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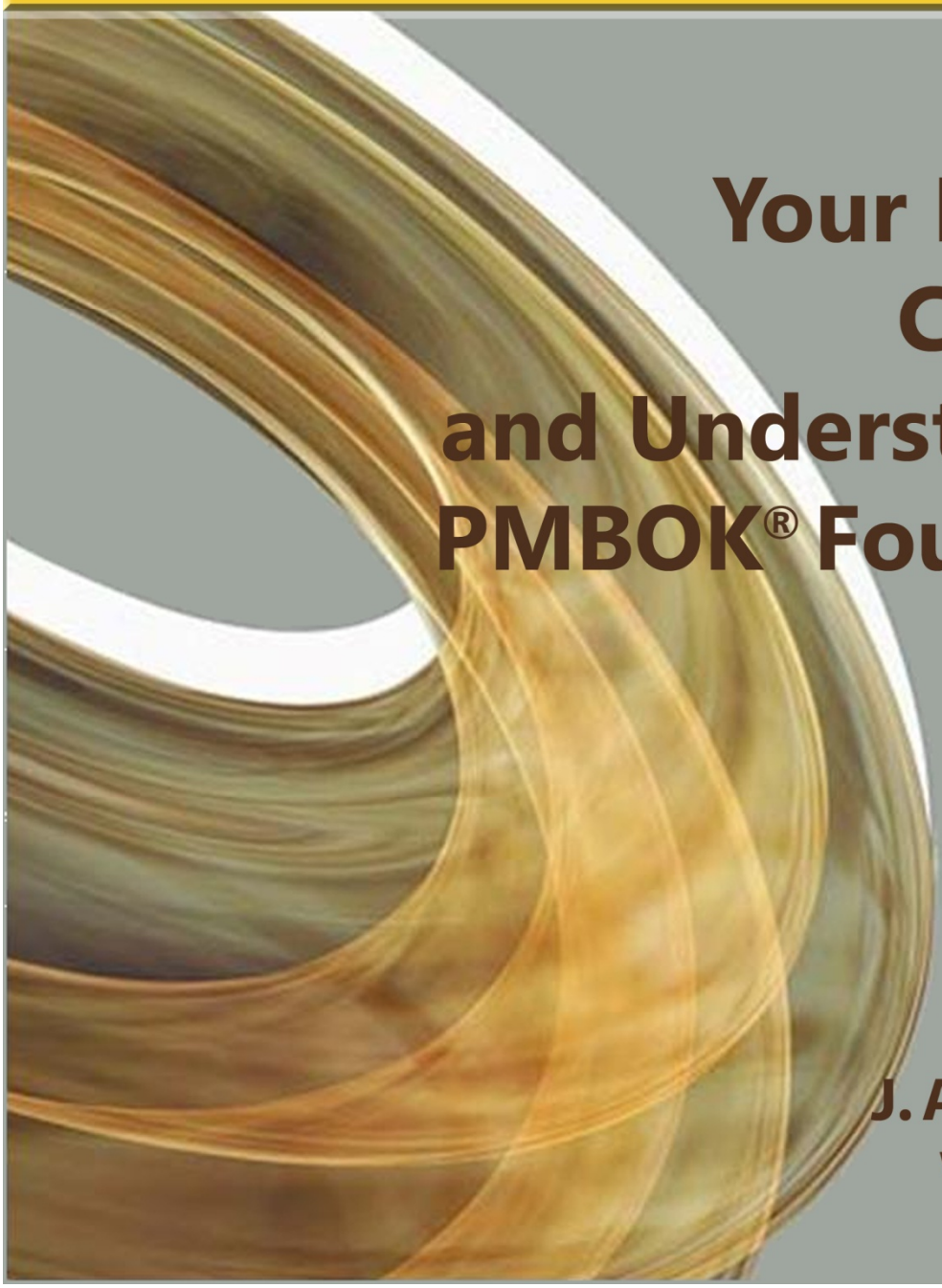
For the Project Management Professional®



Your Key to PMP Certification and Understanding the PMBOK® Fourth Edition

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www.PMRoadTrip.com

Project Management Road Trip for the Project Management Professional:
Your Key to PMP Certification and Understanding the PMBOK Fourth Edition

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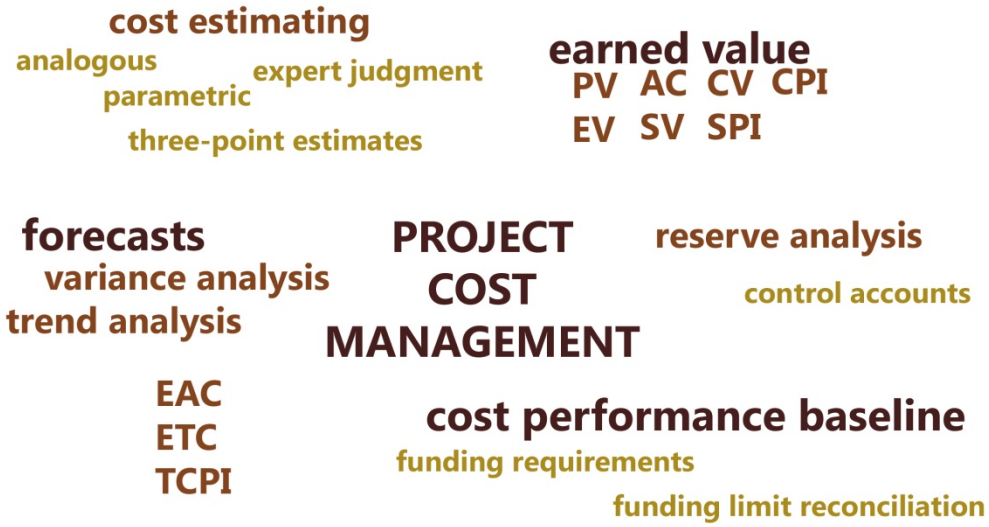
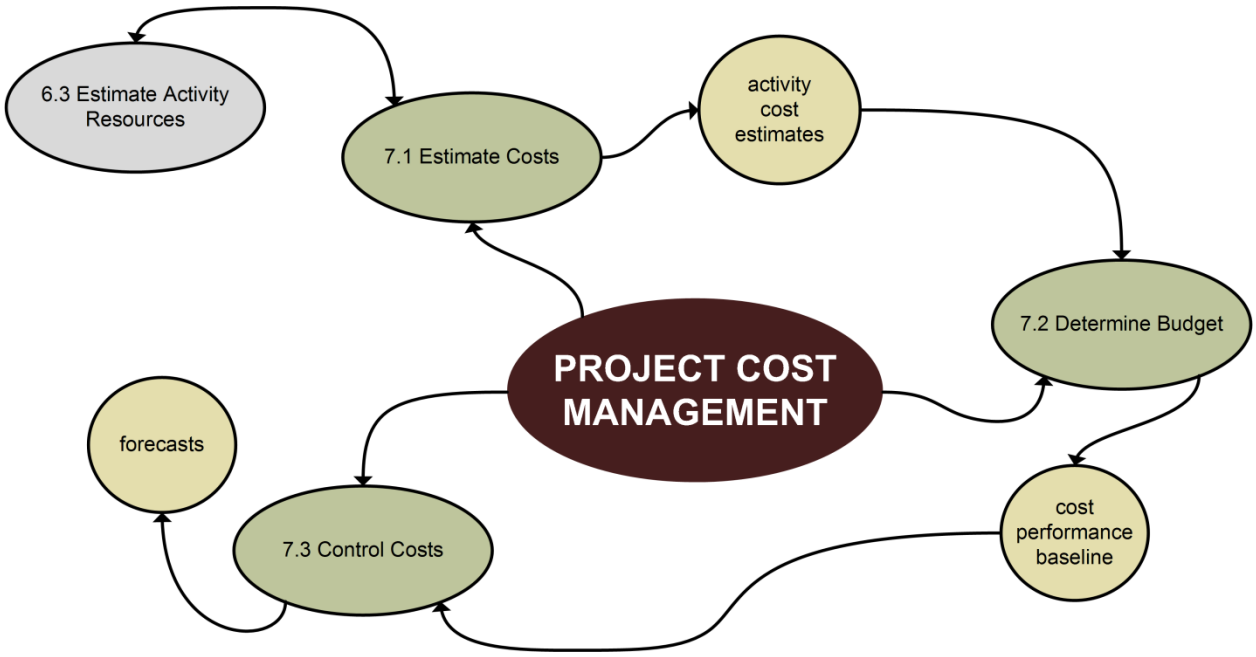
7.0 Project cost management

The **Project Cost Management** knowledge area is concerned with estimating, budgeting, forecasting, and controlling the cost of the project.

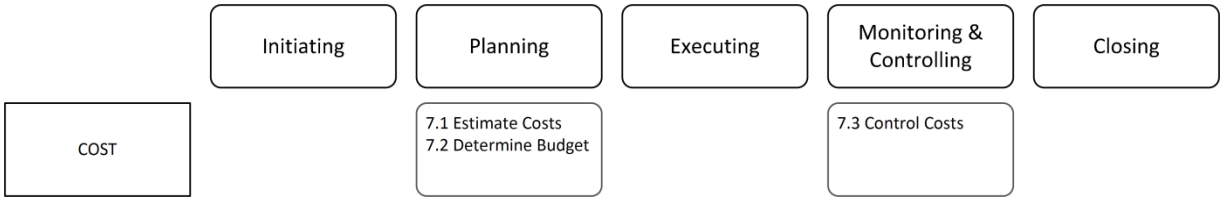




Keywords

- ☐ activity cost estimates
- ☐ actual cost (AC)
- ☐ analogous estimating
- ☐ basis of estimates
- ☐ bottom-up estimating
- ☐ budget at completion (BAC)
- ☐ budget reserve
- ☐ contingency reserve
- ☐ cost management plan
- ☐ cost performance baseline
- ☐ cost performance index (CPI)
- ☐ cost variance (CV)
- ☐ direct costs
- ☐ earned value (EV)
- ☐ earned value management (EVM)
- ☐ estimate at completion (EAC)
- ☐ estimate to complete (ETC)
- ☐ fixed costs
- ☐ funding limit reconciliation
- ☐ indirect costs
- ☐ management reserve
- ☐ parametric estimating
- ☐ planned value (PV)
- ☐ project cost baseline
- ☐ project funding requirements
- ☐ reserve analysis
- ☐ schedule performance index (SPI)
- ☐ schedule variance (SV)
- ☐ S-curve
- ☐ three-point estimates
- ☐ to-complete performance index (TCPI)
- ☐ trend analysis
- ☐ variable costs
- ☐ variance analysis
- ☐ variance at completion (VAR)

Overview



The project management cost processes typically follow the scope and schedule development processes. The three processes in this knowledge area are:

- **Estimate Costs:** Develop estimated costs for each scheduled activity.
- **Determine Budget**: Aggregate activity costs into an approved project budget.
- **Control Costs:** Monitor, manage, and control costs.

