Unit 5: Cost Management
(PMBOK® Guide, Chapter 7)

The questions on this topic have historically been more difficult than average for some exam takers because of unfamiliarity with some of the math. You will be responsible for a broad range of cost concepts and the subject of earned value. The good news is that you don’t have to be a certified public accountant to answer the questions; they are approached from a project manager’s perspective.

NOTE: You may use a basic six-function calculator, which is built into the computer at the test center. The calculator will not be programmable or be capable of automated statistical functions. See course slide #5-1 for an overview of cost management.

Major Processes

7.1 Plan Cost Management (establishing procedures for planning, managing, expending, and controlling project costs)
7.2 Estimate Costs (estimating the total cost of all project activities)
7.3 Determine Budget (aggregating estimated costs to establish a cost baseline)
7.4 Control Costs (monitoring cost status and controlling changes to the cost baseline)

You should be aware that PMI endorses the concept of life cycle cost (also called the “total cost of ownership”). Specifically, project teams should consider not only the project costs, but also the entire life cycle cost of the major project deliverables. For instance, the PM might lower project costs by reducing the number and extent of design reviews. However, those project savings are likely to cause a substantially greater increase in operating costs for the customer. Life cycle costs include the following components:

- Project costs (the costs of acquiring an item)
- Operating and maintenance costs incurred by the user
- Disposal costs incurred at the end of an item’s useful life (must be done in a safe and environmentally responsible manner)

NOTE: PMI observes that the ability to influence costs is greatest in the early stages of a project and numerous government and industry studies have drawn the same conclusion. Therefore, early scope definition is critical to successful cost performance.
7.1 Plan Cost Management (PMBOK® Guide, p. 195)

Plan cost management establishes procedures for planning, managing, expending, and controlling project costs. This plan is a component of the project management plan.

### Plan Cost Management

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#### Four Key Inputs for Plan Cost Management (PMBOK® Guide, p. 196):

1. **Project Management Plan**: The following three items provide information that is useful in developing a cost management plan.

   - **Scope baseline**: Contains the scope statement (product description, key deliverables, constraints, and assumptions) and the WBS with the detailed WBS dictionary.
   - **Schedule baseline**: Defines when the costs will be incurred.
   - **Other information**: Any information from scheduling (such as resources or changes), communications (keeping stakeholders aware of cost issues), or risk (list of risk events, associated analysis, and response plans) that may affect costs.

2. **Project Charter**: Identifies high-level cost estimates and approval requirements for spending.

3. **Enterprise Environmental Factors**: Cost planning may be affected by the following environmental factors:

   - Organizational structure (PM level of authority over spending)
   - Market conditions and currency exchange rates
• Published commercial information concerning resource rates, materials costs, and equipment costs
• Project management information system

4. Organizational Process Assets: The following organizational processes, policies, procedures, and knowledge bases may affect cost planning:

• Financial control procedures (review of expenditures, accounting practices, and standard procurement procedures)
• Historical information, lessons learned, and financial databases
• Formal and informal cost estimating and budgeting policies


1. Expert Judgment: Expert judgment, guided by historical information on similar projects, is used to develop the most appropriate cost management plan.

2. Analytical Techniques: Analytical techniques may be used for evaluating funding choices such as self-funding, funding with equity, or funding by incurring debt. These techniques may also be used to decide when to lease, rent, purchase, or make the item yourself. Financial evaluations may use payback period, return on investment, internal rate of return, discounted cash flow, and net present value.

3. Meetings: Meetings held to develop the cost management plan. These meetings may be attended by the project sponsor, project manager, project team members, and other selected stakeholders.

One Key Output for Plan Cost Management (PMBOK® Guide, p. 198):

1. Cost Management Plan: As part of developing the project management plan, a cost management plan is established which documents how estimating, budgeting, and controlling are to be approached. Among other things, the cost management plan may establish the following:

• Units of measure: For example, the unit of measure for tracking key resources and time might be days, weeks, or months of effort. The unit of measure for materials might be liters, tons, or cubic yards and so on.
• Level of precision: Will a cost estimate of $995.60 be rounded to $1000 or will a different rule be applied?
- **Level of accuracy:** The acceptable range for cost estimates (which may be affected by various factors including the stage of the project life cycle and the quality of the available data). See specific ranges of accuracy provided in the next process (Estimate Costs).

- **Organizational procedures links:** The extent to which the WBS and control accounts (cost accounts) will be used to plan and track cost information. Using a code of accounts numerical identifier, each control account is linked to the organization’s accounting system.

- **Control thresholds:** Establishes an allowable amount of variation before corrective action is triggered.

- **Rules of performance measurement:** Earned Value rules for calculating how much credit to take for partially completed activities (e.g., 0-100, 50-50, and so on). Will be covered later in the chapter.

- **Reporting formats and process descriptions:** The processes of estimating, budgeting, and control are described and desired formats for reporting are established.

