9 Budget and Resources

Introduction

Do you create a budget for your projects? Do you have practical experience managing and controlling project budgets? 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 presented.

While managing cost (i.e., the project budget) the project manager is primarily concerned with estimating, and with earned value management (EVM). A subset of budget management is material resource management since resources cost money, so must be in the project budget. Cost management includes estimating and uses the same estimating techniques covered in the Schedule chapter. In this chapter we explain in detail the EVM content, which is also applicable to both schedule and cost.

Think About It. A project manager has to be able to think simultaneously about the big picture as well as the details. To think holistically, it's hard to think about cost without also considering scope and schedule. The team uses the project budget and schedule to build the project scope. Many of the same estimating and EVM methods are used for cost management as well as schedule management. Earned value analysis is all about how much of the project's schedule and budget have been used to build the scope as compared to what was planned to be built and spent at a certain point in time.

If you recall, a plan-driven project decomposes the product and project management work into work packages, the artifact of which is the WBS ("Scope" chapter). The activities to build the work packages are then sequenced into a schedule network diagram ("Schedule" chapter) where activity duration estimates are placed. In this chapter, we'll discuss how cost is estimated based on those activities.

Agile teams have a fixed cost and time so budgeting is more straightforward. For agile projects the work is also decomposed, but remember it is kept track of in a backlog. A product backlog is somewhat analogous to a WBS in this context because it should include everything in the project. The backlog is broken down from the feature level to the story level, and then each story may be broken into tasks. Here the (agile) use of the word "task" is analogous to "activity" in plan-driven projects. In either case the work is being broken down so it can be easily understood, estimated, and assigned to resources. On exam questions, look for the appropriate context so you can identify the correct answer.

Definitions Related to Budget and Resource Management

Here is the budget-related vocabulary you will want to be sure you know for reading this chapter and for the exam. Vocabulary related to specific EVM metrics will be discussed in the Earned Value Management section later in this chapter.

Earned Value (EV)

EV is a metric that gives the estimated value of the work that has actually been completed on the project to date. A project manager uses EV along with other metrics in earned value analysis to determine how well the project is doing compared to its performance measurement baseline (the scope, schedule, and cost baselines).

QUICKTEST

- Cost Management process
- Earned value (EV)
- Earned value analysis (EVA)
- Earned value management (EVM)
- Cost management plan
- Types of cost
  - Variable
  - Fixed
  - Direct
  - Indirect
- Top-down estimating
- Bottom-up estimating
- Estimate ranges
  - Rough order of magnitude (ROM)
  - Budget
  - Definitive
- Basis of estimates
- Adaptive estimating
- Cost aggregation
- Burn rate
- Progress reports
- Reserve analysis
- Earned value terms
  - PV
  - SV
  - AC
  - BAC
  - EAC
  - ETC
  - VAC
- Formulas for earned value analysis

Earned Value Analysis (EVA)

This is an analysis method that uses earned value and other metrics to evaluate how well the project is doing relative to what was planned to date. The previous CV example is one measure, but schedule variance (SV) can also be measured, and together with other measures the project manager can determine the overall project performance against the performance measurement baseline.

Earned Value Management (EVM)

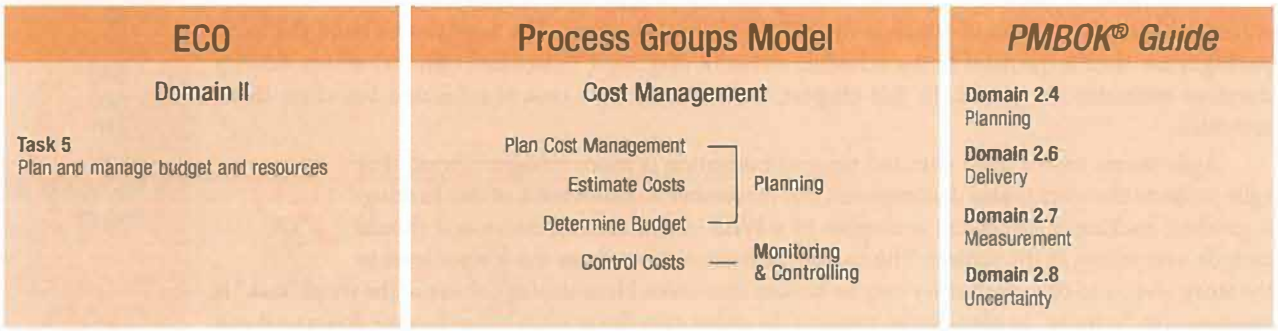
EVM is the practice of managing scope, schedule, and cost using earned value analysis to control the project. The results of earned value management tell the project manager what changes, if any, are needed to complete all the project's scope on time and within budget. Agile projects use earned value management with the qualification that some of the least critical scope stories may be put off to another release or a later project to meet cost and time constraints. Anywhere along the spectrum of development approaches, agreed quality requirements must be met.

Cost Management Overview

As you have come to expect, we will use PMI's Process Groups model to help you understand the overall Cost Management process.