Though cost estimating and budget development are distinct processes, on many projects they are done concurrently, sometimes at the same time as resource needs for the scheduled activities are determined (Estimate Activity Resources, 6.3). There is no definite project role with explicit responsibilities for cost processes because it largely depends upon the type of project and the organization. Some projects may rely on professional estimators for all or part of the cost processes, and some organizations may have the analysis of project financial performance handled by people outside the project. But for our PMP examination, we should assume the project manager has the ultimate responsibilities for the cost processes.

> One of the most common mistakes IT organizations make is not allocating adequate time for budgeting. "Preparing a project budget is a mini-project in itself."[1]
>
> E.M. Bennatan, author of *On Time, Within Budget*

Project cost decisions can't be made in a silo. Costs have impacts to other project factors, such as scope, quality, risks, and total cost of ownership. For example, a decision to reduce project costs by using a component that costs less but requires more frequent maintenance over the life of the product increases the customer's costs. Project constraints also influence cost decisions. Though the most obvious constraint is a limited budget, other constraints only indirectly related to project cost usually have financial repercussions, including staffing and scheduling constraints.

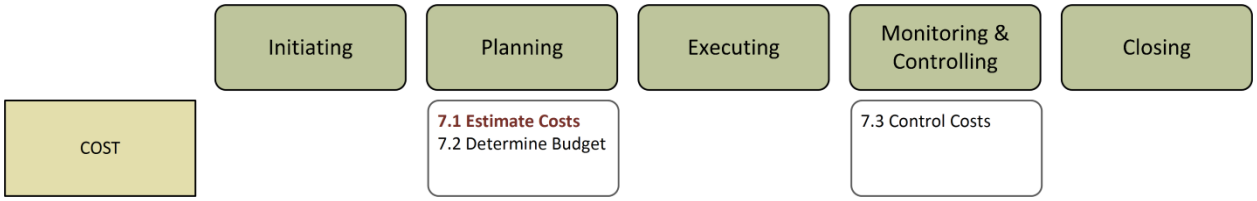
Cost management plan

Each knowledge area has at least one subsidiary plan focusing on a specific subject as part of the overall project management plan. Preplanning is the purpose of these components, and these plans map out the specific requirements for the deliverables and project management processes that will take place in that knowledge area. This preplanning may sound like a lot of work, but we can think of these subsidiary plans as being the scope statements for the knowledge area because they describe the who, what, where, why, and how of the project management work that will be performed for that section's subject matter.

The **cost management plan** is a part of the project management plan, and it provides guidance for all the cost processes. It establishes how project costs will be planned for, estimated, organized, reported on, forecasted, and managed. It addresses topics that cover:

- what types of indirect costs, if any, will be posted against the project
- units of currency to be used
- precision level/acceptable rounding for costs
- currency conversion issues
- acceptable thresholds for cost variances
- the general ledger or control accounts for expenses and costs
- the performance measurement formulas that will be used
- at what points in the project performance measurements will be made
- how and when costs incurred should be posted against the project budget.

7.1 Estimate costs

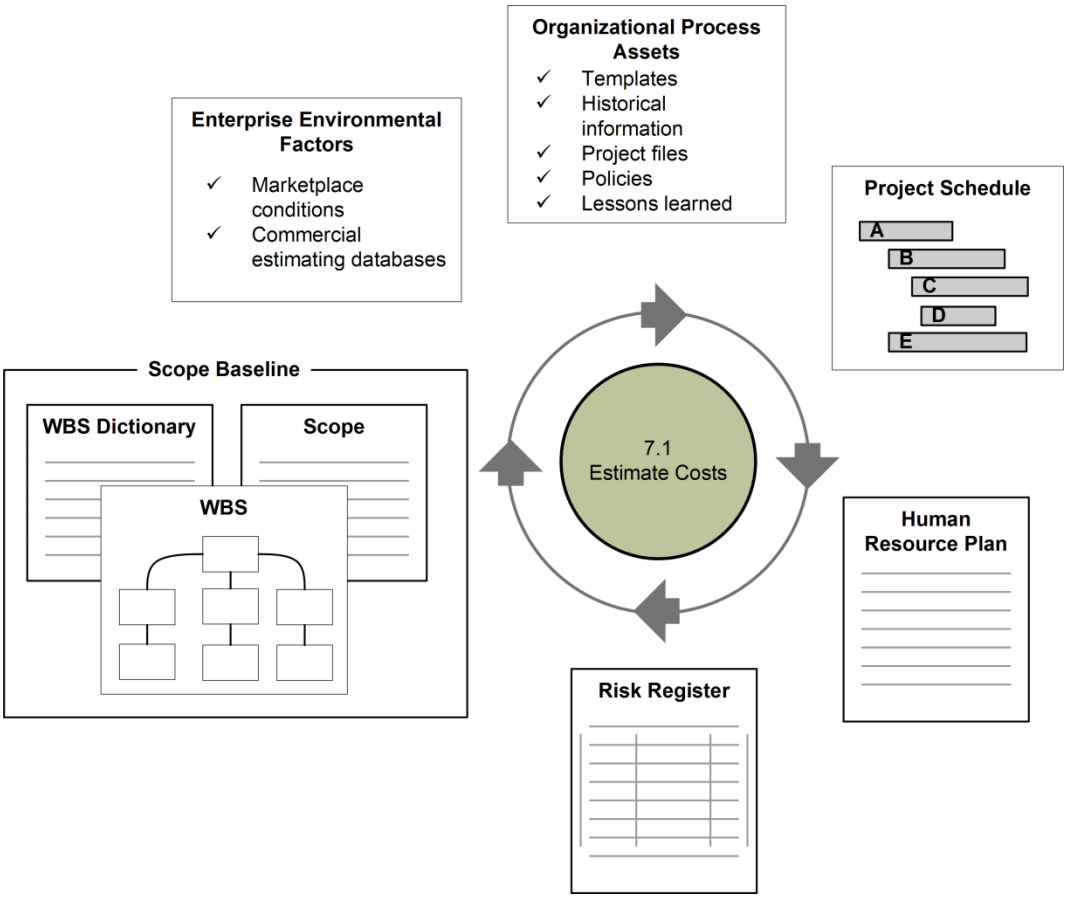


Expected costs for all scheduled activities are established through the **Estimate Costs** process. The cost estimate is *a quantitative assessment of the likely costs for the resources required to complete the activity*[2].

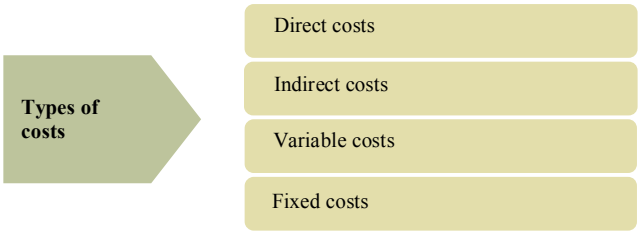
This process occurs at least once, though it's most likely that estimates will undergo several revisions as the planning processes are underway with fewer changes occurring once executing processes begin. In most organizations, cost estimating is performed by the project manager though for some project types professional estimators may also be involved.

There are several key inputs to this process. The schedule and its associated data containing activity resource requirements and durations form the basis for estimating costs. The scope statement, WBS, and WBS dictionary are essential to this process because they contain the deliverables, constraints, and assumptions that will have a direct impact on costs. The human resource plan is also needed because it contains the pay rates and recognition and rewards methods for the project team. The risk register is also needed because it contains the risk management activities that will be taken to minimize negative risks, and there is a cost involved in those activities.
A solid project budget begins with an accurate and complete inventory of activities, so the cost estimating process is a good place to double-check that all items are accounted for in the scope, WBS, and resource breakdown structure. Missing items could trigger scope or schedule change requests if baselines have already been established.

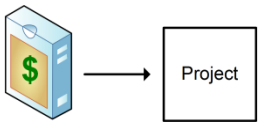
The main outputs of cost estimating are the activity cost estimates and the basis of estimates. The **activity cost estimates** contains the expected cost of every project activity, and it is the main source of data for the project funding requirements and the project budget. The **basis of estimates** is the supporting detail that provides supplementary information about the activity estimates, such as any assumptions made, constraints, how the estimate was derived, the confidence level in the estimate, and any risk factors that were considered.


Organizational Process Assets
✓ Templates
✓ Historical information
✓ Project files
✓ Policies
✓ Lessons learned
Enterprise Environmental Factors
✓ Marketplace conditions
✓ Commercial estimating databases
Project Schedule
A
B
C
D
E
Scope Baseline
WBS Dictionary
Scope
WBS
7.1
Estimate Costs
Human Resource Plan
Risk Register

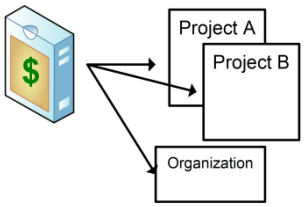
Types of costs



Costs can be classified as direct or indirect, and as either variable or fixed. Direct fixed costs are the most accurate since they can be easily quantified while indirect and variable often have some guesswork involved in how they're estimated, so they are less reliable.