### 7.2 Estimate Costs (PMBOK® Guide, p. 200)

Cost estimating involves developing an estimate of the costs of all resources needed to complete the project. The resources that need to be estimated include labor, equipment, materials, facilities, services, and any special categories such as contingency or an allowance for anticipated inflation.

The accuracy of estimates tends to improve as a project moves through its life cycle. Ranges of accuracy that are used in some industries and have been tested in the past include:

- **Order of Magnitude estimates:** “Ballpark” estimates without detailed data, for example, analogous estimates. This estimate is also called a ROM (Rough Order of Magnitude) in some organizations. The range of accuracy is given as -25 to +75% and would be used for initiating or project approval.

- **Budget estimates:** Based on slightly better data and used to establish initial funding during the early stages of planning. The range of accuracy is given as -10 to +25%.

- **Definitive estimates:** Prepared from well defined, detailed data. A bottom-up estimate using estimates of WBS work packages is a common example of this kind of estimate. This estimate would be done in the latter stages of planning and be used to establish a cost baseline. Range of accuracy is -5 to +10%.
Finally, cost estimating potentially includes evaluating trade-offs among alternatives such as spending more money in the design phase to save money during production or operations.

### Estimate Costs

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**Seven Key Inputs for Estimate Costs (PMBOK® Guide, p. 202):**

1. **Cost Management Plan:** Defines how costs will be managed and controlled, including methods and levels of accuracy.

2. **Human Resource Management Plan:** Cost estimates may be affected by personnel rates and any associated rewards programs. The HR plan also contains the resource calendar with a staffing plan. This plan provides estimated time frames for various resources.

3. **Scope Baseline:** The following three items form the scope baseline and contain information that is necessary for accurate cost estimating.
   - **Scope statement:** Contains the product description, key deliverables, constraints, and assumptions. For cost estimating, a decision must be made as to whether the estimates will include only direct costs or will also include indirect costs.
   - **WBS:** Provides a structure to organize the cost estimates into useful categories (cost accounts or control accounts).
• **WBS dictionary:** Provides the detailed information of what is needed to produce the deliverables for each work package.

4. **Project Schedule:** Cost estimates are closely related to what resources will be used and for how long (activity durations). Data from Estimate Activity Resources (Section 6.4) and Estimate Activity Durations (Section 6.5) must be coordinated carefully with cost estimating.

5. **Risk Register:** The risk register should be reviewed so that projected risk mitigation costs may be included in the cost estimates.

6. **Enterprise Environmental Factors:** For cost estimating purposes, environmental factors would include:
   - Market conditions (what products are actually available in the marketplace for any portions of the project that may be outsourced)
   - Commercial databases that contain cost information

7. **Organizational Process Assets:** The following organizational processes, policies, procedures, and knowledge bases may affect cost estimating:
   - Cost estimating policies and templates.
   - Historical information and lessons learned

**Ten Key Tools for Estimate Costs** *(PMBOK® Guide, p. 204):*

1. **Expert Judgment:** Expert judgment, guided by historical information on similar projects, is used to improve the accuracy of available estimating data. Expert judgment may also assist in choosing the most appropriate estimating method.

2. **Analogous Estimating:** Previously described as one of the tools for duration estimating, the technique is also used for estimating costs. Key points are:
   - Uses the actual costs from a similar project and adjusts the estimate according to whether the current project is expected to be harder or easier than the previous one.
   - Also called top-down estimating.
   - Done early in the project life cycle in most cases.
   - Is a form of expert judgment.
   - *Less costly* than other techniques but also *less accurate.*
• Most reliable when:
  a) The previous projects were similar in fact and not just in appearance.
  b) The estimators have the needed expertise.

3. **Parametric Estimating:** Mathematical modeling for the purpose of predicting project costs. The models seek factors that are highly correlated, for example, dollars per square foot of living space in residential construction. Parametric models are most reliable when:

  a) The historical information used to develop the information was accurate
  b) The parameters in the model are readily quantifiable
  c) The model is scalable (works well for small as well as large projects)

4. **Bottom-up Estimating:** Estimating the cost of individual work items and then “rolling up” or summarizing the estimates to get a project total. The most widely accepted technique uses the work packages as the “individual items”. As the items estimated get smaller, the estimates usually become more accurate but also more costly to develop.

5. **Three-Point Estimating:** Used exactly in the same way that it was for duration estimates. Three-point or PERT estimates are useful when there is underlying uncertainty in the work. As before, optimistic, most likely, and pessimistic estimates are used to calculate an average cost that considers the range of uncertainty in the estimates. The formulas are the same except that the estimates are for costs rather than durations. PMI states that the following two distributions are used to distinguish three-point from PERT:

  - **Triangular distribution:** Used to model the three-point method where the average cost would be calculated as a simple average of the three estimates. \( E(c) = (O + M + P) / 3 \)
  - **Beta distribution:** Used to model the PERT method where the average cost is calculated with a weighted average approach (same as for schedule). \( E(c) = (O + 4M + P) / 6 \)

6. **Reserve Analysis:** Cost estimates must consider potential risks in the estimates for individual activities. Extra money can be incorporated into the estimates as “reserves” or contingency reserve. Additional money can be incorporated into the plan in two classic ways:

  - Place the money into the budget for an individual work package that is considered risky. This approach is for handling “known unknowns,” is
referred to as contingency reserve, and the money is already in the cost baseline. In part, this money is intended to handle the costs of implementing risk mitigation actions for risky work packages.