The *Examination Content Outline* and Process Groups Model

Below you will see how in the *Examination Content Outline* (ECO), the single budget and resources management task maps to the Cost Management process in the Process Groups model. Like with scope and schedule management, the Process Groups model has processes related to Planning and Monitoring and Control, but not to executing. This is because the team does the work of spending time and budgetary resources to build the scope of the product while the project manager monitors and controls that work—equivalent to the "manage" part of "Plan and manage budget and resources" in the ECO Process domain.



Think About It. Estimating is initially done during planning, and EVM is used to control costs (and possibly resources and procurement) throughout the project. As you manage costs you will also:

- Manage conflict and negotiate project agreements (domain I, tasks 1 and 8)
- Promote team performance through training and the use of emotional intelligence (domain I, tasks 5 and 14).

These all support value-driven delivery and cost savings. What can you add to this list of interactions between processes and ECO tasks? Practice thinking holistically by scanning the ECO for other tasks that work in unison with these. Think about how decisions around financial resources might affect project risks and other project constraints. These decisions influence how the project is planned across all constraints 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.

Figure 9.1 can help you visualize the cost management process from the Process Groups model perspective, which can help you understand, in general, cost management no matter a project's development approach. Take time to review it before moving on to the rest of this chapter.

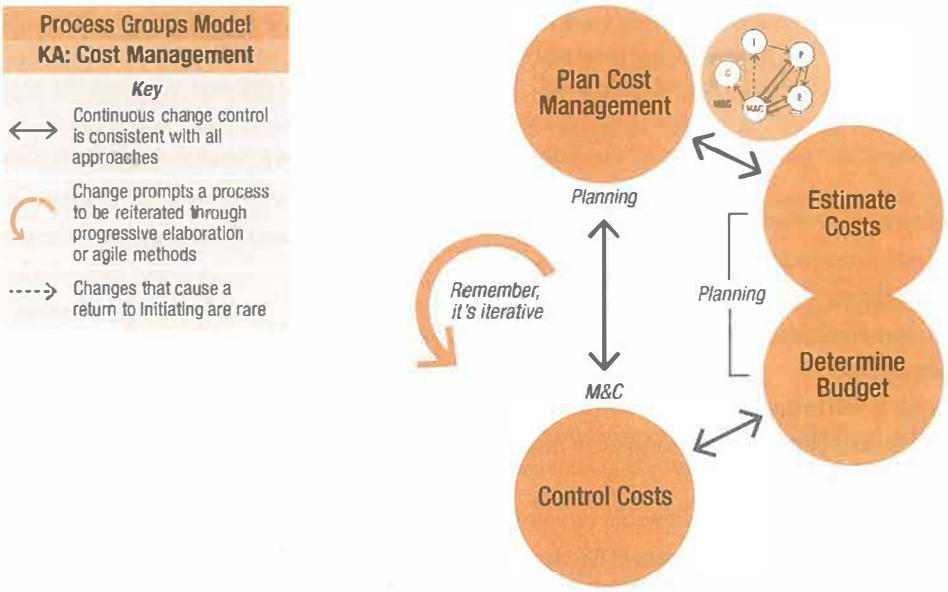


FIGURE 9.1 *Cost management process*

Desired Outcomes From Successful Budget and Resources Management

Assume for the exam that project budget and resources are properly planned and managed unless information in an exam question indicates otherwise. This means that the following outcomes should be expected as a result of successful communications management:

- Budget strategies on the project are planned and executed according to the needs of the project. This results in few or no problems that cause the need to increase the budget baseline. Risk planning helps with this goal because most risks will have planned contingency plans and budgets built into the project budget.
- Good servant leadership in the management of the team should have the outcome that the project has on it a qualified, motivated, and high-functioning team. This team will have the support and training needed to build and deliver the project's deliverables at the appropriate levels of quality and within the project budget.

Plan and Estimate Project Costs

Besides having a plan for how costs will be managed, the project manager also needs to estimate costs and determine the budget. The Plan Cost Management process involves answering questions such as, "How will I go about planning cost for the project and who needs to be involved?" and "How will I effectively manage the project to the cost baseline and manage variances?"

The project charter includes the high-level cost constraint and other available 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.

Process Groups Model
PG: Planning
Process: Plan Cost Management; Estimate Costs

ECO
Domain II
Task 5 Plan & manage budget/resources

PMBOK® Guide
Domain 2.4 Planning
Domain 2.8 Uncertainty

Plan Cost Management

In some organizations, cost planning may 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. As the project manager gets detailed estimates and develops the budget, calculations are used that were created for project selection (covered in the "Foundations" chapter), like net present value (NPV), return on investment (ROI), payback period, and discounted cash flow. With these the project manager evaluates whether the project is still feasible within the charter and whether the measurable project objectives can be achieved.