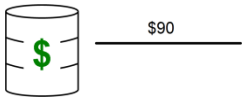


Direct costs can be attributed specifically to a detailed or summary activity of the project. Direct costs include dedicated labor, material, supplies, equipment, licenses, fees, training, travel, or professional service fees. The defining characteristic for a direct cost is that the goods or services are used exclusively for the project.



Indirect costs are incurred by the project, but the goods or services are also used for non-project activities. Common indirect costs might be facility or equipment rentals and utilities. Indirect costs are typically harder to quantify. For example, if a color printer is shared by several project teams, it's difficult to definitively determine what percentage of costs each should share.

Variable costs fluctuate and can't be predicted with absolute certainty. For example, travel or transportation costs that can change depending upon the cost of fuel or certain commodities and types of raw materials.



Fixed costs are static throughout the project or have only a small likelihood of fluctuation. Fixed costs are usually for items such as rents, leases, licenses, salaries, and fixed fees.

Major factors affecting costs

Some of the major factors we need to consider while estimating costs are risks, total cost of ownership, cost of quality, and market place conditions.

Risks

During early phases, the greatest risk to budget accuracy is usually that the scope, activity, and constraints aren't fully known. When that's the case, the basis of estimates (supporting detail to activity cost estimates) should make this clear. Risk planning is discussed more fully in chapter 11.

Total Cost of Ownership/Life-Cycle

In chapter one we saw the relationship between the product life cycle and the project life cycle. The important thing we should have taken away from that discussion is that decisions made within the project impact the product over its entire life cycle. We need to keep in mind a longer-term view of the product as we consider project costs. This can be difficult since our authority as project managers may be limited to the project boundaries, but we have to make efforts to ensure that cost decisions within the project don't have unacceptable repercussions to the total cost of ownership of the product, whether the product is for our organization or for external customers.

> ...an electrical subcontractor sought to switch out the specified light fixture for a similar looking unit...In checking the alternative's specs, though, it was determined that the energy use was almost twice the original fixture. [3]
>
> Steve Wiser, Ten Tips for Avoiding Common Pitfalls in Health Care Construction Costs.

Cost of Quality

The cost of quality is about making trade-offs between perfection and acceptable levels of quality in the product. We'll find out more about quality in chapter 8, but for now we need to know what is the acceptable level of quality needed by the product and what will it cost to ensure that quality level is met.

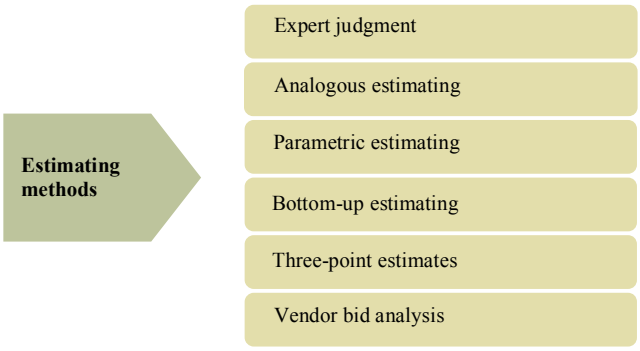
Marketplace Conditions

Market conditions over the course of the project will impact resource costs. Though difficult to anticipate, trends need to be factored into costs, especially for longer projects or when there are clear fluctuations occurring for project resources. Marketplace conditions can also be thought of as assumptions, so the logic involved should be well-documented when they're included in cost estimates.

> Inflation in the construction industry averages about 1 percent, sometimes more, per month.[4]
>
> Don Bodin, owner of Hotel Development Services

Another marketplace condition that factors into costs is what resources are available and at what cost. For example, if the resource is in high demand or scarce, the price is likely to be higher. There could also be only a handful of suppliers from whom a resource can be purchased from, or the organization may have an approved seller list, which limits where the resources can be procured from at what price.

Estimating methods



Several methods help us establish reliable project costs. Expert judgment always plays a part because there are so many interrelated factors that influence costs. **Expert judgment** relies on historical experience to assess and adjust estimates.

Analogous estimating uses the costs from similar projects or activities as the basis for the current project. As long as the two activities are similar and are occurring under similar situations this can be a fairly reliable technique.

Parametric estimating uses mathematical formulas to derive estimates from. It isn't applicable to all activities, but when it is it usually produces the most accurate estimates. For example, if it's known that a material will cost $10 per cubic meter and 100 cubic meters are needed, the estimated cost is $1,000.

Bottom-up estimating decomposes activities to the lowest level possible for cost estimating purposes, and then aggregates component costs back up to a summary activity level. Bottom-up estimating can take some time to do well, and it requires specific details to be known about the activity, so it isn't generally an available option early in the project planning processes. **Top-down estimating** is the counterpart to bottom-up, and it estimates costs by looking only at broad, summary-level activities. Top-down estimates are the least accurate.

Three-point estimates, sometimes called PERT analysis, help to remove the uncertainty from estimates by providing a weighted average using the pessimistic, optimistic, and most-likely values. We saw this formula in chapter six when we were estimating activity durations:

Cost Estimate =(Optimistic Cost Estimate + (4 x Most-Likely Cost Estimate) + Pessimistic Cost Estimate) / 6

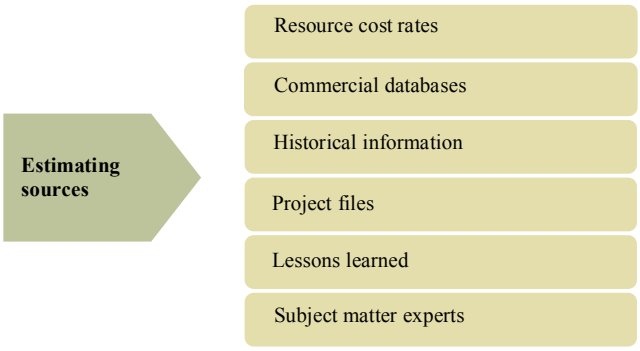
$$C_E = \frac{C_O + 4C_M + C_P}{6}$$

Optimistic Cost Estimate	Most Likely Cost Estimate	Pessimistic Cost Estimate
$75	$100	$150

Three-point estimate = ($75 + (4 x $100) + $150) / 6
Three-point estimate = ($75 + $400 + $150) / 6
Three-point estimate = $625 / 6
Three-point estimate = $104.17

If the project involves procurement activities, vendor bid analysis may also be used to develop estimates. In chapter 12 we'll look at procurement processes in greater detail, but for now we just need to know that **vendor bid analysis** involves additional techniques to ensure that the bids and work they represent are accurate, reasonable, and acceptable.

Estimating sources



Sources for analogous estimating are varied and will depend upon the project type and resources of the organization..

Resource Cost Rates: It's necessary to know the unit cost for resources, both personnel and non-personnel. Personnel rates can be found in the human resource plan, or may need to be determined if the staffing processes haven't yet occurred. Contracts, commercial databases, and vendor bids will also include resource cost rates.

Commercial Databases: For some activities, tables or databases of costs can be referred to. Commercial databases provide resource rates by region or other relevant classifications.

Historical Information: Historical information within the organization is another valuable source for costs. For example, the organization may be able to provide the running average cost for attorney fees based on previous actual experience.

Project Files: Cost data may also be derived from past projects as long as sufficient supporting detail about the activity and the actual costs are accessible.

Lessons Learned: Lessons learned documents are always useful. Reviewing lessons learned might avert a cost estimating issue that was encountered by another project team.

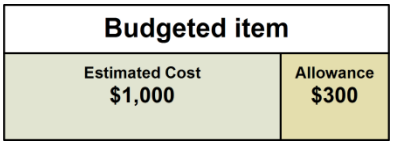
Subject Matter Experts: Based on their past experiences, the project team and other subject matter experts can assist in providing cost data. Though this advice is helpful, it's less reliable than documented data.

Reserve analysis

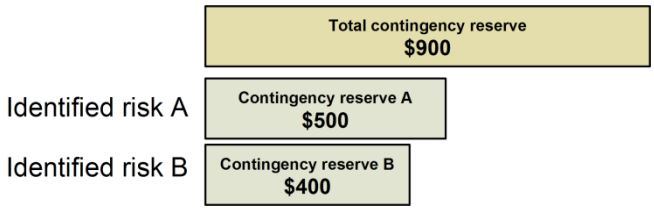
It's rare for actual costs to exactly match up with their original estimates. Technically, all cost variances stem from risks, and these can range from the risk of minor estimating errors to major risk events that have the potential to sink the project. **Reserve analysis** evaluates risks by making financial allowances for them in the project's funding requirements. Appropriate funding for risks is a factor in how well the project recovers from risk events should they occur. There are three general budgeting techniques for addressing financial uncertainty.

> Care must be exercised when setting contingencies for risks. Contingency should be sufficient to cover the costs or time to avoid, transfer, mitigate, or bear the realization of risks...It is not enough to have a Contingency Fund that is large enough. It is equally important for the Contingency Funds not to exceed needs.[5]
>
> Noor and Tichacek, Contingency Misuse and other Risk Management Pitfalls

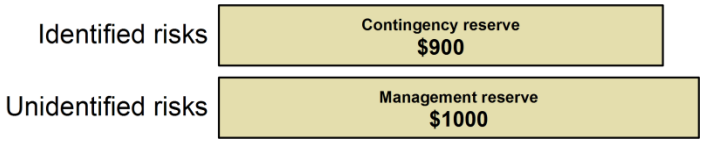
First, there's the potential for minor irregularities in the activity cost estimates. There may be insufficient detail to accurately estimate the activity cost, or the activity's cost may depend on factors not yet fully explored or decisions not yet made. For example, the activity cost may depend upon a later decision for equipment purchase between two vendors, one with a quote of $1,000 and a second with a quote of $1,300. For these types of variances a line-item **budget allowance** or **budget reserve** is generally made. These types of variances are not for unexpected occurrences but are tied specifically to a line item or activity, and it's use is generally pre-approved, meaning that the project manager has the flexibility to use as needed for the purpose intended.