- The money may be a separately planned quantity that is not associated with specific work packages. This approach is for handling “unknown unknowns,” i.e., situations that are difficult to predict. This amount of money is known as management reserve, is often a percentage of the estimated cost, and is not in the currently approved cost baseline.

The use of either type of reserve is intended to reduce the chance of a cost overrun and the topic is discussed further in the chapter on risk management.

7. Cost of Quality (COQ): The cost of quality includes activities such as training and audits that are done as part of quality management (which will be covered in more detail in the chapter on quality).

8. Project Management Software: Facilitates rapid consideration of the cost estimates for various project scenarios.


10. Group Decision-Making Techniques: Techniques such as brainstorming, Delphi, or nominal group may be used to improve the accuracy of cost estimates. PMI believes that involving people in these techniques may increase commitment to achieving the cost estimates.

Three Key Outputs for Estimate Costs (PMBOK® Guide, p. 207):

1. Activity Cost Estimates: Quantitative assessments (usually expressed in units of currency) of the likely costs of the resources needed to complete the project. Cost estimates may be improved through refinements during the project life cycle. Cost estimates should consider risks and should address the following areas: labor, materials, supplies and services, facilities, information technology, and special categories such as inflation and cost reserve.

2. Basis of Estimates: Should include the following information:

- Description of the work (usually WBS)
- Basis of the estimate (how it was developed: parametric, bottom-up, …)
- Assumptions and constraints
• A range of possible results
• Confidence level (related to the range, i.e., a wide range indicates less confidence in the probability of a given outcome)

3. Project Documents Updates: Documents that may be updated as a result of cost estimating include the risk register.

7.3 Determine Budget (*PMBOK® Guide, p. 208*)

Cost budgeting involves *aggregating estimated cost estimates for all individual activities or work packages* so that a *cost baseline* can be established for measuring performance. The baseline includes authorized budgets and contingency reserves, but excludes management reserves (the extra amount for “unknown unknowns”).

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Nine Key Inputs for Determine Budget (*PMBOK® Guide, p. 209*):

1. **Cost Management Plan**: Describes how project costs will be managed and controlled.

2. **Scope Baseline**: The following three items form the scope baseline and contain information that is relevant to establishing the cost baseline.

   • **Scope statement**: The scope statement is relevant to budgeting if it identifies any constraints on the expenditure of money (such as a fiscal year that constrains when certain funds can be spent).
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- **WBS**: Provides a structure to organize the cost estimates into useful categories (cost accounts or control accounts).

- **WBS dictionary**: Provides the detailed information of what is needed to produce the deliverables for each work package.

3. **Activity Cost Estimates**: Cost estimates for each activity within a work package are aggregated so that the cost of each individual work package is known. Work package estimates can then be aggregated at the control account level and so on.

4. **Basis of Estimates**: Described in *PMBOK® Guide* Section 7.2.3.2 (includes scope, deliverables, how the estimate was created, assumptions, constraints, and an estimated range of possible outcomes). This information should also address whether indirect costs are included in the budget.

5. **Project Schedule**: The schedule must be known to establish when specific costs will be incurred.

6. **Resource Calendars**: The availability of resources affects both the cost as well as the timing of the work. Resource calendars were considered previously as part of activity resource and duration estimating.

7. **Risk Register**: The risk register provides information necessary to account for the costs of risk response strategies.

8. **Agreements**: Provides information on costs incurred through outsourcing of portions of the work.

9. **Organizational Process Assets**: The following organizational process assets may affect cost budgeting:

   - Formal and informal cost budgeting procedures and guidelines
   - Cost budgeting tools
   - Reporting methods

**Five Key Tools for Determine Budget (PMBOK® Guide, p. 211):**

1. **Cost Aggregation**: Described previously. Cost estimates are established for work packages and summarized at higher levels such as control accounts or the project total.
2. Reserve Analysis: Also discussed under cost estimating, reserve analysis establishes the approach for both contingency and management reserves. The course slides will show an example of how reserve analysis relates to the cost baseline (at the first output below, cost baseline).


4. Historical Relationships: Described previously for duration estimating, this technique, formerly called parametric estimating (the use of mathematical correlations), is also used for cost estimating and budgeting. As before, parametric models are most accurate when:
   a) The historical information used to develop the information is accurate
   b) The parameters in the model are readily quantifiable
   c) The model is scalable (works well for small as well as large projects)

5. Funding Limit Reconciliation: Some organizations “reconcile” funding expenditures to prevent large fluctuations in disbursements. In some cases, this process relies on tinkering with the timing of certain activities through the use of imposed date constraints.

