to focus on time. We cannot change the project schedule baseline arbitrarily. That would be unethical."

Another team member suggests that since the project is doing well on cost, the project manager could bring in another programmer from the IT department to work on the project to get the next two activities completed more quickly.

The project manager says, "That sounds like the most effective choice in this situation. Let's see if we can find someone who will improve performance, at the lowest cost. Thanks for your help."

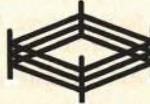
The best way to learn the earned value analysis technique is to use it. The following exercises are designed to give you a chance to practice both calculations and interpretation. Earned value questions on the exam have generally required fewer calculations per question than these exercises.

**Exercise** The cost performance index (CPI) and the schedule performance index (SPI) can be charted each month to show the project trends. Based on the diagram, what would you be more concerned about—cost or schedule—if you were taking over this project from another project manager?



**Answer** Since these calculations were made in the past, the data in the chart is historical data. The last, most current measurement was in the fourth quarter, which shows both SPI and CPI being above one (good). As of the fourth quarter, the SPI is lower. Therefore, the answer is schedule. An easy way to answer performance index questions that ask whether cost or schedule should concern you most is to pick the option with the lowest index.

**Exercise The Fence #1** You have a project to build a new fence. The fence will form a square, as shown at right. Each side is to take one day to build, and \$1,000 has been budgeted per side. The sides are planned to be completed one after the other. Today is the end of day 3.



Using the following project status chart, calculate PV, EV, etc. in the spaces provided. Then check your answers. Interpretation is also important on the exam. Can you interpret what each answer means?

Do the calculations to three decimal places on the exercises. On the real exam, round the results of your calculations to two decimal places when you are ready to check your answers against the choices provided.

Activity	Day 1	Day 2	Day 3	Day 4	Status End of Day 3
Side 1	S-----F				Complete, spent \$1,000
Side 2		S-----PF	----F		Complete, spent \$1,200
Side 3			PS--S---PF		50% done, spent \$600
Side 4				PS-----PF	Not yet started

**Key** S = Actual Start, F = Actual Finish, PS = Planned Start, and PF = Planned Finish

What Is:	Calculation	Answer	Interpretation of the Answer
1	PV		
2	EV		
3	AC		
4	BAC		
5	CV		
6	CPI		
7	SV		
8	SPI		
9	EAC		
10	ETC		
11	VAC		

**Answer The Fence #1**

What Is:	Calculation	Answer	Interpretation of the Answer
1 PV	\$1,000 plus \$1,000 plus \$1,000	\$3,000	We should have done \$3,000 worth of work.
2 EV	Complete, complete, and half done, or \$1,000 plus \$1,000 plus \$500	\$2,500	We have actually completed \$2,500 worth of work.
3 AC	\$1,000 plus \$1,200 plus \$600	\$2,800	We have actually spent \$2,800.
4 BAC	\$1,000 plus \$1,000 plus \$1,000 plus \$1,000	\$4,000	Our project budget is \$4,000.
5 CV	\$2,500 minus \$2,800	-\$300	We are over budget by \$300.
6 CPI	\$2,500 divided by \$2,800	0.893	We are only getting about 89 cents out of every dollar we put into the project.
7 SV	\$2,500 minus \$3,000	-\$500	We are behind schedule.
8 SPI	\$2,500 divided by \$3,000	0.833	We are only progressing at about 83 percent of the rate planned.
9 EAC	\$4,000 divided by \$0.893	\$4,479	We currently estimate that the total project will cost \$4,479.
10 ETC	\$4,479 minus \$2,800	\$1,679	We need to spend an additional \$1,679 to finish the project.
11 VAC	\$4,000 minus \$4,479	-\$479	We currently expect to be \$479 over budget when the project is completed.

Did you select the correct EAC formula? If not, did you miss information in the question that could have guided you to the correct formula? In this example, side 2 cost \$1,200. Side 3 is 50 percent complete and has cost \$600. This suggests a trend that indicates side 4 is likely to cost \$1,200 when complete. When there is a trend and no other information to indicate the trend will not continue, it's most appropriate to use the BAC/CPI formula.

**Exercise The Fence #2** You have a project to build a new fence. The fence will form a square, as shown at right. Each side is to take one day to build, and \$1,000 has been budgeted per side. The sides were planned to be completed one after the other; however, circumstances changed on the project, and work on the sides was able to proceed in parallel. Assume therefore that the sides have a finish-to-finish relationship instead of a finish-to-start relationship, so more than one side can be worked on at the same time. Today is the end of day 3.



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Using the following project status chart, calculate PV, EV, etc. in the spaces provided. Then check your answers.