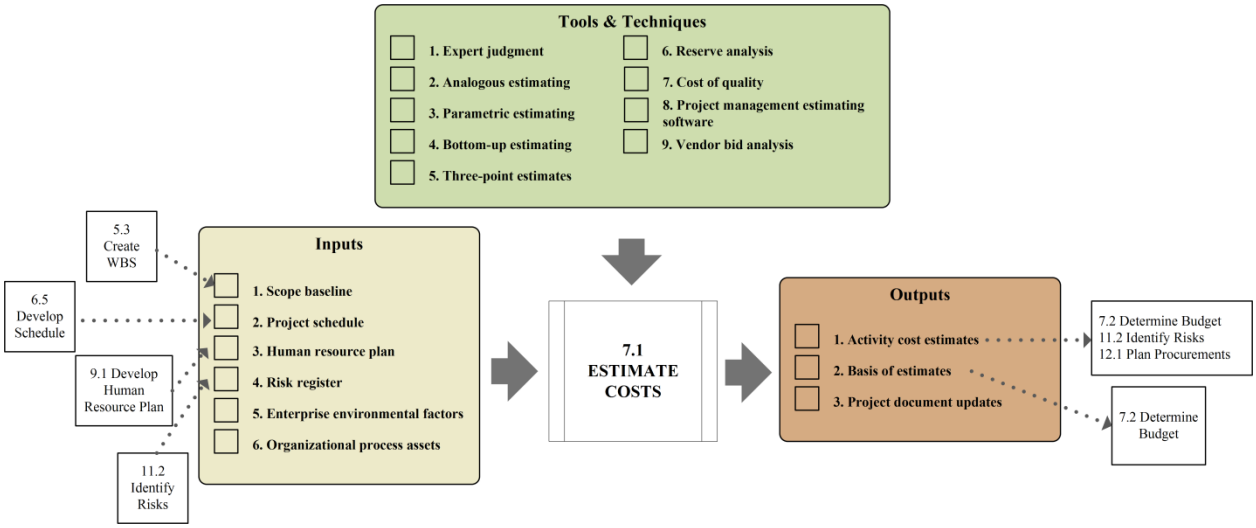
Second, every project has the potential for risk events. Those risks, their probability of occurring, and their impact on the project should they occur are quantified during risk planning. It may be necessary to set aside costs for these "known unknowns" so that the project has the financial resources to recover should they occur. Other risk events, such as those related to human resource scarcity can also create a need for reserve cost buffers distributed to sets of activities. Reserve funds of these types are **contingency reserves**, and a project may have one or more contingency reserves set aside for them. Contingency reserves are to be used at the discretion of the project manager for the risk intended. If the risk events for which contingency reserves were established don't occur, these funds are released from the project and returned to the performing organization.



Third, there are some projects that are especially likely to have significant and unforeseen scope changes. These could be projects with deliverables relying on new technology or projects whose deliverables are unconventional in their approach. The impact of a major scope shift or change in the project essentially blows the project's budget, so this third type of reserve fund is intended to help re-fund a project should these types of changes occur, and it's known as a **management reserve** because the funds are under control of the organization's upper management and not within the project manager's control.



7.1 Process decomposition



Inputs

☐ **Scope baseline**
The scope baseline is the approved project scope statement, WBS, and WBS dictionary. These collectively provide the deliverables, statements of work, constraints, and assumptions that are necessary for accurate cost estimating.

☐ **Project schedule**
The project schedule specifies the planned start and finish date for each scheduled activity, and the accompanying schedule data provides the specific activities and resource requirements.

☐ **Human resource plan**
The human resource plan contains the details on how the project will be staffed, and how the project team will be trained, evaluated, compensated, rewarded, and released from the project. It also contains labor rates, needed for estimating costs, and recognition and rewards programs for the team that must be budgeted for.

☐ **Risk register**
The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans. The level of risk inherent in any activity impacts its cost.

☐ **Enterprise environmental factors**
Factors beyond the project's boundaries impact costs, including marketplace conditions and the pool of available suppliers. Cost estimates for some activities can also use commercially available databases providing standardized estimates based on a number of categories.

☐ **Organizational process assets**
Lessons learned, project files, and historical information from the organization are crucial for good estimates. The organization may also have templates that can be used as starting points.

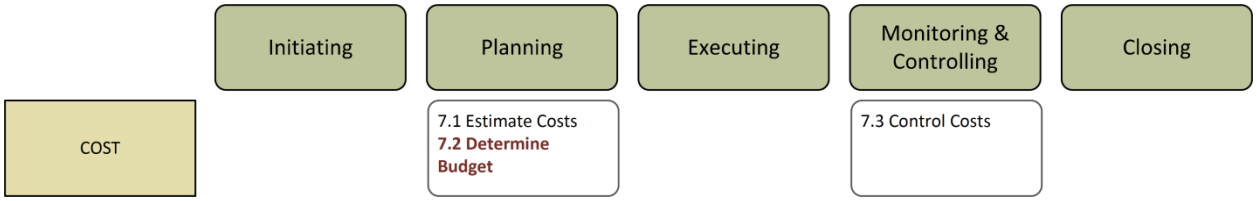
Tools and Techniques

- **Expert judgment**
  Expert judgment is a form of analogous estimating based upon the experience and knowledge of subject matter experts. It's used to assess and evaluate the inputs and the information they contain.
- **Analogous estimating**
  Analogous estimating is a form of expert judgment that uses similar activities from past projects to provide duration or cost estimates.
- **Parametric estimating**
  Parametric estimating uses mathematical formulas, usually involving quantity and productivity rates, to determine estimates.
- **Bottom-up estimating**
  Bottom-up estimating looks at all the components of an activity in order to provide estimates. These component estimates are then aggregated to derive an estimate for the activity. This is in comparison to top-down estimating, which relies heavily on expert judgment and looks only at the activity at high, overall level.
- **Three-point estimates**
  Three-point estimates provide a weighted average that helps level out some of the uncertainty in estimates. Three point estimates use the optimistic, pessimistic, and most likely estimates.
- **Reserve analysis**
  Reserves are time or cost buffers in the project schedule or budget that help the project respond to uncertainties. Reserve analysis monitors these buffers and will use, reduce, or eliminate them based on the current situation.
- **Cost of quality**
  The cost of quality quantifies the cost of adhering to the expected level of quality in the deliverables. It is a time and financial determination based on the needed level of quality the deliverable must meet.
- **Project management estimating software**
  Software and automated tools can help in developing, simulating, and reporting on estimated activity costs.
- **Vendor bid analysis**
  Vendor bid analysis involves additional techniques to ensure that the bids and work they represent are accurate, reasonable, and acceptable.

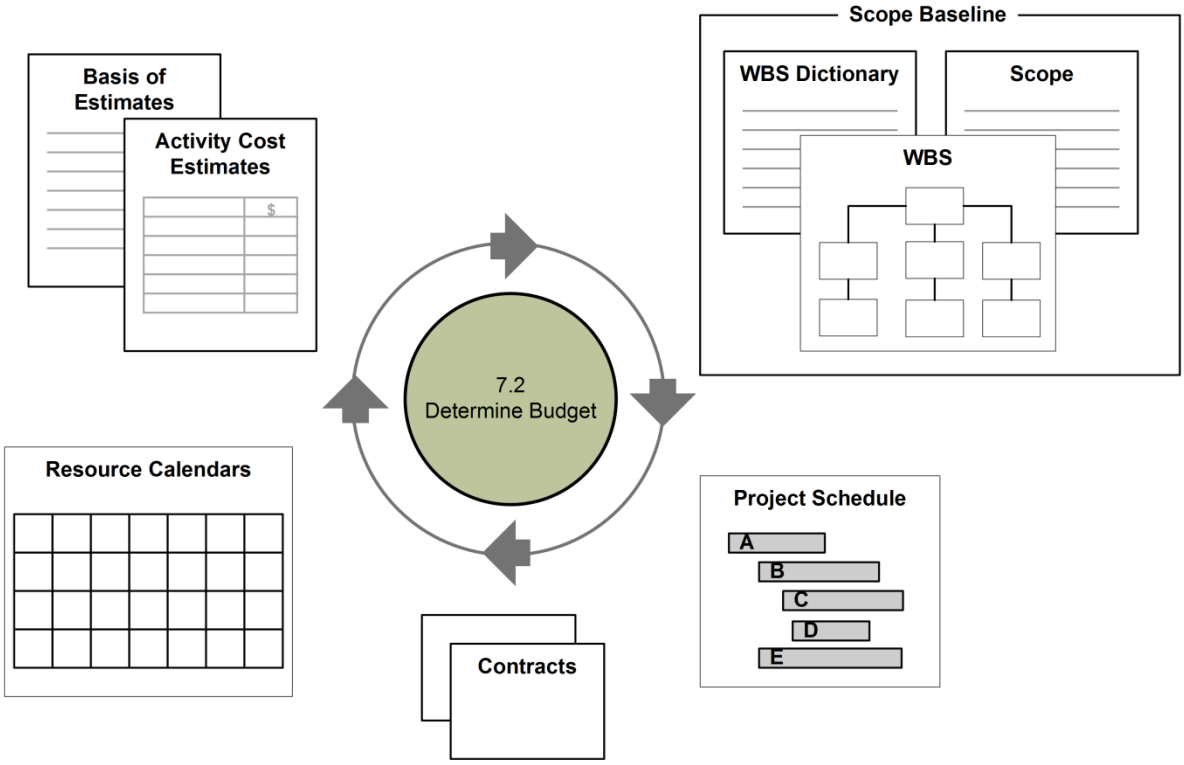
Outputs

- **Activity cost estimates**
  Activity cost estimates are a complete accounting of all component costs, such as labor, resources, services, fees, licenses, of a scheduled activity. These can be presented in detail or summary form.
- **Basis of estimates**
  Basis of estimates is the supporting detail to the activity cost estimates. What it contains depends upon the project and activity type, but it includes documentation on how the estimate was arrived at, what assumptions were made, what constraints were in place, its range of accuracy, and the confidence level in the estimate.
- **Project document updates**
  The process of estimating costs can result in updates to several project documents, including the risk register, WBS, and the WBS dictionary.