The cost management plan can be formal or informal, but it is part of the project management plan. It may include the following:

- Specifications for how estimates should be stated (in what currency)
- Levels of estimate precision needed
- Approved estimating techniques
- Roles and responsibilities for various cost activities (e.g., estimating, tracking, reporting)
- Reporting formats
- Whether costs will include indirect costs (not directly attributable to one project, like overhead)
- Guidelines for establishing a cost baseline to measure against
- Methods for documenting costs
- Control thresholds (amount of allowable variation before the project manager needs to act)
- Rules for measuring cost performance
- Cost change control procedures
- Information on control accounts or other ways to monitor spending
- Funding decisions
- Guidelines for dealing with potential fluctuations in resource costs and exchange rates

Estimate Costs

The process of estimating project costs involves estimating individual components and then aggregating all estimates into a time-phased spending plan (detailed next in Determine Budget).

Think About It. In the "Schedule" chapter there is a checklist called "Things to Know about Estimating for the Exam" on page 197. Take some time now to review that list since it applies to estimating schedule and cost. It is helpful to have those concepts fresh in your mind before continuing.

So what costs should be estimated? In addition to labor and material resources and training for the project, the project manager also estimates the following:

- Labor costs for all project activities or tasks
- Material resources to complete activities or tasks
- Training
- Quality efforts
- Risk efforts
- Project management activities
- Physical spaces used directly for the project
- Overhead costs, as applicable (those indirect costs like management salaries and general office expenses)

Types of Cost

In the past, the exam has included questions regarding types of cost. A cost can be either variable or fixed, direct or indirect—and these two pairs are not mutually exclusive. For example, there can be both direct variable costs and direct fixed costs.

- **Variable costs** These change with the amount of production work.
  Examples Materials, supplies, wages.
- **Fixed costs** These do not change as production changes.
  Examples Rent, utilities.

- **Direct costs** These are directly attributable to work on the project.
  Examples Team wages, training, travel and recognition expenses; project materials costs.
- **Indirect costs** These are overhead costs incurred for the benefit of more than one project.
  Examples Taxes, fringe benefits, janitorial services.

Artifacts Needed to Estimate Costs

We all would agree we'd want our estimates to be as accurate as possible. Where is the first place you would look for help with this? Previous, similar projects! Imagine having a repository of all the previous WBSs for similar projects, 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 projects? Other historical project artifacts include:

- Resource requirements documentation
- Cost and quality management plans
- Scope and schedule baselines
- Lessons learned and risk registers
- Policies and historical records related to estimating
- Templates and processes including those from past projects
- Corporate governance
- Marketplace conditions, commercial cost databases, exchange rates, inflation, and supply sources

Estimating Methods and Accuracy

As described in the "Schedule" chapter, estimates should be created from ranges as it is very unlikely an activity's completion will result in a single, exact estimated time or cost. Estimating is done using common methods like analogous, parametric, and three-point estimating.

Think About It. From a general perspective, these methods fall into the top-down or bottom-up categories. For example, say someone walks into your office and asks you to estimate the total cost of a new project. The first question you may ask is, "How accurate do you want me to be?" Early in the project during initiating, estimates are top-down, high-level estimates. Over time, as you break down project deliverables during planning, you narrow the estimate range as you do bottom-up estimating.

Top-down and bottom-up estimating each have the following advantages and disadvantages:

Top-Down (Analogous) Estimating	
Advantages	**Disadvantages**
• Quick • Activities do not need to be identified • Less costly to create • In initiating, provides cost constraints to evaluate high-level project feasibility • Overall project costs can be capped for this type of estimate	• Low accuracy level • Reflects limited information about the project or key deliverables • Requires considerable experience to do well • Conflicts to gain budget priorities may not have the data able to justify the need • Difficult for projects with uncertainty or without similar projects to reference • Does not consider differences between projects

Bottom-up Estimating	
Advantages	**Disadvantages**
• Based on detailed project and deliverable analyses • More accurate (at the activity or task level) • Gains buy-in from the team because the team helps creates the estimates • Provides a basis for control and management	• Requires that the project be well defined and understood • Requires effort to break project deliverables into smaller pieces • Takes relatively more time and money • Risk of padded estimates unless the team understands the use of reserves

Estimate Ranges The standard estimate range types are order of magnitude, budget, and definitive. Using each implies a particular level of accuracy. These are discussed below:

- **Rough order of magnitude (ROM) estimate** Usually made during initiating, a typical range for ROM estimates is −25 to +75 percent. It varies depending on how much is known about the project.
- **Budget estimate** A refinement from a ROM estimate, a budget estimate is typically in the range of −10 to +25 percent. The range is narrowed from ROM before reiterating the budget.
- **Definitive estimate** As planning progresses, the estimate should become even more refined. Some project managers use the range of +/−10 percent, while others use −5 to +10 percent, and this may depend on what management requires.

TRICKS OF THE TRADE® What you see here may be different from your experience. For the exam, make sure you understand estimating in ranges and that estimates become more refined as project planning progresses. Remember that organizations have different rules for the acceptable estimate range for an activity or the project. 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.

Example "$1,000,000 (−5 to +10 percent)."