Activity	Day 1	Day 2	Day 3	Day 4	Status End of Day 3
Side 1	S-----F				Complete, spent \$1,000
Side 2		S---F---PF			Complete, spent \$900
Side 3		S---	PS-----PF		50% done, spent \$600
Side 4			S---	PS-----PF	75% done, spent \$600

**Key** S = Actual Start, F = Actual Finish, PS = Planned Start, and PF = Planned Finish

What Is:	Calculation	Answer	Interpretation of the Answer
1	PV		
2	EV		
3	AC		
4	BAC		
5	CV		
6	CPI		
7	SV		
8	SPI		
9	EAC		
10	ETC		
11	VAC		

### Answer The Fence #2

What Is:	Calculation	Answer	Interpretation of the Answer
1	PV	\$1,000 plus \$1,000 plus \$1,000	\$3,000 We should have done \$3,000 worth of work.
2	EV	Complete, complete, half done, and 75% done, or \$1,000 plus \$1,000 plus \$500 plus \$750	\$3,250 We have actually completed \$3,250 worth of work.

What Is:	Calculation	Answer	Interpretation of the Answer
3 AC	\$1,000 plus \$900 plus \$600 plus \$600	\$3,100	We have actually spent \$3,100.
4 BAC	\$1,000 plus \$1,000 plus \$1,000 plus \$1,000	\$4,000	Our project budget is \$4,000.
5 CV	\$3,250 minus \$3,100	\$150	We are under budget by \$150.
6 CPI	\$3,250 divided by \$3,100	1.048	We are getting about \$1.05 out of every dollar we put into the project.
7 SV	\$3,250 minus \$3,000	\$250	We are ahead of schedule.
8 SPI	\$3,250 divided by \$3,000	1.083	We are progressing at about 108 percent of the rate planned.
9 EAC	\$4,000 divided by \$1.048	\$3,817	We currently estimate that the total project will cost \$3,817.
10 ETC	\$3,817 minus \$3,100	\$717	We need to spend an additional \$717 to finish the project.
11 VAC	\$4,000 minus \$3,817	\$183	We currently expect to be \$183 under budget when the project is completed.

In this example, you are looking for the value of the work that has actually been done. The finish-to-finish relationship allowed the team to work on more than one side at the same time. In this case, work is being done on both sides 3 and 4 at the same time. Since the value of each side is \$1,000, we look at how much of each side is complete and apply that percent to the value. Here sides 1 and 2 are completed, so each receives a value of \$1,000. It doesn't matter what it actually cost—just the value. Side 3 is 50 percent done and receives a value of \$500 (50 percent of \$1,000). Side 4 is 75 percent done and receives a value of \$750 (75 percent of \$1,000). The earned value to date is \$3,250.

Understanding the meaning of the results of each calculation is as important as knowing how to calculate them.

Expect questions on the exam such as: "The CPI is 0.9, and the SPI is 0.92. What should you do?" You will need to interpret this and other data in the question and then determine which choice would address the issue(s) described. In the fence example, there are both cost and schedule problems.

You may also see questions on the exam that require you to perform multiple calculations (for example, you need to perform one calculation to come up with a result that can be used as an input for a second calculation). We have a few exercises coming up that will help you understand how to answer these questions, but it's helpful to first consider the following useful tip.

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Here's a quick trick for finding EV when a question provides partial information. Depending on the information you're given in a question, you can reverse the formulas you know for CV, SV, CPI, or SPI so you can isolate EV on its own side of the equation, which will make it much easier to solve. For example, say a question gives you CV and AC and asks you to solve for EV. You already know that  $CV = EV - AC$ , so now you can reverse this formula by adding AC to both sides of the equation as follows:

$$CV = EV - AC$$

$$CV + AC = EV - AC + AC$$

$$CV + AC = EV$$

Do you understand why we added AC to both sides of the equation? You're trying to isolate EV on one side of the equation. By adding AC to the right side of the equation, you cancel out the  $-AC$ , so you end up with EV on its own. But whatever you do on the right-hand side of the equation, you have to do on the left-hand side as well. (Here's a little algebra refresher: you can perform an operation—such as adding, subtracting, dividing, or multiplying—on one side of the equation so long as you do the exact same thing on the other side as well. This allows you to manipulate an equation to make it easier to solve.)

So now, to solve for EV, all you have to do is add CV and AC.

Similarly, say a question gives you CPI and AC and asks you to determine EV. You already know the formula for CPI ( $CPI = EV/AC$ ), but how can you isolate EV on one side of the equation? Instead of adding AC to both sides of the equation, in this case, you would multiply both sides by AC:

$$CPI = \frac{EV}{AC}$$

$$CPI \times AC = \frac{EV}{AC} \times AC$$

$$CPI \times AC = EV$$

You can also simply memorize the reverse formulas in the table below.