Three Key Outputs for Determine Budget (PMBoK® Guide, p. 212):

1. Cost Baseline: The cost baseline is a time-phased budget used to measure and monitor cost performance. The baseline is developed by summing estimated costs by time period and displaying them (often in the form of an S-curve). The approved baseline should never be changed without formal change control procedures. Large projects may have multiple cost baselines. See Figure 7-8 on PMBoK® Guide, p. 213 and Course Slides #5-2 through #5-5 for examples of an S-curve and the use of reserve.

2. Project Funding Requirements: As mentioned above, funding is not always a smooth, continuous process. The availability of the funds usually occurs in increments and disbursements may not automatically be spread evenly. Many organizations attempt to smooth the process as much as possible. See Figure 7-9 on PMBoK® Guide, p. 214 for an example of the typical incremental approach to funding.
3. Project Documents Updates: Documents that may be updated include:

- Risk register
- Cost estimates
- Project schedule

7.4 Control Costs (*PMBOK® Guide*, p. 215)

Cost control is part of integrated change control. Effective cost control requires management of the approved cost baseline (sometimes referred to as time-phased budget) and any changes to that baseline. The two primary factors are managing cost variances and cost changes. Cost control includes the following:

- Influencing the factors which create changes
- Ensuring that change requests are acted on in a timely manner
- Managing the change process
- Keeping costs within authorized funding
- Detecting and understanding cost variances
- Recording all changes
- Preventing inappropriate or unapproved changes
- Informing stakeholders of changes
- Bringing expected cost overruns within acceptable limits

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Four Key Inputs for Control Costs (PMBOK® Guide, p. 216):

1. **Project Management Plan**: Contains the following information used to control costs:

   - **Cost baseline**: The baseline (plan) is compared with actual results to determine if changes, preventive actions, or corrective actions are necessary.
   - **Cost management plan**: Describes how project costs are to be managed and controlled.

2. **Project Funding Requirements**: Described previously in PMBOK® Guide, Section 7.3.3.2.

3. **Work Performance Data**: Includes the following status information:
   - Deliverables completed or partially completed
   - Costs authorized vs. costs incurred (plan vs. actual)
   - Estimates for completing the work (forecasts)
   - Percent physically complete for work in progress

4. **Organizational Process Assets**: The following organizational process assets may affect cost control:
   - Formal and informal cost control procedures and guidelines
   - Cost control tools
   - Monitoring and reporting methods


1. **Earned Value Management**: Earned value is a method of performance measurement that provides current cost and schedule status at regular intervals. The PMBOK® Guide, pp. 217-219 describes earned value as it relates to current status.

2. **Forecasting**: Work performance information through each successive reporting period is used to predict future performance on the project, PMBOK® Guide pp. 220-221.
3. **To-Complete Performance Index:** Calculates the cost performance (CPI) that must be maintained to achieve a performance goal. Usually the preference is to maintain the original budget (finish at the BAC) or in some cases performance may have deteriorated to the point that the current EAC becomes an acceptable goal. See *PMBOK® Guide*, p. 221.

4. **Performance Reviews:** Regular meetings to review and assess cost performance information. One or more of the following techniques are normally employed (*PMBOK® Guide*, pp. 222-223):

   - **Variance analysis:** Planned versus actual performance in the areas of cost and schedule. Three earned value formulas are used for variance analysis (cost variance, schedule variance, and variance at completion).
   - **Trend analysis:** Examining performance over time and projecting to the future to determine whether performance is improving, remaining the same, or deteriorating.
   - **Earned value:** A special technique that accomplishes both variance analysis as well as trend analysis (CPI, SPI).

See course slides #5-6 through #5-28 for coverage of earned value techniques that you must know for the exam.

5. **Project Management Software:** Automates the analysis of data by tracking the values for PV, EV, and AC.

6. **Reserve Analysis:** Used to monitor whether contingency and management reserves need adjusting (increased or decreased).

**Six Key Outputs for Control Costs (*PMBOK® Guide*, p. 225):**

1. **Work Performance Information:** This involves the actual documentation and communication of calculated measurements such as CV, SV, CPI, SPI, VAC, and TCPI. This information is documented and communicated to appropriate stakeholders.

2. **Cost Forecasts:** Calculations such as EAC should be recorded and communicated to stakeholders.

3. **Change Requests:** Change requests may lead to changes in the budget (increase or decrease) and, as usual, change requests must be processed using integrated change control.
4. **Project Management Plan Updates:** Components of the project management plan that may be updated as a result of cost control include:

- **Cost baseline:** The baseline (plan) is compared with actual results to determine if changes, preventive actions, or corrective actions are necessary. In some cases, cost variances are so severe that the baseline must be extensively revised to produce a realistic budget.

- **Cost management plan:** Describes how project costs are to be managed and controlled (*PMBOK® Guide*, Introduction to Chapter 7, p. 193).