Human and Material Resource Cost Rates

It may seem obvious that resource costs involve estimating the work of consultants, sellers, and suppliers. Although many project managers do not have access to this information on their projects, the exam assumes a project manager also uses the actual cost of internal human resources when performing cost estimating.

Estimating Costs: Final Notes

Spreadsheets and software within the PMIS can speed up calculation and analysis and integrate finance and accounting. Quality, risk, and scheduling tools are useful here as well. Alternatives analysis, reserve analysis, and decision making (all discussed in the "Schedule" chapter) may also be used as part of the Estimate Costs process.

The Estimate Costs process results in cost estimates and the basis of the estimates (an explanation of how the estimates were derived). It can also result in project document updates, such as the risk register, assumption log, and lessons learned register.

Once the project manager has completed estimating costs they have the costs for each work package or story based on the activities needed to build them, the documentation on the basis of estimates (what are their assumptions, etc), and other project artifact updates like those to the assumption log and the lessons learned and risk registers.

Determine Budget

The project manager aggregates the total estimated costs (including estimated risk reserves) for the project to determine the cost baseline. An approved budget includes that baseline plus a management reserve (more on reserves in the "Risks and Issues" chapter). The traditional project's cost baseline is a measure of project success. The project manager uses it to control costs while the project work is being done.

The project manager also revisits the feasibility of the project in determining the budget during planning. They review the business case and the benefits management plan. The business case may be expressed in financial terms such as expected return on investment (ROI). The benefits management plan can be used to compare the estimated budget to the business value the project is supposed to bring to the organization and its stakeholders.

Process Groups Model
PG: Planning
Process: Determine Budget

ECO
Domain II
Task 5 Plan & manage budget/resources

PMBOK® Guide
Domain 2.4 Planning

Let's review the planning process as it culminates in getting to this point with the project's cost baseline. Here the project manager has done the following:

- In initiating, incorporated the information provided (through top-down estimating) into a project charter, which became a basis for planning since planning and executing must remain true to the project charter.
- Determined the project scope—both what is and what is not included in the project. This becomes the scope baseline.
- Decomposed product scope into deliverables and then smaller, more manageable pieces (like activities or tasks) for the purpose of estimating, assigning resources, and building that scope.
- Estimated time and costs for each of the product scope components.
- Calculated the aggregate costs for the project using the estimates for each of the product scope components (bottom-up estimating).
- Assigned time estimates to each activity along a network diagram to help establish the project's critical path and the project schedule baseline.

To finish the budget the project manager will include estimated risk reserves (included in the cost baseline) and management reserves (part of the budget but not the cost baseline; see figure 9.2).

Future Performance Measurement

Once risk planning is included (see the "Risk and Issues" chapter), the project manager has the project's performance measurement baseline: the scope, schedule, and cost baselines. We cover performance measurement in more detail in the following Control Costs section of this chapter.

Adaptive Estimating Methods

On adaptive projects the team breaks down scope using t-shirt sizing, affinity estimating, and Planning Poker®. The team uses story maps to plan releases. Refer to the "Schedule" chapter for a review of these concepts. A story map is analogous to a network diagram, but do not take the analogy too far. The resulting schedules and budgets approved for traditional projects are thought to be more fixed, where a release map is meant to give a general idea of how the product releases will unfold. Agile projects do tend to fix cost and time while varying scope, but if a customer decides to drop some features as the product is developed during early releases, this will inevitably affect the project's costs. Adaptive teams also use retrospectives to determine the accuracy of budget estimates and whether budget adjustments should be made.

Artifacts of Determine Budget

Two artifacts of Estimate Costs—cost estimates and the basis of estimates—are essential inputs to the Determine Budget process. Many of the inputs to Estimate Costs are used here as well:

- Cost management plan
- Scope baseline
- Project schedule model
- Risk register
- Existing policies on cost control and cost budgeting
- Resource requirements documentation (for example, for how long and at what rates for particular resources)
- Agreements (regarding the purchase of services or products for the project)

Aggregating Costs into a Budget

To prepare the budget for approval, the project manager needs to do what's called cost aggregation. To do this, they would pull together the costs of all activities—including risk management activities, which go into the budget as risk reserves (covered in the "Risk" chapter).

Think About It. Review the following list and follow along with the Figure 9.2. Read the figure from the bottom up as you think about the items in this list:

1. **Activity estimates** are rolled up into work package estimates (see #2).
2. **Work package estimates** are rolled up to control account estimates (see #3).
3. **Control account estimates** track entities that cost will be assigned to (and do not affect totals).
4. **Project estimates** is a total for the budget, to this point.
5. **Contingency reserves** are established during risk planning. When added here, contingency reserves determine the cost baseline (#6).
6. **Cost baseline** An estimated total cost performance measurement baseline.
7. **Management reserves** are added in the final step.
8. **Cost budget** is a total that includes the cost baseline + management reserves.

Notes: 1) Estimated costs and reserves are shown aggregated at the cost budget level and depicted in figure 9.2, but remember contingency reserves are added at the activity level and work package levels initially during planning for risk management. 2) It is the management reserve (covered in the "Risk" chapter) that makes the difference between the cost baseline and the budget.