Original Formula	Reverse Formula to Determine EV
$CV = EV - AC$	$EV = CV + AC$
$SV = EV - PV$	$EV = SV + PV$
$CPI = \frac{EV}{AC}$	$EV = CPI \times AC$
$SPI = \frac{EV}{PV}$	$EV = SPI \times PV$

Just keep in mind that this quick trick for reversing the formula only works for EV. Although you can reverse other earned value formulas, to do so would generally require multiple steps.

**Exercise** What is the EV if your CPI is 1.1, your SPI is .92, and your AC is \$10,000? Which reverse formula would you use?

**Answer** Since the question gives us the CPI and AC, we can reverse the CPI formula to get to the EV. So the reverse formula would be  $EV = CPI \times AC$ , or  $EV = 1.1 \times \$10,000$ , which works out to \$11,000. For this question, there was no need to use the SPI information.

**Exercise** What is the SPI if the CV is \$10,000, the SV is -\$3,000, and the PV is \$100,000?

**Answer** To find the SPI, you actually need to perform two calculations here. The formula for SPI is  $SPI = EV/PV$ ; we know what the PV is, but we don't know the EV. Luckily, we can figure it out using the information given in the question. We're given the SV and PV, so we can use the following reverse formula to determine EV.

$$EV = SV + PV$$

$$EV = -\$3,000 + \$100,000$$

$$EV = \$97,000$$

We can then plug the PV and EV into the SPI formula as follows.

$$SPI = \frac{EV}{PV}$$

$$SPI = \frac{\$97,000}{\$100,000}$$

$$SPI = .97$$

If your equation requires you to solve for something other than EV (for example, AC or PV), the math will be slightly more complicated, but don't worry: we've got an exercise to help you understand what to do.

**Exercise** Using the information from the previous exercise, determine AC.

**Answer** We need to look at the information from the previous exercise to determine what formula to use to figure out AC. We know the CV is \$10,000 and the EV is \$97,000 (from the calculation we performed in the previous exercise). With this information, we can determine the AC by using the formula  $CV = EV - AC$ . To do this, we first plug the information we know into the formula:

$$CV = EV - AC$$

$$\$10,000 = \$97,000 - AC$$

To solve for AC, we need to get AC alone on one side of the equation. First, add AC to both sides of the equation:

$$\$10,000 + AC = \$97,000 - AC + AC$$

$$\$10,000 + AC = \$97,000$$

The  $-AC$  and  $+AC$  on the right-hand side of the equation canceled each other out. But we still need to isolate AC on the left-hand side of the equation. To do this, we're going to subtract  $\$10,000$  from both sides.

$$\$10,000 + AC - \$10,000 = \$97,000 - \$10,000$$

$$AC = \$87,000$$

**Exercise** In the latest earned value report for your project, you see the CPI is 1.2, the SPI is 0.8, the PV is  $\$600,000$ , and the SV is  $-\$120,000$ . You can't find the CV in the report, so you need to calculate it based on the information given. What is the CV?

**Answer** The formula for CV is  $CV = EV - AC$ . Therefore, we need to find EV and AC to calculate CV. We can do this by using one of the reverse formulas we learned earlier. Since we know the values for SPI (0.8) and PV ( $\$600,000$ ), we can use  $EV = SPI \times PV$  (this is the reverse formula for  $SPI = EV/PV$ ).

$$EV = SPI \times PV$$

$$EV = 0.8 \times \$600,000$$

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$$EV = \$480,000$$

Now we need AC, which we can get from the EV we just determined and the CPI given in the question (1.2).

$$\text{The formula is } CPI = \frac{EV}{AC} \text{ or } 1.2 = \frac{\$480,000}{AC}.$$

We need to isolate AC on one side of the equation to figure out what it is. Start by multiplying both sides of the equation by AC.

$$1.2 \times AC = \frac{\$480,000}{AC} \times AC.$$

The resulting equation is:

$$1.2 \times AC = \$480,000$$

To get AC on its own, we need to divide both sides by 1.2.

$$\frac{(1.2 \times AC)}{1.2} = \frac{\$480,000}{1.2}$$

The resulting equation is:

$$AC = \frac{\$480,000}{1.2}$$

$$\text{So, } AC = \$400,000.$$

Now that we know the EV and the AC, we can figure out what the CV is:

$$CV = EV - AC$$

$$CV = \$480,000 - \$400,000$$

$$CV = \$80,000$$

Earned value analysis enables the project manager and team to identify and analyze trends in cost performance, as well as variances that may require action to bring project results in line with what was planned. Earned value analysis also includes monitoring the use of contingency reserves to ensure the amount of reserves remaining is adequate. It may identify the need to request additional reserve funds through integrated change control.

The Control Costs process provides measurements that indicate how the work is progressing and allow the project manager to create reliable forecasts and take action to control the project. This process may result in requested changes to the cost management plan, performance measurement baseline, and other parts of the project management plan, recommended corrective or preventive actions, and updates to project documents.