5. **Project Documents Updates:** Documents that may be updated include:

- Cost estimates
- Basis of estimates

6. **Organizational Process Assets Updates:** Organizational Process Assets that may be updated as a result of cost control include:

- Causes of variances
- Corrective actions chosen and the reasons
- Other lessons learned as a result of cost control

**Other Topics:**

**Financial management tools and concepts:**

- **Opportunity cost:** The cost of choosing one alternative and giving up the potential benefits of another alternative. The concept has special relevance to project selection; failure to accurately assess opportunity costs may cause a company to miss projects that would yield the best financial returns.

- **Sunk cost:** Expended costs which you no longer control; "water over the dam" so to speak. Sunk costs represent money already spent that cannot be recovered. Financial management principles have long held that sunk costs should be ignored when deciding whether to spend additional funds to complete a project.

**NOTE:** Course slides #5-29 through #5-37 cover the following concepts from payback period through parametric estimates.
• **Payback period:** The amount of time until net cumulative cash flows are greater than zero, that is, the point at which the project first makes a net cumulative profit. When comparing projects, the shortest payback period indicates the project that will become profitable most quickly. However, payback period may ignore the potential magnitude of the profit.

• **Benefit-Cost Ratio (BCR):** BCRs provide a measure of expected profitability by dividing expected revenues by expected costs for a project. Key points for the exam:
  - A BCR of 1.0 means that expected benefits (revenues) and costs are equal, in other words, you have a “break-even” project.
  - A BCR less than 1.0 means that costs are expected to exceed revenues, in other words, the project is expected to lose money.
  - A BCR greater than 1.0 is a profitable project; the higher the ratio the better the project. For example, a BCR of 3.0 means that every dollar invested in the project will generate a gross payback of $3.00.

• **Present Value:** Present value provides financial evaluation of future cash flows to 1) judge the expected profitability of a project and 2) compare projects for project selection purposes. The exam has historically focused primarily on concepts, but you may have to do some calculations as well. Key points for the exam:
  - PV is the value today of a future cash flow.
  - Payment today is worth more than payment tomorrow.
  - Conversely, a cost incurred today is more costly than a cost incurred tomorrow.

\[
PV = \frac{V_t}{(1 + i)^t}
\]

- \(V_t\) = the amount of a cash flow “t” time periods from now
- \(i\) = interest rate (also called discount rate)
- \(t\) = time period
Real-world projects do not consist of a single cash flow and, therefore, the concept of evaluating multiple cash flows becomes necessary to properly evaluate real projects. **Discounted cash flows (DCF)** and **net present value (NPV)** are used to evaluate the estimated cash flows of real projects. DCF calculations convert future cash flows into their present-day value. NPV uses the calculations from discounted cash flows to determine whether a project will recover any initial investment and make a profit.

- **Expected Present Value (EPV):** EPV stands in direct contrast with Net Present Value (NPV). With NPV, the estimated cash flows are assumed to be known and reasonably accurate (statisticians would use the term “deterministic”). EPV is used whenever financial outcomes are less certain and a certain amount of risk is involved. EPV uses multiple possible outcomes with an associated probability for each outcome.

Example: NPV would evaluate estimated cash flows and produce a single, deterministic outcome. Let’s assume that, after such analysis, the NPV for a project was calculated as $500,000.

The approach using EPV would be to consider different possible outcomes such as the following:

There might be a:

- 10% chance of a profit of $800,000
- 30% chance of a profit of $600,000
- 40% chance of a profit of $500,000
- 20% chance of a profit of $300,000

The evaluation of these data would multiply each probability by its associated cash outcome and sum all the results. Notice that the probabilities total to 100 percent.

Therefore, the EPV would be:

\[
.10 \times 800,000 = 80,000 \\
.30 \times 600,000 = 180,000 \\
.40 \times 500,000 = 200,000 \\
.20 \times 300,000 = 60,000 \\
\text{Total} = 520,000
\]

Again, the major distinction with EPV is that it **explicitly considers risk** and accounts for the effects of different potential profit outcomes.
• **Internal Rate of Return (IRR):** The IRR is an estimate of a project's profitability expressed as a percentage. It can be thought of as an average rate of return. The definition is frequently stated as “the interest rate that makes the present value of the costs (outflows) equal to the present value of the revenues (inflows).” The higher the IRR, the better the project.

• **Return on Investment (ROI):** ROI is another profit indicator usually expressed as a percentage. The classic formula is earnings divided by investment. The challenge in the real world is for an organization to decide how to measure earnings and investments. There are numerous ways to do so and no single “correct” way really exists. When specifically applied to projects, the formula is (Benefits - Costs) / Costs.

• **Economic Value Added (EVA):** A measure of a company’s financial performance that adjusts after-tax operating profits by deducting the total cost of capital. The formula is Net Operating Profit After Tax (NOPAT) - Total Annual Cost of Capital. Created by Stern Steward & Co., EVA has also been called economic profit because its original purpose was to measure the true economic profit of a company. Key points include:
  
  • The most distinctive aspect of EVA is including a charge for the cost of capital. Peter Drucker wrote in a *Harvard Business Review* article, "Until a business returns a profit that is greater than its cost of capital, it operates at a loss."