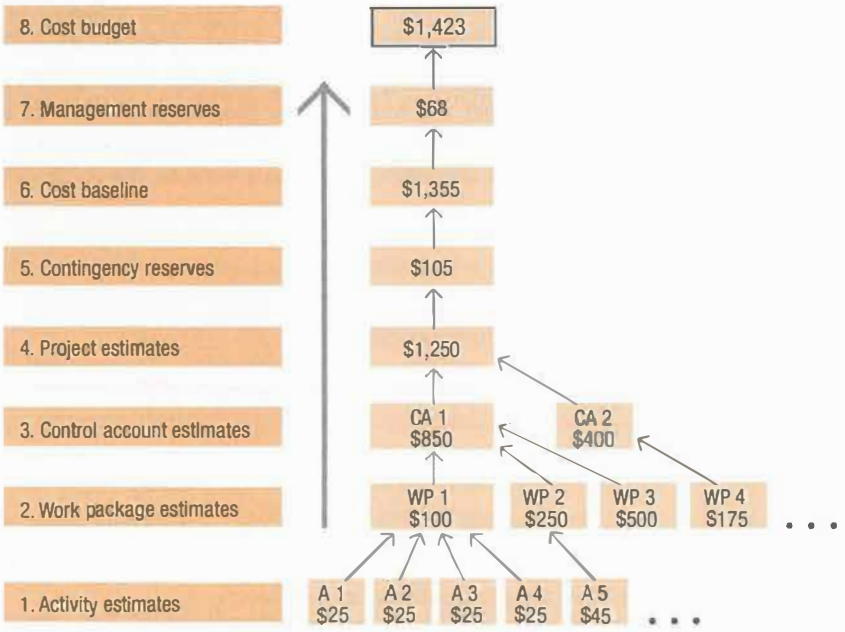


FIGURE 9.2 *Aggregating costs to create a budget*

After the cost baseline and budget are estimated, the project manager may compare these numbers to parametric estimates or to expert judgment, or perform an 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.

Cash Flow, Financing, and Budget Reconciliation

For the exam, a well-planned, approved budget assumes that the project manager has worked with the performing organization's finance department to ensure that cash flow planning for the organization will include expenditures for the project just when they are needed. The cost baseline, therefore, is time-phased.

Example 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.

Burn rate on agile projects Are you familiar with the term "burn rate"? It is a common business metric referring to the rate at which an entity—in this case an agile team—is using (or losing) money. You may remember that on adaptive projects, teams are often stable and consistent because more value is placed on retaining project knowledge and keeping together a team that has already developed its high-performance capabilities. One advantage of stable teams is that there are consistent burn rates and simplified cost estimating. As discussed in the "Schedule" chapter, agile teams use velocity to help create a project schedule based on story point estimates. Velocity can help anticipate future budgetary issues as well.

Think About It. A team is averaging 50 story points per month and there are 500 story points left in the backlog. They would need 10 more months to complete the project. If their salary burn rate is $45,000 per month, can you estimate the cost for the 10 months?

It is **10 x $45,000 = $450,000**. Knowing this, you can look at the budget and decide if you have correctly estimated a budget for 10 more months of the team's monthly salary burn rate.

Checking with the Project Charter

The project budget must be reconciled with any cost constraints in the charter. If the project estimate exceeds these constraints, the project manager must meet with the sponsor, explain why their cost requirement cannot be met, and propose options to decrease costs. If that cannot be done, the project's budget baseline must be increased. Pay particular attention to these last two sentences. As with the schedule, project managers have a professional responsibility to reconcile the budget in this way.

When the Determine Budget process is complete, the cost baseline, including all funding requirements, is established. Naturally, many of the inputs to the process will be updated, for example the cost estimates, the risk register, and the project schedule.

Control Costs

Once the project cost measurement baseline and budget are complete, the project manager will need to continuously look for anything that affects that baseline even if it can cause the project to be terminated. Start this section by completing the following exercise and imagine how this would apply to real-world projects.

Think of yourself as a detective looking for anything that can get in the way of project success. This mindset will help you select the best choice when answering questions on the exam that may seem to have more than one correct answer.

Process Groups Model
PG: Monitoring and Controlling
Process: Control Costs

ECO
Domain II
Task 5 Plan & manage budget/resources

PMBOK® Guide
Domain 2.6 Delivery Performance
Domain 2.7 Measurement
Domain 2.8 Uncertainty

9.1 Exercise

This is an important topic so be sure to take your time to think this through. In your Exercise Notebook, list the actions a project manager may take to control costs.