7.2 Determine budget



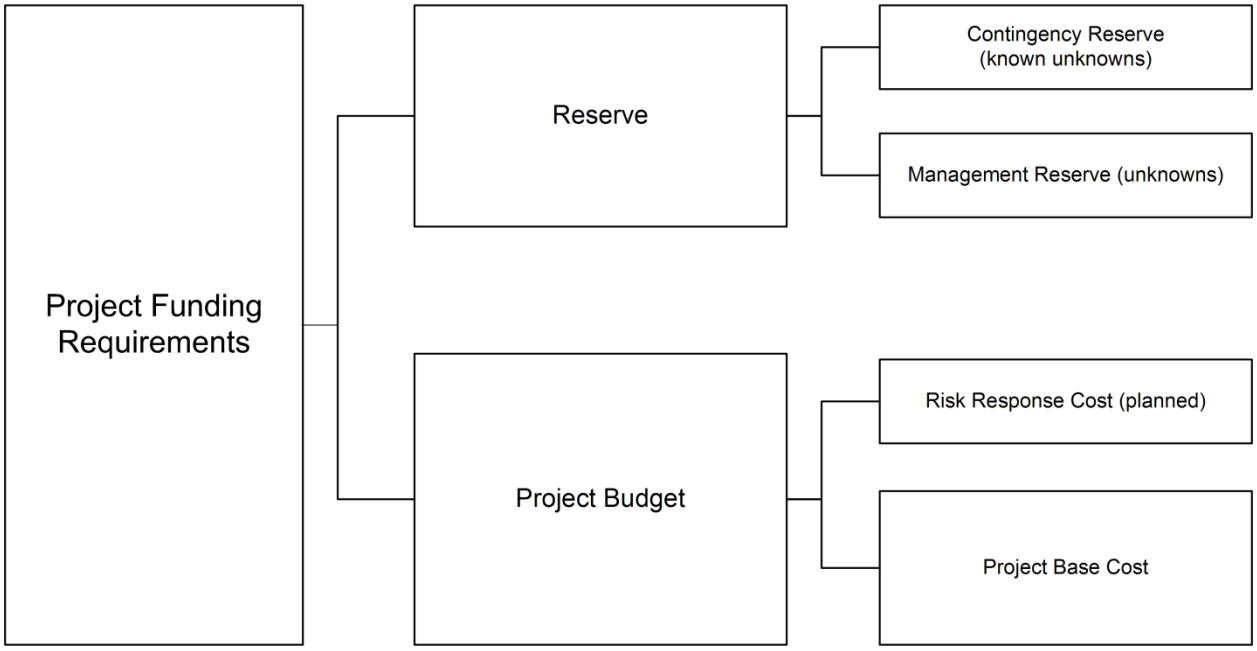
Just as its name implies, the **Determine Budget** process results in the project's funding requirements and the project cost performance baseline. This process occurs at least once on every project, but it's likely to reoccur many times during project planning and as change requests affecting costs are approved. Since project costs are so closely aligned with other project management processes, most approved change requests will directly or indirectly impact the budget.



To create the project budget and cost baseline, we'll rely primarily on the activity cost estimates, but we'll also use the project scope statement, WBS, and any project contracts since they'll contain cost constraints. Since both the project budget and project cost baseline will be aggregated to show costs by calendar periods, we'll need the schedule to determine when costs will be incurred. The WBS can also be used to aggregate the activity cost estimates to the work package and deliverable level, providing another means of cost control and reporting.

Project funding requirements

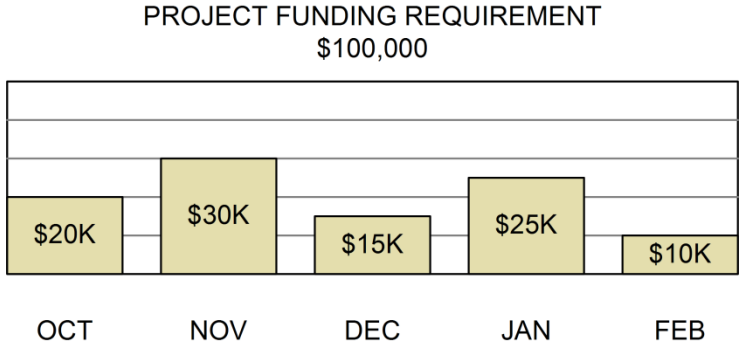
The performing organization needs to know the financial costs of the project so that it can appropriate money. The entire estimated cost of the budget, including any contingency or management reserves, is the **project funding requirements**. When we're referring to the project's *budget*, we're usually talking about project's base costs.



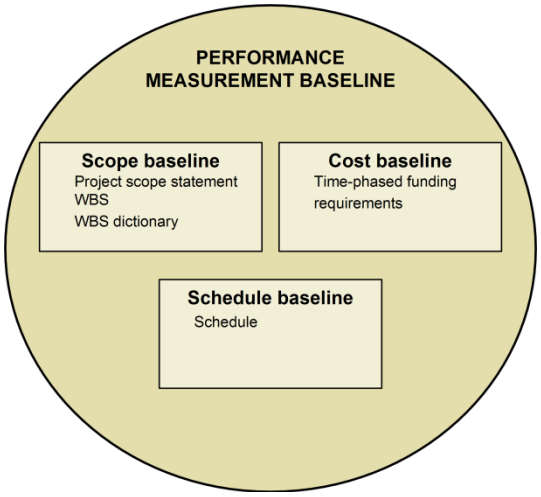
Every organization will each have different requirements and terminology for the contents and categorization of the project budget, but a budget is usually classified in the same categories as what was used by the resource breakdown structure. At a broad level, the budgetary classifications are generally:

- Reserves
- Labor/Personnel
- Professional, Contracted, or Outside Services
- Supplies, Materials
- Equipment, Hardware, and Software
- Training, Travel
- Licenses, fees
- Indirect Costs

The performing organization will also need to know when it can expect project costs to be incurred, so the project's budget is also shown by calendar periods. When broken down into a time-phased budget, this can also serve as the project cost performance baseline.

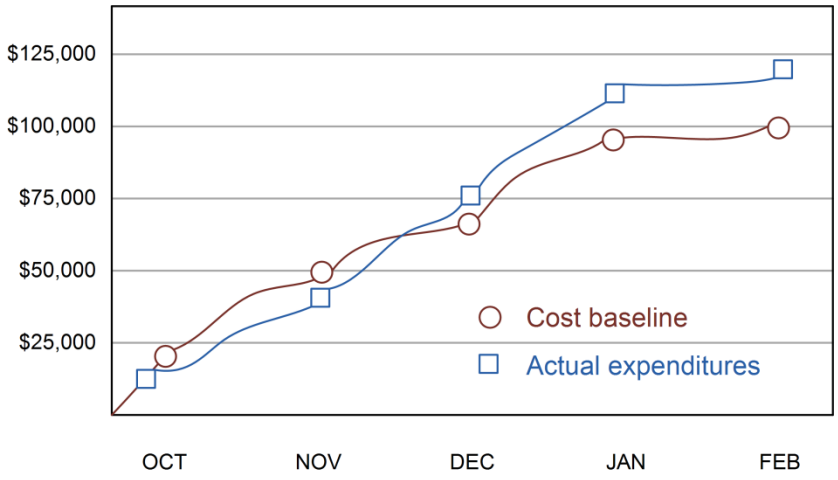


Cost performance baseline



In addition to knowing the project funding requirements, the performing organization needs to know when the project will need money. The **cost performance baseline** is a time-phased budget that is used for project cost management, monitoring, and reporting. Though they're both derived from the same source, the project budget and project cost baseline are not interchangeable terms. The project cost baseline is normally shown as an **S-curve** graph, and other project accounting measures, like its actual project expenditures, are also shown plotted on the graph.

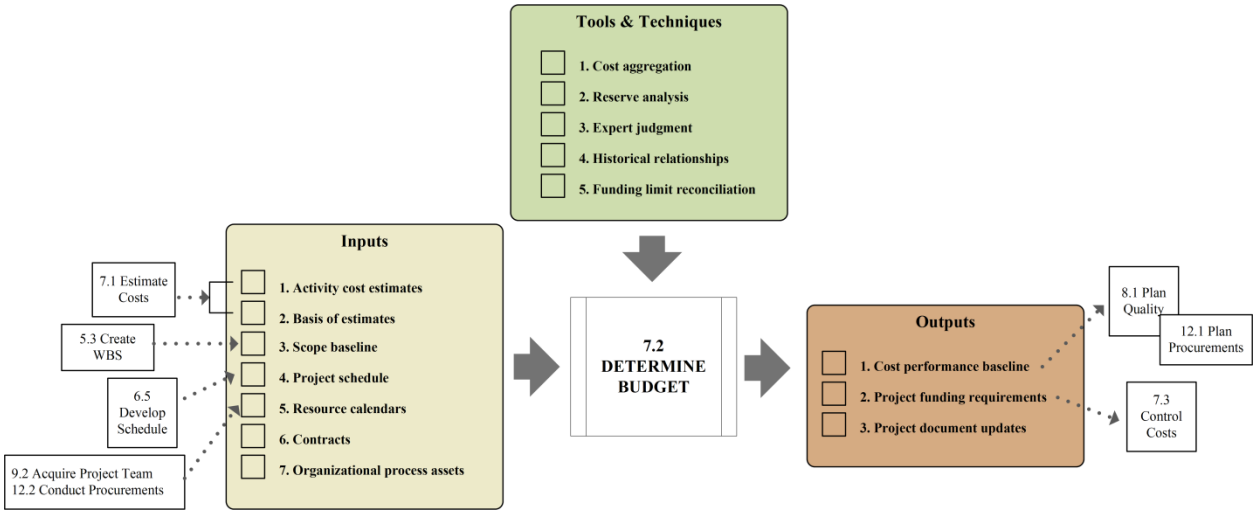
The project cost baseline can effectively show many different views of project performance. Because it's such a useful graph, a project to have several different cost-related baselines that will focus on specific cost categories, such as labor costs, raw material costs, or any other cost classification that's necessary for monitoring. Just as with all other baselines, the cost baseline reflects all approved changes.