  • EVA is profit the way shareholders define it. If shareholders expect a 10% return on their investment, they meet that goal only when their share of after-tax operating profits exceeds 10% of their investment. In other words, your project must return at least as much money as the shareholder would earn in some other investment.

  • EVA is conceptually simple for non-financial managers. It focuses on operating profits and accounts for the cost of capital invested in the company. It allows managers to focus their attention on income and the assets required to conduct business.

  • EVA can be applied to an entire company, a division, one plant, or a single project.

  • See the following Web sites for more information: http://www.sternstewart.com/evaabout/whatis.php and http://www.investopedia.com/terms/e/eva.asp
- **Parametric estimates:** Rely on mathematical relationships between two or more characteristics of a project. You are likely to be tested on two related concepts:

1. **Regression analysis:** Statistical modeling that represents parametric relationships in a graphical display. For example, regression analysis could model the relationship between the number of scope changes and overall project cost. The relationship would likely show that as the number of changes increases, the overall cost would also increase.

   ![Graph of regression analysis](image)
   - Number of scope changes
   - $\leftarrow$

2. **Learning curve:** A frequently used parametric model in some industries, the learning curve shows that the time it takes to perform some tasks will decrease as we perform the task more frequently. Specifically, learning curve theory says that *each time we double the number of times we have performed a task, the time it takes to perform the task will decrease in a regular pattern*. Learning curve modeling, which often uses regression analysis, can determine the rate at which the improvement (learning) occurs.

- **Depreciation of capital:** When money is spent to purchase capital equipment, there are several ways to write the expense off of taxable income:
  - **Straight line method:** Takes an equal credit during each year of the useful life of the equipment.
  - **Accelerated depreciation methods:** Used to write off the expenses faster. You should know the names of two of these methods (*double declining balance* and *sum of the years digits*).

- **Value analysis (also called value engineering):** Value analysis is a cost reduction tool that involves a careful analysis of a design or item to 1) *identify all of the functions* the item provides and 2) *at what cost*. The approach then evaluates 3) *whether each function is really necessary* and whether it can be provided at a 4) *lower cost* without degrading performance or quality.

- **Law of diminishing returns:** Situations where you put more and more into something and get less and less back. For instance, investing more and more money into technical performance improvements will often eventually reach the point of diminishing returns.
• **Variable versus fixed costs**: Variable costs rise directly with the size of the project, for example, labor and materials costs consumed directly by the project. Fixed costs are nonrecurring expenses such as establishing a production line or purchasing equipment. Fixed costs do not change because you decide to produce more units.

• **Direct versus indirect costs**: Direct costs are incurred directly by a specific project and include such items as salaries of project staff, materials used directly on the project, subcontractors’ costs, and so on. Indirect costs are the organization’s *cost of doing business*, and prorated shares of those costs are often allocated to various projects in the form of overhead costs. Examples include security guards, electricity, fringe benefits, insurance, and taxes.

• **Working capital**: Current assets minus current liabilities.
Cost Exercise

Assume an interest rate of 10%

Use the data provided in the following table and then answer the questions posed below.

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1. What is the PV for time period 2?

2. What is the payback period?

3. What is the BCR (Benefit Cost Ratio)?

4. What is the NPV (Net Present Value)?

5. What is the ROI (Return on Investment)?

The solution is on the last page of this unit.
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## Question Answer

1. In earned value, how is a cost variance calculated?

   **Note:** All page numbers in this drill practice refer to the study guide unless otherwise indicated.

   1. **EV - AC or BCWP - ACWP**

      If $3,000 worth of work has been accomplished (BCWP) and it cost $2,800 to complete that work (ACWP), the cost variance is **positive $200, indicating a cost underrun** (p. 5-13 and course slide 5-8).

2. In earned value, how is a CPI calculated?

   2. **EV / AC or BCWP / ACWP**

      The CPI uses the same numbers as a cost variance, but divides them to create a ratio.

      If BCWP is $1,000 and ACWP is $1,000, the CPI is 1.0 meaning that cost performance is exactly according to plan. (p. 5-13 and course slide 5-18)

3. What is the EAC and how is it calculated?

   3. **The estimate at completion is a revised estimate of total project cost and can be calculated several ways** (p. 5-13 and course slides 5-21/22).