Answer

- Follow the cost management plan for how to control costs
- Tailor control activities to the needs of the project
- Consider policies, procedures, tools, and reporting templates and formats related to controlling costs (selected from organizational process assets during planning)
- Measure project performance and compare it against the plan
- Determine if variances require change, including preventive and corrective action
- Request changes
- Implement approved changes
- Prevent unnecessary changes
- Look for the root cause of factors causing costs to rise
- Conduct earned value measurement
- Conduct reserve analysis (related to risk)
- Aggregate data, analyze it, and produce reports

Managing Change

Controlling costs is an important responsibility for project managers, but you must also understand and plan for potential budget variations. No matter how well the project manager plans in a predictive environment, change is inevitable. In adaptive environments changes to scope are more frequent so agile teams have built in methods to handle changes throughout the project and meanwhile try to preserve the original budget if possible. Change management is covered in more detail in the "Integration" chapter. In any case, it should go without saying that changes to the cost baseline must be made formally with approval.

Think About It. Your team worked overtime to complete a new feature for an upcoming sponsor demo. While the new feature was completed on time, the overtime work means your monthly budget goal for payroll will be missed. As the project manager, you weighed the value of this through an analysis of benefits and costs. The benefit outweighed the cost, so you approved the overtime. You need to revisit this decision when forecasting the future of the project. Was this month's higher payroll atypical or has your team consistently needed overtime hours to complete the necessary work? Should you adjust the budget for future months or adjust the schedule to avoid unnecessary overtime?

There can be many unplanned scenarios that impact the project budget, and additional costs may be unavoidable. As the project manager, you should look for these situations, anticipate the potential risks, and plan ahead. You will never be able to foresee everything, but if you try to imagine the unplanned costs on your project, you will have a much easier time planning and managing a realistic budget.

Progress Reporting

Through earned value measurement, the project manager analyzes data about project progress to help control the schedule and costs and to assess whether the project is on track (described later in this section). Progress reports convey information based on this data analysis method. Asking team members for percent complete of their deliverables may be used by some project managers but this does not convey a realistic estimate of progress. They can carefully track progress using percent complete at the work package or story level but the cost and schedule estimates for the work package or story should also be factored in.

In terms of data gathering, an often-cited metric on traditional projects is that 80 hours is a small enough work increment to track progress against and still have accurate data. For the exam, remember that traditional projects using proper project management make use of a WBS, and activities to produce work packages are broken down to an appropriate level for controlling.

On agile projects, data gathering and analysis will be centered around the backlog and how many features have been developed to date relative to what was planned. Story points by iteration are tracked for the team's use and burnup and burndown charts are used for both the team and other stakeholders. Review these types of reports in figure 6.6 in the "Build and Support Team Performance" chapter.

Reserve Analysis

Remember the *contingency reserves* that get factored into the cost baseline to address known risks? Reserve analysis allows you to identify and apply lessons learned in controlling costs. Part of cost control is analyzing where contingency reserves are still necessary or where new reserves are required. Both of the following examples would require a formally approved change request.

Example A project team identifies a highly ranked risk and sets aside a contingency reserve to address it. If the risk does not occur and is no longer a threat, the contingency reserve can be removed from the cost baseline.

Example A risk review on a project identifies new risks, which could lead to a decision to increase the contingency reserves.

Think About it. A formally approved change request is also required to move *management reserve* funds into the cost baseline for a similar purpose. It may also be necessary to reassess the amount of management reserve that was set aside to address unknown risks. This difference between contingency reserves (for identified risks) and management reserves (for unknown risks) is an important distinction that can help you get more questions right on the exam. We have mentioned this distinction earlier in this chapter and discuss it again in the "Risks and Issues" chapter.

Earned Value Management

As a project manager, you manage project performance and you account for that performance to stakeholders by comparing planned to actual results. This is the essence of earned value management, which includes earned value analysis. Earned value analysis is a data analysis method used to evaluate project performance against the entire performance measurement baseline (the scope, schedule, and cost baselines). Earned value analysis results indicate whether there are any potential deviations from the performance measurement baseline.

Earned value analysis can be used to forecast future performance and project completion dates and costs. This information is conveyed to stakeholders through reports in meetings and other communication methods.

Formulas for Earned Value Analysis

As of this book's publication, very few questions on the exam contain formulas. Nevertheless, you should go through this section carefully. Even if you get few or no formula questions, earned value analysis is on the exam and understanding this content will help you get those questions right. Of course, memorizing the formulas we specify in this section will help you with questions requiring you to calculate formulas, even if there are not many.

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? Keep the benefits of the earned value analysis method in mind as you read this section.

Think About It: 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?

Think About It: 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.

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 (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? \$_____.
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.*	AC + 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 (TCPI)	$\frac{(BAC - EV)}{(BAC - AC)}$	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 one is good.
Estimate to complete (ETC)		How much more will the project cost?
NOTE: *You can determine ETC by either using the formula listed here 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?

TRICKS OF THE TRADE

The following should help solidify your understanding about CV, SV, CPI, and SPI:

- **EV comes first** in each of these formulas.
- 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 😀.

  Example A –200 cost variance means you spent more than planned ☹ (are 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.

Understanding Earned Value Terminology

People often incorrectly answer exam questions requiring them to simply interpret earned value terms without having to calculate formulas. This section is an opportunity to help you get those questions right.