## Practice Exam

1. One common way to compute estimate at completion (EAC) is to take the budget at completion (BAC) and:
  - A. Divide by SPI.
  - B. Multiply by SPI.
  - C. Multiply by CPI.
  - D. Divide by CPI.
2. The finance department requires that you keep them updated on the costs being spent on the capital project you are leading. You were required to submit a funding plan, and monthly forecasts are necessary so that any changes to the funding plan can be requested in advance and evaluated. Exceeding the budget limit is unacceptable, as it will impact the stock value. You have successfully implemented processes and practices to anticipate funding changes, and you evaluate them to minimize problems and increase the efficient use of funds. You have employed a variety of reporting and analysis techniques to meet the finance department requirements. One of them is EAC, which is a periodic evaluation of:
  - A. The cost of work completed
  - B. The value of work performed
  - C. The anticipated total cost at project completion
  - D. What it will cost to finish the project
3. If earned value (EV) = 350, actual cost (AC) = 400, and planned value (PV) = 325, what is the cost variance (CV)?
  - A. 350
  - B. -75
  - C. 400
  - D. -50
4. The customer responsible for overseeing your project asks you to provide a written cost estimate that is 30 percent higher than your estimate of the project's cost. He explains that the budgeting process requires managers to estimate pessimistically to ensure enough money is allocated for projects. What is the best way to handle this?
  - A. Add the 30 percent as a lump sum contingency fund to handle project risks.
  - B. Add the 30 percent to your cost estimate by spreading it evenly across all project activities.
  - C. Create one cost baseline for budget allocation and a second one for the actual project management plan.
  - D. Ask for information on risks that would cause your estimate to be too low.
5. You've recently been assigned to manage a marketing project to brand a sustainable development program. Even though you are just starting your efforts, the sponsors are concerned about the likelihood of reaching planned milestones during the project. They are wondering how you will go about estimating. Analogous estimating:
  - A. Uses bottom-up estimating techniques
  - B. Is used most frequently during project executing
  - C. Uses top-down estimating techniques
  - D. Calculates estimates using actual detailed historical costs

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6. You have been working with the subject matter experts to estimate the activity durations and costs on the project. All the following are outputs of the Estimate Costs process except:
  - A. An understanding of the cost risk in the work that has been estimated
  - B. The prevention of inappropriate changes from being included in the cost baseline
  - C. An indication of the range of possible costs for the project
  - D. Documentation of any assumptions made during the Estimate Costs process
7. The product your project team is working on is a replacement of a device the company launched a couple of years ago. That device did not meet market projections for sales, even though it was revolutionary in its capabilities. The reason it did not meet projections was that the life cycle costing was not fully considered and analyzed during the device development. When the original device was offered to the market, it had initial success until a trade publication analyzed the life cycle costs and determined they were unreasonably high. Sales lagged due to the negative reports. Internal tests showed that the trade publication was correct. This time the team is taking life cycle costs into consideration as they develop the product. The main focus of life cycle costing is to:
  - A. Estimate installation costs.
  - B. Estimate the cost of operations and maintenance.
  - C. Consider installation costs when planning the project costs.
  - D. Consider operations and maintenance costs in making project decisions.
8. You're managing a project to develop a new mobile application for the inventory-tracking-and-control system of a restaurant franchise organization. Schedule is the highest-priority constraint for the leadership team, but the franchise owners are most concerned about cost and the quality of the application. If there are bugs and errors in the system, they will pay higher costs on waste or lost sales. But investing a lot of effort into delivering great functionality could be expensive. It was decided that an adaptive approach to the project life cycle would likely be the best way to balance the competing priorities and deliver a working, cost-effective application. The franchise decision team has been meeting with the development team. The groups feel good about the project's progress, but they are hearing concerns from other stakeholders about what the impact will be to the bottom line and whether the system will be ready for launch. These concerns were anticipated in planning, and will be managed with cost performance measurement. Cost performance measurement is best done through which of the following?
  - A. Asking for a percent complete from each team member and reporting that in the monthly progress report
  - B. Calculating earned value, and using indexes and other calculations to report past performance and forecast future performance
  - C. Using the 50/50 rule, and making sure the life cycle cost is less than the project cost
  - D. Focusing on the amount expended last month and what will be expended the following month
9. A cost performance index (CPI) of 0.89 means:
  - A. At this time, we expect the total project to cost 89 percent more than planned.
  - B. When the project is completed, we will have spent 89 percent more than planned.
  - C. The project is progressing at 89 percent of the rate planned.
  - D. The project is getting 89 cents out of every dollar invested.