      - **EAC = BAC / CPI** (primary formula which assumes that current performance will continue into the future)
      - **EAC = AC + (BAC-EV)** (which assumes that remaining work will be accomplished at the original budgeted rate)
      - **EAC = AC + [(BAC-EV) / (CPI x SPI)]** (which is used if you need to also consider the effect of the schedule if you have an imposed deadline)

4. What is accelerated depreciation?

   4. A way to write capital expenses off corporate taxes more quickly (p. 5-19).

5. Name two methods of accelerated depreciation.

   5.  
      - Double declining balance
      - Sum of the years digits (p. 5-19)
---|---
7. What is the purpose of management reserve? | 7. Reduce the chance of a cost overrun (p. 5-8).
8. What is a BCR? | 8. A benefit-cost ratio is calculated by the formula: Revenues / Costs

A ratio greater than 1.0 indicates a profitable project (p. 5-16).
9. What is value analysis and how does the process work? | 9. A cost reduction tool comprised of four major steps:
   a. Analyze a proposed design (determine inherent functions)
   b. Determine relative cost of each function
   c. Assess whether each function is really needed
   d. Assess how to provide the necessary functions at the lowest cost without compromising quality or performance (p. 5-19).
10. What is the cost management plan? | 10. A component of the project management plan that documents how estimating, budgeting, and controlling are to be handled (pp. 5-3/4).
11. What is an IRR? | 11. The internal rate of return is an estimate of a project’s profitability expressed as a percentage.

It can also be thought of as an average rate of return. The higher the percentage, the better the project profit (p. 5-18).
<table>
<thead>
<tr>
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</table>
| 12. What is a bottom-up cost estimate?                                  | A bottom-up estimate uses three primary steps:  
   a. Create a project WBS  
   b. Do detailed cost estimates for each work package  
   c. Add the cost estimates to provide estimates for higher levels in the WBS *(pp. 5-4 and 5-7).* |
| 13. What is an approximate range of accuracy for a bottom-up estimate?  | -5 to +10 percent *(p. 5-4).*                                                                                                           |
| 14. What is payback period?                                             | The first time periods in which net cumulative revenues exceed net cumulative costs. Helps assess which project might become profitable most quickly *(p. 5-16).*                                           |
| 15. Regression analysis relies on what kind of cost estimating?         | Parametric *(p. 5-19).*                                                                                                                   |
| 16. What is an opportunity cost?                                        | The benefit that is lost by investing in a given project instead of an alternative. *(p. 5-15)*                                                                                                   |
| 17. What is the cost baseline?                                          | A time-phased budget used to measure and monitor cost performance on a project *(p. 5-11).*                                                                                                       |
| 18. What is cost control?                                               | a. Influencing the factors which create changes  
   b. Ensuring requested changes are agreed upon  
   c. Managing the actual changes as they occur  
   d. Determining that the cost baseline has changed *(p. 5-12).*                                                                         |
<table>
<thead>
<tr>
<th>Question</th>
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</thead>
<tbody>
<tr>
<td>19. What is a sunk cost?</td>
<td>Costs already expended and no longer under your control. They are considered irrelevant when deciding whether to spend more money to finish a partially completed project (p. 5-15).</td>
</tr>
<tr>
<td>20. What is EPV?</td>
<td>Expected present value (when compared to net present value) considers uncertainty in cash flows. The technique considers multiple financial outcomes and the associated probabilities of those outcomes (p. 5-17).</td>
</tr>
<tr>
<td>21. What is the learning curve theory?</td>
<td>The learning curve theory holds that costs will decrease as you get better at doing a repetitive task. Formally stated, the learning curve approach says: Unit costs will decrease in a regular pattern each time the number of units produced is doubled (p. 5-19).</td>
</tr>
<tr>
<td>22. Present value is ______.</td>
<td>The value today of future cash flows (p. 5-16).</td>
</tr>
<tr>
<td>23. Distinguish variable from fixed costs.</td>
<td><strong>Variable costs</strong> rise directly with the size of the project, e.g., labor cost &amp; materials consumed directly by project work. <strong>Fixed costs</strong> are non-recurring, start-up expenses such as establishing a production line or purchasing equipment (furniture, test equipment). Fixed costs do not change when you decide to produce more units (p. 5-20).</td>
</tr>
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</table>
### 24. Distinguish direct from indirect costs.

**Direct costs** are incurred directly by a specific project, e.g., salaries of project staff, materials used directly on the project, subcontractors’ costs, and so forth.

**Indirect costs** are the organization’s cost of doing business and prorated shares of those are often allocated to various projects in the form of overhead costs. Examples include security guards, electricity, fringe benefits, insurance, and taxes *(p. 5-20).*

### 25. If variable costs are $100 per unit and fixed costs are $2,000:

a. What is the cost of producing 10 units?

\[ (10 \times 100) + 2,000 = 3,000 \]

b. What is the cost of producing an extra 10 units?

\[ 10 \times 100 = 1,000 \] *(p. 5-19)*

### 26. What are the main characteristics of EVA?

Economic value added measures financial profit by a) focusing on true economic profit, b) considering the cost of capital, and c) thinking of profit the way shareholders would *(p. 5-18).*

### 27. Using more and more resources and getting less and less resulting output describes what law?

Law of diminishing returns *(p. 5-19).*

### 28. What document provides the basis to identify all the work that will incur costs on a project?

WBS (a component of the scope baseline) *(p. 5-5, input #3).*
29. If:
PV (BCWS) = $2,200
EV (BCWP) = $2,000
AC (ACWP) = $2,500
BAC = $10,000

   a. What is the schedule status?
   b. What is the cost performance thus far?
   c. What is the expected variance at project completion?