Think About it. Sometimes thinking about things in a different way can give you that "aha" moment when everything falls into place. Think about the following bulleted lists and figure 9.3. Together they illustrate the terminology to help you see it from another angle. Then, if you are still uncomfortable with earned value concepts put it aside for now. However, come back another day and review all the content from the "Earned Value Management" section of this book. Sometimes new information takes a bit of extra effort and this area is certainly in that category for many students.

Planned value (PV) and actual cost (AC) look backward at what has been done on the project:

- **PV**: What is the expected value of work done at this point in the project (according to the plan)?
- **AC**: What has the actual cost been on the project to this point?

Budget at completion (BAC), estimate to complete (ETC), and estimate at completion (EAC) look forward at the project:

- **BAC** refers to the project's currently approved budget. It is a known quantity indicating 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 been done on the project, considering 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.

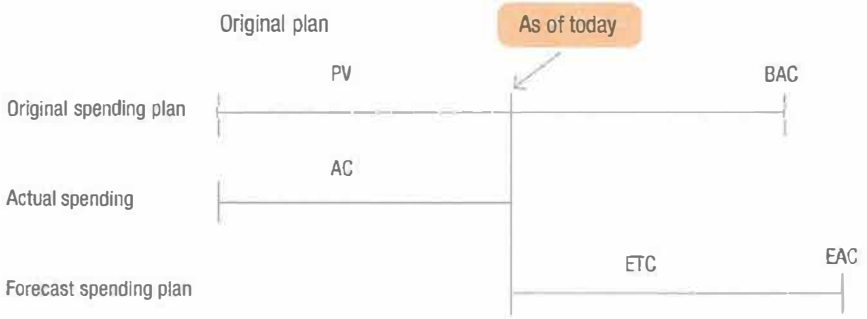


FIGURE 9.3 *Earned value concepts by looking backward and forward on a project*

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 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 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 looks at the network specialist and says, "It would sadden me to lose you, and your suggestion would improve costs but not schedule. You are the company's best network specialist. Someone else would not be as proficient as you in completing the work." To the IT coordinator's suggestion, the project manager responds that canceling the new computers would save money but not time. "Let's focus on time."

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.

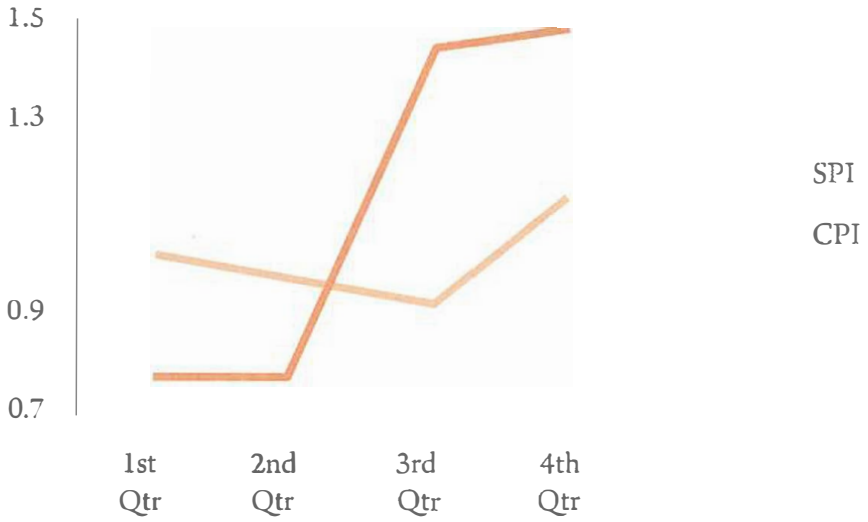
The project manager says, "That sounds like the most effective choice in this situation. Let's see if we can find someone who will improve performance, at the lowest cost. Thanks for your help."

Earned Value Analysis Practice

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.

9.2 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, would you be more concerned about cost or schedule if you were taking over this project from another project manager? Write the answer in your Exercise Notebook.



Answer

You should be more concerned about schedule. The data in the chart is historical. 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. 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.

9.3 The Fence Exercise

You have a project to build a new fence. The fence has four sides equal in length. 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 information in the project status chart, calculate the following in your Exercise Notebook. Interpretation is important on the exam. Can you interpret what each answer means?

1. PV=	5. CV=	9. EAC=
2. EV=	6. CPI=	10. ETC=
3. AC=	7. SV=	11. VAC=
4. BAC=	8. SPI=	

Project Status Chart

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

Answer: The Fence Exercise

	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.

Understanding the meaning of earned value analysis calculations is as important as knowing how to calculate them. Expect questions on the exam such as:

Example "The CPI is 0.9, and the SPI is 0.92. What should you do?"

The data show the project as both over budget and behind schedule ☹. You need to interpret this and other data in the question and then determine which choice would address the issue(s) described.

9.4 Exercise

What is the SPI if the CV is $10,000, the SV is –$3,000, and the PV is $100,000? Write the answer in your Exercise Notebook.

Answer

To find the SPI here, you need to perform two calculations. 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.