10. The team's attitude toward the project is very positive. They are excited about the research and development work they are doing. The value of the work completed today is \$60 million. The potential consumers from the product testing and focus groups have stated "the product will be amazing" and "they would absolutely buy it." The phase gate review board has received the reports and is asking for market projections and launch plans. They are wondering when this product can start returning value to the organization. The project is budgeted to cost \$77 million. The value of the work planned to be done to this point is \$78.9 million. What does the schedule performance index (SPI) for this project tell you?
- A. You are over budget.
  - B. You are ahead of schedule.
  - C. You are progressing at 76 percent of the rate originally planned.
  - D. You are progressing at 24 percent of the rate originally planned.
11. The project management team is busy breaking down deliverables, and the procurement department has started looking for possible sellers to help produce the deliverables. There are departmental concerns that the project could go over budget because the scope will be iterated and the planning and development will be done in increments. At a recent company gathering, the sponsor asked questions of the project manager and the project management staff team about how changes in scope will affect the estimates. The sponsor wanted to know how the project estimates could be relied upon, given that they were planning to iterate the scope. The project manager reassured them that the team has the right tools with which to provide accurate estimates, and will utilize the tools throughout the project. Which of the following is not needed in order to come up with a project estimate?
- A. A WBS
  - B. A network diagram
  - C. Risks
  - D. Change requests
12. Which of the following is an example of a parametric estimate?
- A. Dollars per module
  - B. Learning bend
  - C. Bottom-up
  - D. CPM
13. A rough order of magnitude (ROM) estimate is made during which project management process group?
- A. Planning
  - B. Closing
  - C. Executing
  - D. Initiating

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14. For each activity on your project, you have worked with designers, engineers, technical experts, and consultants to come up with details on the resources needed to complete the activity. For some of the activities the lists are quite long, as you need raw and finished materials, equipment, and people. You have a limited amount of warehousing available, so you have to coordinate the deliveries and work so that the materials and equipment are delivered as close to the start of an activity as possible. You and the project management team have identified the amount of time and money needed for each of the activities, which you have then aggregated and analyzed with their help. These efforts will eventually result in the creation of a cost baseline for the project. A senior manager is trying to better understand the work of project management and has asked which process produces the cost baseline. What is the correct response?
- A. Estimate Activity Resources
  - B. Estimate Costs
  - C. Determine Budget
  - D. Control Costs
15. During which project management process group are budget forecasts created?
- A. Monitoring and controlling
  - B. Planning
  - C. Initiating
  - D. Executing
16. Which type of cost is team training?
- A. Direct
  - B. NPV
  - C. Indirect
  - D. Fixed
17. Project setup costs are an example of:
- A. Variable costs
  - B. Fixed costs
  - C. Overhead costs
  - D. Opportunity costs
18. The quality efforts on the project have gone through some changes during the first four months of project work. Two processes in particular have undergone extensive change. The customer is happy with the work to date, but has heard that the competition is working on a similar product. The team has been asked to analyze and create options for the customer. Value analysis is performed to get:
- A. More value from the cost analysis
  - B. Management to buy into the project
  - C. The team to buy into the project
  - D. A less costly way of doing the same work
19. Which estimating method tends to be most costly for creating a project cost estimate?
- A. Bottom-up
  - B. Analogous
  - C. Parametric
  - D. 50/50

20. To gain a clear indication of how the project is progressing, the buyer expects periodic reporting that includes analysis of the work that has been accomplished according to plan, the dollars that have been spent and how they reflect the planned expenses, the accepted deliverables, and evaluation of the risk events that have occurred. Which of the following represents the estimated value of the work actually accomplished?
- A. Earned value (EV)
  - B. Planned value (PV)
  - C. Actual cost (AC)
  - D. Cost variance (CV)
21. Which of the following are all items included in the cost management plan?
- A. The level of accuracy needed for estimates, rules for measuring cost performance, and specifications for how duration estimates should be stated
  - B. Specifications for how estimates should be stated, rules for measuring cost performance, and the level of accuracy needed for estimates
  - C. Rules for measuring team performance, the level of accuracy needed for estimates, and specifications for how estimates should be stated
  - D. Specifications for how estimates should be stated, the level of risk needed for estimates, and rules for measuring cost performance
22. Your project has a medium amount of risk and is not very well defined. The sponsor hands you a project charter and asks you to confirm that the project can be completed within the project cost budget. What is the best method to handle this?
- A. Develop an estimate in the form of a range of possible results.
  - B. Ask the team members to help estimate the cost based on the project charter.
  - C. Based on the information you have, calculate a parametric estimate.
  - D. Provide an analogous estimate based on past history.
23. You are leading a project to introduce a new healthcare appointment scheduling application. As you are creating plans detailing how the team will respond to possible events that may impact the project, you and the team determine the amount of cost contingency reserve needed. The cost contingency reserve should be:
- A. Hidden to prevent management from disallowing the reserve
  - B. Added to each activity to provide the customer with a shorter critical path
  - C. Maintained by management to cover cost overruns
  - D. Added to the cost of the project to account for risks
24. You are having difficulty estimating the cost of a project. Which of the following best describes the most probable cause of your difficulty?
- A. Inadequate scope definition
  - B. Unavailability of desired resources
  - C. Lack of historical records from previous projects
  - D. Lack of company processes
25. Your cost forecast shows you will have a cost overrun at the end of the project. Which of the following should you do?
- A. Eliminate risks in estimates and reestimate.
  - B. Meet with the sponsor to find out what work can be done sooner.
  - C. Cut quality.
  - D. Decrease scope.