29.
   a. $SV = 2,000 - 2,200 = - $200; behind schedule
   b. $CV = 2,000 - 2,500 = - $500; cost overrun
   c. $VAC = BAC - EAC (therefore need to calculate the EAC)

      EAC = $BAC / CPI  where CPI = EV / AC
      CPI = 2,000 / 2,500 = .80
      EAC = 10,000 / .80 = $12,500

      Finally, $VAC = 10,000 - 12,500 = -$2,500; the project is expected to finish with a $2,500 cost overrun (pp. 5-13/14).

30. What is a Life Cycle Cost (LCC) estimate?

30. A cost estimate covering the entire cost of ownership for the customer, i.e., the cost of the project (acquiring the product or service), the costs of operating and maintaining the item, and disposition costs if appropriate (p. 5-1).

31. What are the two conditions under which analogous estimating works best?

31. Analogous estimates, while less costly than other techniques, are also less accurate. They are most reliable when:
   a. The previous projects used for comparison are similar in fact and not just in appearance, and
   b. The estimators have the needed expertise (pp. 5-6 and 5-7).

32. Identify the three outputs of estimate costs.

32.
   Activity cost estimates
   Basis of estimates
   Project documents updates
   (pp. 5-8/9)
<table>
<thead>
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<tbody>
<tr>
<td>33. In earned value, what is the 50-50 rule?</td>
<td>It is one way to determine how much work has been completed on a project, i.e., the BCWP.</td>
</tr>
<tr>
<td></td>
<td>If a task is budgeted to cost $100, credit is taken for half ($50) when the task begins and the other half is credited only when the task is complete.</td>
</tr>
<tr>
<td></td>
<td>The rule is most accurate if work packages are approximately the same size (pp. 5-3/4 and course slide 5-27).</td>
</tr>
<tr>
<td>34. When is parametric modeling most reliable?</td>
<td>A. The historical information used to develop the model was accurate</td>
</tr>
<tr>
<td></td>
<td>B. The parameters used in the model are in fact quantifiable</td>
</tr>
<tr>
<td></td>
<td>C. The model is scalable (appropriate for small and large projects) (p. 5-7, tool #3).</td>
</tr>
<tr>
<td>35. What five types of supporting detail are recommended for cost estimating?</td>
<td>Description of the work</td>
</tr>
<tr>
<td></td>
<td>Basis for the estimate (how developed)</td>
</tr>
<tr>
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<td>Constraints and assumptions</td>
</tr>
<tr>
<td></td>
<td>The range of possible results</td>
</tr>
<tr>
<td></td>
<td>Confidence level (pp. 5-8/9).</td>
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<td>36. What is the cost baseline?</td>
<td>A time-phased budget used to measure and monitor cost performance. Often displayed in the form of an S-curve (p. 5-11).</td>
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<td>37. Is it possible to have multiple cost baselines?</td>
<td>Yes, especially on larger projects where one might want to measure different aspects of cost performance (p. 5-11).</td>
</tr>
<tr>
<td>38. How is present value calculated?</td>
<td>[ PV = \frac{V_t}{(1 + i)^t} ]</td>
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<tr>
<td></td>
<td>( V_t = \text{cash flow in time period “t”} )</td>
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<tr>
<td></td>
<td>( i = \text{the interest rate} )</td>
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<td>( t = \text{the relevant time period} ) (p. 5-16)</td>
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### 39. What is an order of magnitude estimate?

A guesstimate or ballpark estimate usually done early when detailed information is not available.

Range of accuracy is -25 to +75 percent (p. 5-4).

### 40. What is a definitive estimate?

A detailed, accurate estimate prepared from techniques such as bottom-up.

Range of accuracy is -5 to +10 percent (p. 5-4).
Solution: Cost Exercise

Assume an interest rate of 10%

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1. What is the PV for time period 2? $6,611.57: Divide the cash flow of $8,000 by the time adjustment factor which is \((1+i)^t = (1.1)^2 = 1.1 \times 1.1 = 1.21\). Therefore, $8,000/1.21 = $6,611.57

2. What is the payback period? Time period 2 (first period in which the cumulative cash flow is positive; $2,000 total profit considering all revenues and costs to date)

3. What is the BCR (Benefit Cost Ratio)? BCR = Revenue/Cost = $44,000/$18,000 = 2.44. Interpretation: The project will return $2.44 for every dollar invested.

4. What is the NPV (Net Present Value)? The sum of all PVs, which is totaled at the bottom of the PV column as $16,689.93 (which is the expected profit after adjusting for the time value of all cash flows).

5. What is the ROI (Return on Investment)? (Benefit-Cost)/Cost = (44-18)/18 = 1.44 (as a percentage: 144%).