Funding limit reconciliation

Funding limit reconciliation matches the project's planned need for funding with the organization's ability to provide that funding. It can be thought of as "resource leveling" for finances because it reschedules activities to make sure that the budget for the scheduled activities doesn't exceed the available budget for that period. For instance, if the estimated cost for scheduled activities in the second month of a project is estimated to be $50,000, but the organization can only provide funding for $40,000 then there is $10,000 of work that has to be rescheduled to another month.

7.2 Process decomposition



Inputs

☐ **Activity cost estimates**
Activity cost estimates are a complete accounting of all component costs, such as labor, resources, services, fees, licenses, of a scheduled activity. These can be presented in detail or summary form.

☐ **Basis of estimates**
Basis of estimates is the supporting detail to the activity cost estimates. What it contains depends upon the project and activity type, but it includes documentation on how the estimate was arrived at, what assumptions were made, what constraints were in place, its range of accuracy, and the confidence level in the estimate.

☐ **Scope baseline**
The scope baseline is the approved project scope statement, WBS, and WBS dictionary. These collectively provide the deliverables, statements of work, constraints, and assumptions that are necessary for accurate budgeting.

☐ **Project schedule**
The project schedule specifies the planned start and finish date for each scheduled activity, and the accompanying schedule data provides the specific activities and resource requirements. The schedule is used to aggregate activity costs by calendar period.

☐ **Resource calendars**
Resource calendars indicate when and in what quantity resources are assigned to the project. These calendars help aggregate activity costs by calendar period.

☐ **Contracts**
If applicable to the project, contracts with outside personnel and organizations indicate monetary arrangements including payment amounts and schedule, which are necessary for budgeting.

- **Organizational process assets**
  The organization will have formal or informal budgeting policies and procedures that must be followed. It may also provide tools that aid in project budgeting.

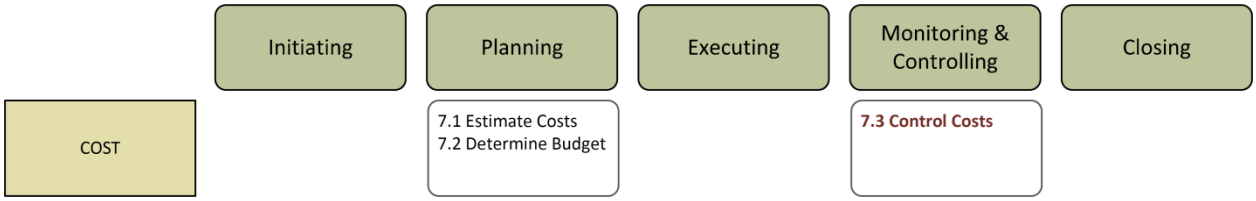
Tools and Techniques

- **Cost aggregation**
  Individual costs are aggregated in many different ways for budgeting purposes, including at the work package, deliverable, summary activity, or other classification levels.
- **Reserve analysis**
  Reserves are time or cost buffers in the project schedule or budget that help the project respond to uncertainties. Reserve analysis monitors these buffers and will use, reduce, or eliminate them based on the current situation.
- **Expert judgment**
  Expert judgment is based upon the experience and knowledge of subject matter experts. It's used to assess and evaluate the inputs and the information they contain.
- **Historical relationships**
  Historical relationships refer to the characteristics of the current and past projects that can be used to develop models that aid in budgeting.
- **Funding limit reconciliation**
  Funding limit reconciliation matches the project's planned need for funding with the organization's ability to provide that funding. It can be thought of as "resource leveling" for finances because it reschedules activities to make sure that the budget for the scheduled activities doesn't exceed the available budget for that period.

Outputs

- **Cost performance baseline**
  The cost performance baseline is a time-phased budget that is used for project cost management, monitoring, and reporting. It is commonly shown as an S-curve graph. The cost baseline is a component of the project performance baseline.
- **Project funding requirements**
  Project funding requirements refers to the entire estimated cost of the budget, including any contingency or management reserves.
- **Project document updates**
  The budgeting process can result in updates to several project documents, including the risk register, activity cost estimates, and the project schedule.

7.3 Control costs

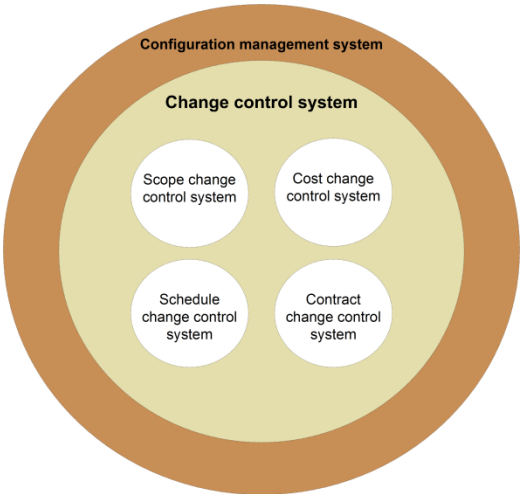


The **Control Costs** process is concerned with controlling, managing, forecasting, and analyzing project costs. It begins as soon as the project budget is approved, and the major activities are:

- Proactively influencing the factors that can lead to cost changes
- Monitoring and reporting
- Managing approved change request and making sure all budget components reflect those changes
- Analyzing variances (even beneficial variances), determining their causes, and documenting them as lessons learned
- Monitoring variances and performance trends and making requests for corrective or preventative actions
- Forecasting project costs

Cost control system

The **project cost change control system** provides the processes and procedures for requesting, logging, reviewing, and implementing cost changes. It is a component of the project change control system, and since most project changes have a cost ramification, it's important for the cost change control system to be well-established and communicated so that everyone knows the procedures to follow. Some projects will require a very extensive, detailed, and rigid system of change control while others may not have a need for a cost control system that's distinct from the project change control system.



One of the project manager's most important cost control functions is to proactively influence the causes of change, and this includes discouraging unnecessary changes that will impact costs. This is not to say that projects should have no changes, but only that *unnecessary* changes must be deterred.

Earned value management

One of the most common cost control techniques is Earned Value Management (EVM). **Earned value** provides a consistent method for monitoring project cost and schedule performance using budgeted work and actual work completed as its basis. Earned value analysis is useful because if the project manager only focuses on work completed versus planned work completed or on actual project costs versus planned project costs, the project may appear to be on-track and healthy when in fact it's behind schedule or over budget.

> ...EV is a measurement of quantity, not *quality*, of work accomplished. A PM should ensure that EV also measures the quality and technical maturity of the technical work products instead of just the quantity of work.[6]
>
> Paul Solomon, Integrating Systems Engineering with Earned Value Management

Because all earned value formulas are closely tied with the schedule and aggregated budgeted activity costs, earned value formulas provide measurements that when taken regularly can identify trouble spots early and give the project manager enough time to take corrective actions. Earned value measurements are taken routinely throughout the project, usually at predefined periods, such as monthly, but generally only after about 20% of the project is work is completed because the EVM measurements are helpful only after there's sufficient data from execution activities.

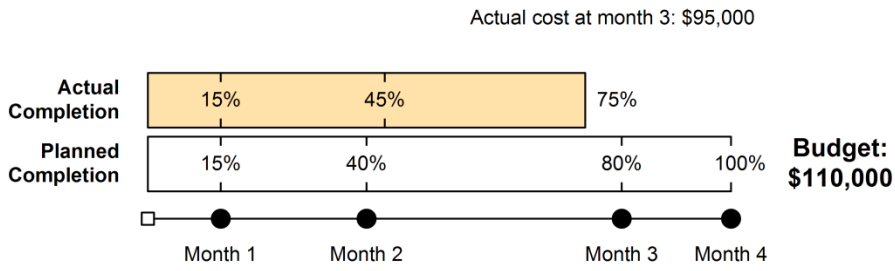
Earned value analysis can also be used to provide performance information for phase-gate decisions, such as whether to continue with the project or not. In these go/no-go decisions, costs already incurred by the project are called **sunk costs**, and though tempting to use as justification for continuing a project, sunk costs shouldn't be a factor in those decisions.

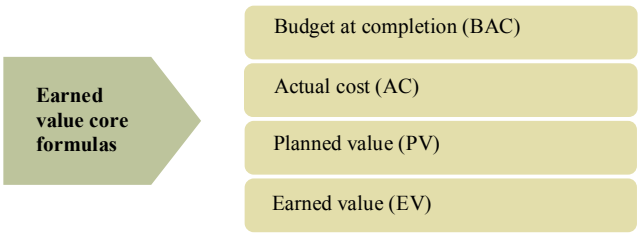
The earned value measurements help identify what project components aren't performing as planned, but they will not identify why. So we have to find out the causes of those variances, even if the variance is beneficial. No project performs perfectly as planned, so EVM values that are regularly reported as perfect are probably an indication that something is awry with the calculations or underlying data.