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26. Early in the life of your project, you are having a discussion with the sponsor about what estimating techniques should be used. You want a form of expert judgment, but the sponsor argues for analogous estimating. It would be best to:
  - A. Agree to analogous estimating, as it is a form of expert judgment.
  - B. Suggest life cycle costing as a compromise.
  - C. Determine why the sponsor wants such an accurate estimate.
  - D. Try to convince the sponsor to allow expert judgment because it is typically more accurate.
27. You have just completed the initiating processes of a small project and are moving into project planning when a project stakeholder asks you for the project's budget and cost baseline. What should you tell her?
  - A. The project budget can be found in the project charter, which has just been completed.
  - B. The project budget and baseline will not be finalized and accepted until the planning processes are completed.
  - C. The project management plan will not contain the project's budget and baseline; this is a small project.
  - D. It is impossible to complete an estimate before the project management plan is created.
28. The project manager is working with cost estimates in order to establish a baseline for measuring project performance. What process is this?
  - A. Cost Management
  - B. Estimate Costs
  - C. Determine Budget
  - D. Control Costs
29. Monitoring cost expended to date in order to detect variances from the plan occurs during:
  - A. The creation of the cost change control system
  - B. Recommending corrective actions
  - C. Updating the cost baseline
  - D. Project performance reviews
30. You're thinking through what approach will make it easiest for the team to take responsibility for providing work performance data for all aspects of the project. As part of this approach, you believe it will be helpful to make sure the team understands how and why the data will be analyzed. You explain to the team that the cost management plan contains a description of:
  - A. The project costs
  - B. How resources are allocated
  - C. The budgets and how they were calculated
  - D. The WBS level at which earned value will be calculated
31. A manufacturing project has a schedule performance index (SPI) of 0.89 and a cost performance index (CPI) of 0.91. Generally, what is the most likely explanation for why this occurred?
  - A. The scope was changed.
  - B. A supplier went out of business, and a new one needed to be found.
  - C. Additional equipment needed to be purchased.
  - D. A critical path activity took longer and needed more labor hours to complete.

32. Although the stakeholders thought there was enough money in the budget, halfway through the project the cost performance index (CPI) is 0.7. To determine the root cause, several stakeholders audit the project and discover the project cost budget was estimated analogously. Although the activity estimates add up to the project estimate, the stakeholders think something was missing in how the estimate was completed. Which of the following describes what was missing?
- A. Estimated costs should be used to measure CPI.
  - B. SPI should be used, not CPI.
  - C. Bottom-up estimating should have been used.
  - D. Past history was not taken into account.
33. In analyzing problems that have occurred during testing, the team discovered that cause-and-effect diagramming is helpful in identifying the best place to focus their efforts. Their coordination of the interrelationships of the deliverables has improved, and the team has discovered efficiencies that have been shared with other projects and the organization for process improvement. This has made a difference in how well the project is aligning to the performance measurement baseline. Stakeholders are anticipating that control efforts and reporting on future projects will be easier. Earned value analysis is the basis for:
- A. Performance reporting
  - B. Planning control
  - C. Ishikawa diagrams
  - D. Integrating the project components into a whole
34. The replacement of the inventory management and portion control system for an international restaurant chain has been prioritized as a key strategic objective for the organization. Stakeholders are very concerned about many aspects of the project. They have shared these concerns and ideas in workshops, focus groups, emails, and surveys. Identified risks are:
- A. An input to the Estimate Costs process
  - B. An output of the Estimate Costs process
  - C. Not related to the Estimate Costs process
  - D. Both an input to and an output of the Estimate Costs process
35. There is confusion among some of the stakeholders about how the cost forecasts will be calculated on the project. They also have concerns about whether enough money has been set aside to cover the cost of risk responses. You are planning to share information in the upcoming team meeting and in reports to stakeholders to clear up the confusion. You are referencing the stakeholder and communications management plans to determine how best to communicate with the stakeholders. You will explain that the difference between the cost baseline and the cost budget can be best described as:
- A. The management reserves
  - B. The contingency reserves
  - C. The project cost estimate
  - D. The cost account
36. You provide a project cost estimate for the project to the project sponsor. He is unhappy with the estimate, because he thinks the price should be lower. He asks you to cut 15 percent off the project estimate. What should you do?
- A. Start the project and constantly look for cost savings.
  - B. Tell all the team members to cut 15 percent from their estimates.
  - C. Inform the sponsor of the activities to be cut.
  - D. Add additional resources with low hourly rates.