Reverse formula: EV = SV + PV.

EV = -$3,000 + $100,000 = $97,000.

Now we can plug the PV and EV into the SPI formula as follows:

SPI = EV/PB = $97000/$100,000 = .97

9.5 Exercise

What is the AC if the CV is $10,000 and the EV is $97,000? Write the answer in your Exercise Notebook.

Answer

Answer. The CV is $10,000 and the EV is $97,000. With this information, we can determine the AC by using the formula CV = EV – AC. We first plug the information we know into the formula.	Known 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

Summary: Earned Value Analysis and Managing Costs

Whew! You made it. In summary, earned value analysis enables the project manager and team to identify and analyze trends in performance and variances. The information gleaned from earned value analysis allows the project manager and team to know how the project is performing at a given point in time and to report on this performance and also provide forecasts for the future of the project. Indications may require action to bring the project in line with what was planned, or formally approved changes to the performance measurement baseline, which may require additional funds for the project.

Control Costs also includes monitoring the use of contingency reserves to ensure the amount of reserves remaining is adequate.

Putting It All Together

Did you recognize the estimating tools that were also used in the "Schedule" chapter? The project manager uses estimating tools to create the budget for the project. Remember that meeting the cost baseline will be a measure of project success, so the budget should be in a form the project manager can use to control costs while the work is being done. During Monitoring and Controlling, the project manager uses earned value measurement to measure project performance against the performance measurement baseline.

For the exam, make sure you understand the difference between the different types of reserves (contingency vs. management). You may get 1-3 questions on the exam that require you to use a formula. It's best if you at least know formulas for SV, CV, CPI, and SPI, and understand what those formulas are measuring.

Revisit the Quicktest at the beginning of this chapter. Do you still have gaps in your knowledge? Go through the chapter again to review the areas you are still unsure about. Then complete the following chapter review.

9.6 Exercise

Read the following case study and review the table to see some examples of what the project manager will do during each of the Cost Management processes.

The city council reviewed a high-level recommendation for the new library (considered the charter for this project). The project manager (PM) reviews the recommendation to plan and develop a more detailed cost estimate along with a schedule.

- The (PM) knows that talking with the architect and construction team leader will help formulate cost estimates.
- Understanding the size and interest rate of the debt will factor into needed funds and scheduling urgency.
- Talking with the mayor will determine how and when to effectively report progress against the budget as the mayor will have final signoff on the budget.
- The PM will ask for clarity on spending authorizations and change orders.
- Reviewing results from the city's last building project will provide insights into costs, risks, and potential resources.
- The city manager will help with reviewing and controlling the budget, as this manager will be responsible for project procurement.
- To track costs, the PM will use the city's financial reporting system, recording all expenditures within a month of their paid dates.
- The PM will create monthly financial reports of expenditures and earned value.
- Any unexpected costs or change orders, over the city authorization policy covering the PM, must be approved by the city manager or mayor.

Cost Process	Examples of the PM's work
Plan cost management	• Plan to talk with architect and head of construction about costs • Plan to talk with major about frequency of reporting expenditures • Review the lessons learned from the prior city building project • Review the expected debt amount with associated interest payments • Learn about PM's authority for expenditures and changes to budget • Get access to city financial system
Estimate costs	• Talk with involved stakeholders; review price estimates of needed resources • Get estimates for several completion dates to compare the time vs. cost considerations
Determine budget	• Present two different budget options to the city council for approval, answer questions as needed. • After council budget selection, prepare the final budget and schedule for the city manager to review. Adjust as needed and get signoff.
Control costs	• Enter expenditures into city financial system within one month of payments. • Monthly reporting of total expenditures, including earned value analysis. • Extra expenditures over PM authorization must be approved by mayor or manager.

9.7 Exercise

This exercise uses agile processes for the library case study. Read the scenario below and then complete the exercise by writing down the meanings of the given terms. Look up any terms for which you do not know the meaning, and do write them down. Writing them will help you learn them better than just reading them will.

For the first set of releases, a team of 5 product developers will be assigned for a period of 6 months (besides the product owner and project manager). Their goal will be to offer as many features to library patrons as can be released in 6 months, based on the product owner's (head librarian's) priority and other stakeholder feedback.

- The team will work in two-week iterations with releases every quarter.
- The PM will track team velocity and report which features patrons value most, compared with the time required to create them.
- At the end of the 6 months, the PM will present accomplishments to management along with the product owner's recommendation for next steps.

Hands-on: Define the following terms, either here or in your Exercise Notebook.

Term	Definition
Release	
Feature	
Product Owner	
Iteration	
Velocity	

Answer

The wording of your answers may not match these exactly, but should be substantively the same.

Term	Definition
Release	A version of the product that is useful to the user and that can be delivered
Feature	A particular, defined aspect of the product that is useful to the user.
Product Owner	The person who decides on the priority of feature development based on expected value to users and cost and time to complete.
Iteration	A timebox used to complete work on a product (for example, a "two-week iteration").
Velocity	A calculated rate of work completed per iteration, usually measured in story points.