> EVM is not about producing perfect scores...[it's] to see how close we are against what we planned, and when we're not close, to ask, 'Why aren't we there, and what are we doing about it?'[7]
>
> Marilyn S. McCauley, owner of McManagement Group

In our study of the earned value formulas, we're going to use the following example throughout:

- 4-month project: Total budget $110,000.
- Project cost at end of month three: $95,000
- Estimated work complete at end of month three: 80%
- Actual work complete at end month three: 75%





Budget at completion

The **budget at completion (BAC)** is simply the total budgeted cost of the project. In our earned value example, the budget at completion is $110,000. The BAC is the aggregated amount of the scheduled activity cost estimates. Let's say that our sample project is made up of 5,500 hours of work at $20 per hour. Our BAC was arrived at by aggregating those activity costs ($20 x 5,500 = $110,000).

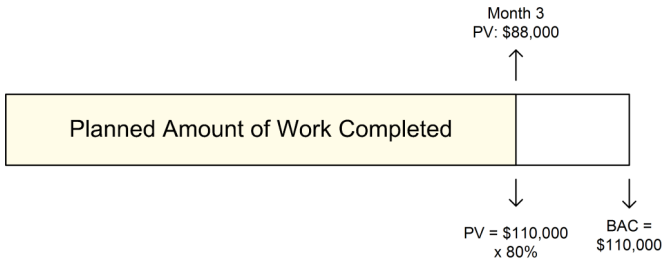
Actual cost

Actual cost (AC) is the expenditures spent thus far or at a specific point in time on the project. There is no formula for actual cost. In our example, our actual cost at the end of month three is $95,000.

Actual cost is not only the hard expenses incurred by the project. Actual cost will include the soft internal or indirect expenses of the project. For example, in an organization that isn't projectized and that doesn't establish a general ledger for projects, the labor costs of internal personnel will not be directly charged to the project. The project manager will have to use some method, such as the time worked by these project team members, to create an actual cost that can be used for earned value measurements.

Planned value

Planned value (PV) is how much work was expected to be completed. Planned value is shown as a monetary value based on the project's BAC. There are alternative methods that show planned value as a unit of time (compared to the project's estimated hours), but the PMP examination questions will only present planned value as money.



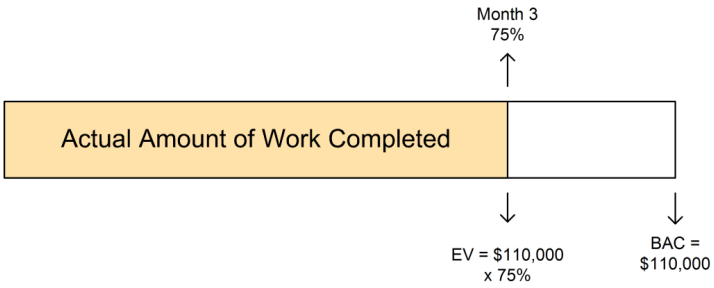
The formula for planned value is: **`PV = Planned % Complete x BAC`**

In our example at the end of month three:

```
PV = 80% x $110,000
PV = $88,000
```

Earned value

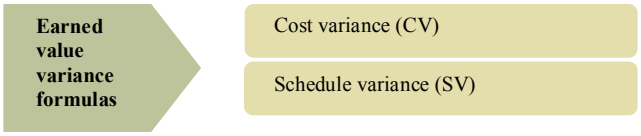
Earned value (EV) is how much work has actually been completed. Just like planned value, it's shown as a monetary value based on the project's BAC.



The formula for earned value is: **EV = Actual % Complete x BAC**

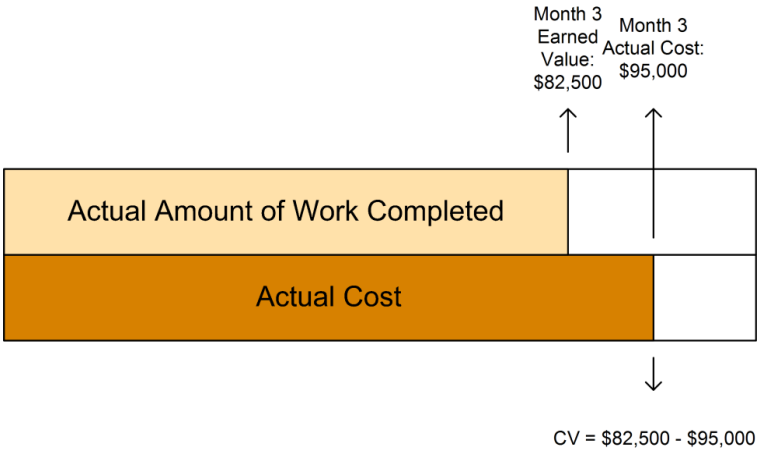
In our example at the end of month three, 75% of the scheduled work has been completed:

```
EV = 75% x $110,000
EV = $82,500
```



Cost variance

Cost variance (CV) shows how the cost of the project is comparing to the value of work completed. It does this by calculating the difference between actual cost and earned value. A negative CV result indicates that the project has spent more than what was expected.



The formula for cost variance is: **CV = EV - AC**

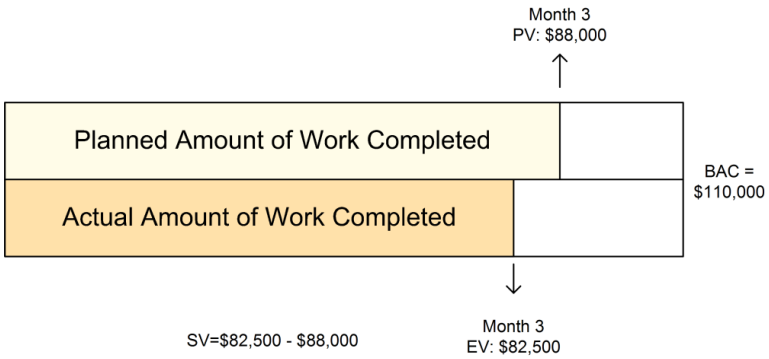
In our example at the end of month three:

```
CV = $82,500 - $95,000
CV = ($12,500)
```

This negative cost variance shows us that our sample project is running over budget.

Schedule variance

Schedule variance (SV) tells us how well the actual work performed compares to the planned schedule. It does this by calculating the difference between earned value and planned value. A negative PV result indicates that work on the project is behind what was scheduled while a positive value indicates that work is ahead is schedule.



The formula for schedule variance is: **SV = EV - PV**

In our example at the end of month three:

```
SV = $82,500 - $88,000
SV = ($5,500)
```

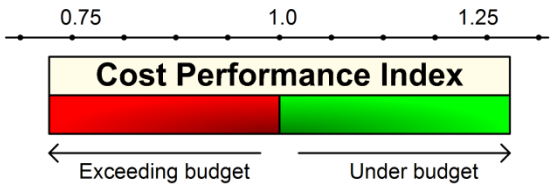
This negative schedule variance indicates that the amount of work actually completed is running behind what was scheduled to be completed.

Earned value performance formulas

- Cost performance index (CPI)
- Cumulative CPI
- Schedule performance index (SPI)
- Cumulative SPI

Cost performance index

The **cost performance index (CPI)** shows how much work is being completed on the project for every unit of cost spent. A CPI of below one indicates that the project work is costing more than expected while a CPI of above one means the project work is being completed at a lesser cost than original expected.



The formula for the cost performance index is: **CPI = EV / AC**

In month three in our sample project, we have an actual cost of $95,000 and an earned value of $82,500:

```
CPI = $82,500 / $95,000
CPI = 0.868
```

For every $1 in cost, our sample project is earning only $0.87 in work output.

Cumulative cost performance index

The **cumulative cost performance index (CPI^C)** provides a more accurate overall performance index for the project based on earlier CPI measurements. Rather than just being focused on one point in time, cumulative CPI uses the aggregate of the previous EV and AC measurements.

The formula for cumulative CPI is: **$CPI^C = EV^C / AC^C$**

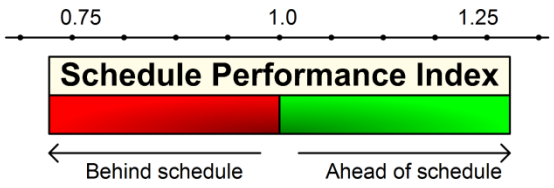
In order to see cumulative CPI, let's assume that we have earned value measurements for the previous two months in our project.

Month	Planned Complete	Actual Complete	Actual Cost	Planned Value	Earned Value	CPI
One	25%	30%	$30,000	$27,500	$33,000	1.1
Two	40%	45%	$47,000	$44,000	$49,500	1.05
Three	80%	75%	$95,000	$88,000	$82,500	0.868
			$172,000		$165,000	

```
CPI^C = $165,000 / $172,000
CPI^C = 0.959
```

Schedule performance index

The **schedule performance index (SPI)** shows how close actual work is being completed compared to the schedule. It's similar to the CPI in that a SPI of below one means that the project work is going slower than expected while a SPI greater than one means that project work is being completed faster than originally expected.



The formula for schedule performance index is: **SPI = EV / PV**

In our example at month three, its planned value is $88,000 and its earned value stands at $82,500:

```
SPI = $82,500 / $88,000
SPI = 0.938
```

For every hour we originally estimated, our project team is actually completing only 0.94 hours.

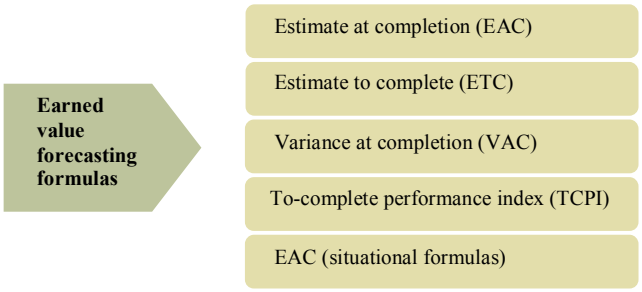
Cumulative schedule performance index

The **cumulative schedule performance index (SPI^C)** provides a more accurate overall performance index for the project based on earlier SPI measurements. Rather than just being focused on one point in time, cumulative SPI uses the aggregate of the previous EV and PV measurements.