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37. Cost risk means:

- A. There are risks that will cost the project money.
- B. The project is too risky from a cost perspective.
- C. There is a risk that project costs could go higher than planned.
- D. There is a risk that the cost of the project will be lower than planned.

38. A project manager is analyzing the project to find ways to decrease costs. It would be best if the project manager looks at:

- A. Variable costs and fixed costs
- B. Fixed costs and indirect costs
- C. Direct costs and variable costs
- D. Indirect costs and direct costs

## Answers

### 1. Answer D

**Explanation** The formula BAC/CPI is used to calculate EAC if no variances from the BAC have occurred or if you will continue at the same rate of spending (as calculated in your cumulative CPI).

### 2. Answer C

**Explanation** When you look at earned value, many of the terms have similar definitions. This could get you into trouble. EAC means the estimate at completion. What it will cost to finish the project is the definition of ETC, or estimate to complete.

### 3. Answer D

**Explanation** The formula is  $CV = EV - AC$ . Therefore,  $CV = 350 - 400$ , or  $CV = -50$ . PV is not a factor in this calculation.

### 4. Answer D

**Explanation** Presenting anything other than your original estimate (allocating more to the budget) is inaccurate and calls into question your competence and integrity as a project manager. The customer should list potential changes and risks related to your estimate. If the costs and risks are justified, you can ethically increase the budget.

### 5. Answer C

**Explanation** Analogous estimating is used most frequently during project initiating and planning, not project executing. Parametric estimating involves calculations based on historical records. Analogous estimating early in the project uses top-down estimating techniques.

### 6. Answer B

**Explanation** This question is asking, "When you finish estimating costs, what do you have?" Many people who do not realize that estimates should be in a range choose that option. Documentation of assumptions is included in the basis of estimates, which is an output of Estimate Costs. The prevention of inappropriate changes is more correctly part of the cost management plan and the change control system.

### 7. Answer D

**Explanation** Life cycle costing looks at operations and maintenance costs and balances them with the project costs to try to reduce the cost across the entire life of the product.

### 8. Answer B

**Explanation** Asking percent complete is not a best practice since it is usually a guess. If the easiest work is done first on a project, it can throw off any percentage calculations of work remaining. The life cycle cost cannot be lower than the project cost, as the life cycle cost includes the project cost. Focusing on the amount spent last month and what will be spent in the next month is often done by inexperienced project managers. Not only does this provide little information, but the data cannot be used to predict the future. Earned value analysis and other calculations is the best answer since this choice looks at the past and uses that information to estimate future costs.

### 9. Answer D

**Explanation** The CPI is less than one, so the situation is bad. The project is only getting 89 cents out of every dollar invested.

**10. Answer C**

**Explanation** This earned value question is asking you to calculate the schedule performance index (SPI) and interpret the results. The formula for SPI is EV/PV. The EV in this question is the estimated value of the work already completed, or \$60 million. The planned value, the estimated value of the work planned to be done is \$78.9 million. Therefore  $SPI = \$60/\$78.9 = 0.76$ . This tells you the project is progressing at 76 percent of the rate planned.

**11. Answer D**

**Explanation** You need the WBS to define the activities, the network diagram to see the dependencies, and the risks to determine contingencies. NOTE: These are high-level risks, not the detailed risks that are identified later in project planning. Change requests are not required to obtain estimates, although they could cause existing estimates to be adjusted. Without the other three choices, you cannot develop good estimates.

**12. Answer A**

**Explanation** Parametric estimates use a mathematical model to predict project cost or time.

**13. Answer D**

**Explanation** This estimate has a wide range. It is done during project initiating, when very little is known about the project.

**14. Answer C**

**Explanation** A cost baseline is an output of the Determine Budget process.

**15. Answer A**

**Explanation** Budget forecasts are an output of Control Costs, which is part of monitoring and controlling.

**16. Answer A**

**Explanation** You are training the team on skills required for the project. The cost is directly related to the project and is therefore a direct cost.

**17. Answer B**

**Explanation** Setup costs do not change as production on the project changes. Therefore, they are fixed costs.

**18. Answer D**

**Explanation** Value analysis seeks to decrease cost while maintaining the same scope.

**19. Answer A**

**Explanation** Because you need project details to estimate this way, the effort expended will be greater with bottom-up estimating.

**20. Answer A**

**Explanation** It can be confusing to differentiate earned value terms from each other. The estimated value of the work actually completed is the definition of EV, or earned value.

**21. Answer B**

**Explanation** Notice how one item in each of the incorrect options makes the entire choice incorrect. Duration estimates are created during schedule management, and measuring team performance is a part of resource management. There is no level of risk required for estimates. Specifications for how estimates should be stated, rules for measuring cost performance, and the level of accuracy needed for estimates are all parts of the cost management plan.

**22. Answer A**

**Explanation** With such limited information, it is best to estimate in a range. The range can be narrowed as planning progresses and risks are addressed.

**23. Answer D**

**Explanation** Hiding the reserve is an inappropriate action. Adding cost to each activity will not shorten the critical path, and is an incorrect statement. Management reserves, not contingency reserves, are maintained by management to cover cost overruns. During the risk management process, you determine appropriate contingency reserves to cover the cost of identified risks. These costs are included in the project cost baseline.

**24. Answer A**

**Explanation** Although all choices could cause difficulty, only inadequate scope definition makes estimating impossible.

**25. Answer A**

**Explanation** Look for the choice that would have the least negative impact on this situation. You would not need to meet with the sponsor to determine which work can be done sooner, and changing the order of activities is unlikely to eliminate the cost overrun. Cutting quality and decreasing scope always have negative effects. The choice with the least negative impact is to eliminate risks in estimates and reestimate.

**26. Answer A**

**Explanation** This is a tricky question. Determining why the sponsor wants such an accurate estimate sounds like a good idea at first. However, analogous estimates are less accurate than other forms of estimating, as they are prepared with a limited amount of detailed information. Reading every word of this choice helps eliminate it. To pick the best answer, you need to realize that analogous estimating is a form of expert judgment.

**27. Answer B**

**Explanation** The overall project budget may be included in the project charter but not the detailed costs. Even small projects should have a budget and schedule. It is not impossible to create a project budget before the project management plan is created. However, it is not wise to do so, as the budget will not be accurate. The project budget and baseline are not finalized and accepted until the planning processes are completed.

**28. Answer C**

**Explanation** Cost Management is too general. The estimates are already created in this situation, so the answer is not Estimate Costs. The answer is not Control Costs, because the baseline has not yet been created. The work described is the Determine Budget process.

**29. Answer D**

**Explanation** Recommending corrective actions and possible updates to the cost baseline result from project performance reviews; they are not concurrent with them. Monitoring costs is part of change control, but not part of creating the change control system. The correct choice is project performance reviews.

**30. Answer D**

**Explanation** The exam may ask you what the management plans include in order to test whether you really understand them. The cost management plan identifies the WBS level at which earned value will be calculated.

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### 31. Answer D

**Explanation** To answer this question, you must look for a choice that would take longer and cost more. Notice one of the choices says scope was changed, but that does not necessarily mean it was added to. If the change was to reduce the scope, it might also have reduced cost. Although it would take time to handle the issue of the need to find a new supplier, the impacted activity might not be on the critical path and might not affect time. Purchasing additional equipment definitely adds cost, but not necessarily time. A critical path activity taking longer and requiring more labor hours to complete would negatively affect both time and cost.

### 32. Answer C

**Explanation** Actual costs are used to measure CPI, and there is no reason to use SPI in this situation. Using past history is another way of saying “analogous.” The most detailed way to estimate is bottom-up. Such estimating would have improved the overall quality of the activity estimates.

### 33. Answer A

**Explanation** Earned value is a great way to communicate the value of work already accomplished. With it, you can show where you stand on budget and schedule, as well as provide forecasts for the rest of the project.

### 34. Answer D

**Explanation** Identified risks are listed in the risk register, an input to the Estimate Costs process. In completing the Estimate Costs process, additional risks may be uncovered. These are added to the risk register as project documents updates.

### 35. Answer A

**Explanation** The costs of activities are included in the project cost estimate, and the contingency reserves (to cover identified risks) are added to that to come up with the cost baseline. Thereafter, the management reserves (to cover unknown, or unidentified, risks) are added to come up with the cost budget. The management reserves make up the difference between the cost baseline and the cost budget.

### 36. Answer C

**Explanation** To answer the question, you must first realize that it is never appropriate for a project manager to just cut estimates across the board. You should have created a project estimate based on realistic work package estimates that do not include padding. Then, if costs must be decreased, you can look to cut quality, decrease risk, cut scope, or use cheaper resources (and at the same time closely monitor the impact of changes on the project schedule).

One of the worst things a project manager can do is to start a project knowing that the schedule or cost for the project is unrealistic. Did you notice the choice of adding additional resources? Even though they have lower hourly rates, that would add cost. Evaluating, looking for alternatives, and then reporting the impact of cost cutting to the sponsor is the best action to take.

### 37. Answer C

**Explanation** While it is true that risk will cost the project money, that is not the definition of cost risk. Stating that the project is too risky from a cost perspective assumes the risk is too great to do the project. Cost risk is the risk that project costs could go higher than planned.

### 38. Answer C

**Explanation** Direct costs are directly attributable to the project, and variable costs are costs that vary with the amount of work accomplished. It is best to look at decreasing these costs on the project.