Month	Planned Complete	Actual Complete	Planned Value	Earned Value
One	25%	30%	$27,500	$33,000
Two	40%	45%	$44,000	$49,500
Three	80%	75%	$88,000	$82,500
			$159,500	$165,000

The formula for cumulative SPI is: **SPI^C = EV^C / PV^C**

```
SPIC = $165,000 / $159,500
SPIC = 1.04
```



Estimate at completion

The **estimate at completion (EAC)** formula forecasts the total cost of the project based on current project performance. There are at least 20 different ways to calculate estimate at completion, and some of those different formulas are based on unique situations. Those alternate formulas are shown at the end of this chapter. But the easiest formula, and the one we'll most likely encounter on the examination is the project's estimated budget at completion divided by its cost performance index. If cumulative CPI is available, it can be used in place of a single CPI measurement.

The formula for estimate at completion is: **EAC = BAC / CPI** or **EAC = BAC / CPI^C**

In our example at month three, our budget at completion is $110,000 and the CPI is 0.868:

```
EAC = $110,000 / 0.868
EAC = $126,728.11
```

This tells us that when our project is completed, its total cost will be just under $127,000.

Estimate to complete

The **estimate to complete (ETC)** formula forecasts how much more money will be required to finish the project. As with the EAC, there are some alternative formulas that can be used based on differing situations.

A common formula for ETC is: **ETC = EAC - AC**

In our example at month three:

```
ETC = $126,728.11 - 95,000
ETC = $31,728.11
```

Based on current performance, our project is going to take just under $32,000 to get it finished.

Variance at completion

The **variance at completion (VAR)** predicts what the difference between the budgeted project cost and actual project cost will be at the conclusion of the project. A negative variance indicates a budget overrun while a positive variance indicates that the project is expected to come in under budget.

The formula for variance at completion is: **VAR = BAC - EAC**

In our example at month three:

```
VAR = $110,000 - $126,728.11
VAR = ($16,728.11)
```

Based on current performance, our project will run about $17,000 over budget.

To-complete performance index

The **to-complete performance index (TCPI)** tells us what performance must be achieved to meet either the budget at completion or estimate at completion. Whether the performance needed by the TCPI can be achieved depends upon the likelihood of meeting the TCPI throughout the remainder of the project.

Based on our sample project, at month three we have:

- Earned value of $82,500
- Actual cost of $95,000
- Budget at completion of $110,000
- Estimate at completion of $126,728.11

The formula for TCPI to meet the BAC is: **TCPI = (BAC – EV) / (BAC – AC)**

```
TCPI = ($110,000 - $82,500) / ($110,000 - $95,000)
TCPI = $27,500 / $15,000
TCPI = 1.83
```

The formula for TCPI to meet the EAC is: **TCPI = (BAC – EV) / (EAC – AC)**

```
TCPI = ($110,000 - $82,500) / ($126,728.11 - $95,000)
TCPI = $27,500 / $31,728.11
TCPI = 0.867
```

EAC and ETC situational formulas

There are a few situations that can occur on the project which will cause inaccurate measurements if the standard EAC and ETC formulas are used. These situations are based around variances from the project plan, and the variances are either caused by original estimates that were inaccurate or anomalies that have thrown the project's schedule or cost off.

When large variances do occur, we have three ways to deal with them.

New Estimate: First, we might develop a new estimate to complete that isn't based on the ETC formula we saw above. Instead, it's just an updated aggregation of revised activity cost estimates from this point in the project going forward.

Atypical Variances: Second, we can use alternative ETC formulas if the variances that have occurred are simply so unusual that they aren't expected to happen again.

Typical Variances: Third, there are alternative ETC formulas that we can use if the variances that have occurred are going to be typical for the duration of the project.

EAC based on a new estimate:
If a new ETC estimate is created, the alternative EAC formula is actual cost plus the new estimate to complete. EAC = AC + ETC

ETC based on new estimate:
This is just the new estimate to complete based on revised activity cost estimates. There is no formula for ETC based on a new estimate.

EAC based on atypical variances:
If the variances are not expected to reoccur then the alternative EAC formula is the actual cost plus the budgeted cost to complete the rest of the project. EAC = AC + (BAC - EV)

ETC based on atypical variances:
This alternate ETC formula uses cumulative earned value. ETC = (BAC - EV^C)

EAC based on typical variances:
When current variances are expected to continue throughout the project, an alternative EAC formula factoring in cumulative CPI is used. EAC = AC + ((BAC - EV)/CPI^C))

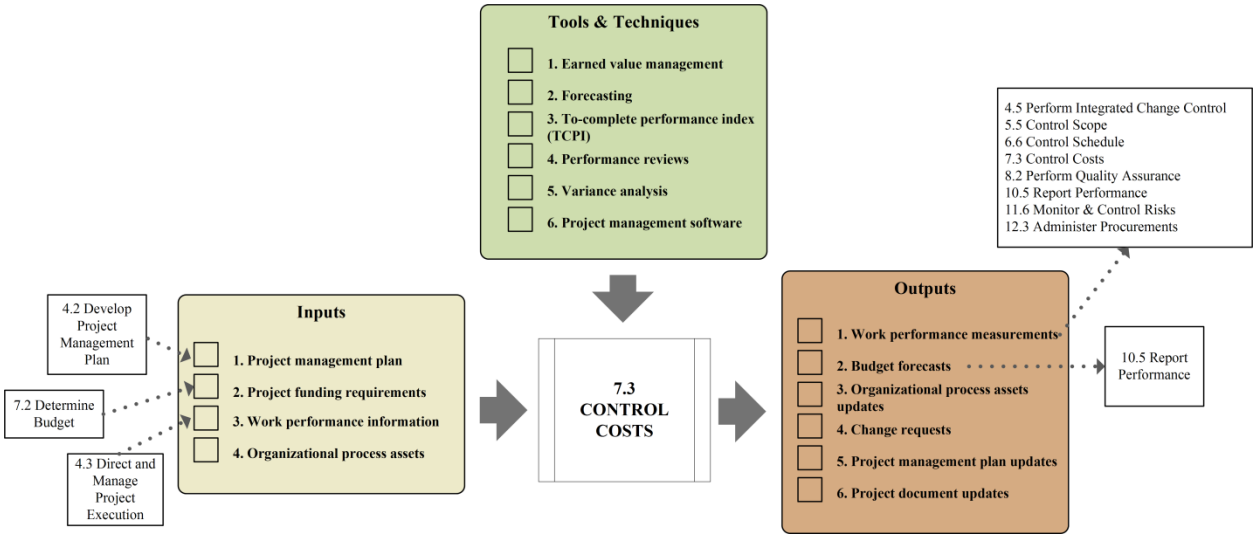
ETC based on typical variances:
This formula factors in cumulative CPI. ETC = (BAC - EV^C)/CPI^C

Earned value formulas

Acronym	Name	Formula
AC	Actual Cost	AC = Actual cost of the project up to the measurement period
BAC	Budget at Completion	BAC = The total budgeted cost of the project
EV	Earned Value	EV = Actual % Complete x BAC
PV	Planned Value	PV = Planned % Complete x BAC
CV	Cost Variance	CV = EV – AC
SV	Schedule Variance	SV = EV - PV
CPI	Cost Performance Index	CPI = EV / AC
CPI^C	Cumulative Cost Performance Index	$CPI^C = EV^C / AC^C$
SPI	Schedule Performance Index	SPI = EV / PV
SPI^C	Cumulative Schedule Performance Index	$SPI^C = EV^C / PV^C$
EAC	Estimate at Completion	EAC = BAC / CPI
ETC	Estimate to Complete	ETC = EAC – AC
VAR	Variance at Completion	VAC = BAC - EAC
TCPI	To-Complete Performance Index for BAC	TCPI = (BAC – EV) / (BAC – AC)
TCPI	To-Complete Performance Index for EAC	TCPI = (BAC – EV) / (EAC – AC)

What are we looking for?	**Which EV formula to use?**
What will the total cost of the project be at completion?	EAC
How much more money will it take to finish the project?	ETC
How much over or under budget will the total project cost be?	VAR
How much work was expected to be finished at this point in time?	PV
How much work has actually been completed at this point in time?	EV
How much more or less has the completed work cost compared to what was planned?	CV
How much more or less work has been accomplished compared to what was planned?	SV
How much is the work being completed costing compared to what was planned?	CPI
How does the work being completed compare to what was planned in the schedule?	SPI
What level of performance must future project work meet in order to meet the budget?	TCPI based on BAC
What level of performance must future project meet in order to meet the project's cost based on past performance?	TCPI based on EAC

7.3 Process decomposition



Inputs

- ☐ **Project management plan**
  The project management plan includes the cost management plan, which describes how project costs will be managed, reported on, and controlled. The cost performance baseline is also part of the project management plan, and it's used to compare actual costs to planned costs.
- ☐ **Project funding requirements**
  Project funding requirements refers to the entire estimated cost of the budget, including any contingency or management reserves. It's used to compare actual costs to planned costs.
- ☐ **Work performance information**
  Work performance information is any data that can be considered related to the work which produces the project deliverables. Examples are schedule and progress status information, budget and cost status, quality status, estimates to complete, resource utilization information, and lessons learned.
- ☐ **Organizational process assets**
  Organizational process assets are the source of existing policies, processes, organizational data and knowledge. The organization may have cost-related policies, procedures, and reporting methods that must be followed.

Tools and Techniques

- ☐ **Earned value management**
  Earned value management mathematically measures the performance of the project and provides formulas that forecast future results. It also provides a way to forecast future performance based on what's happened thus far with the project.
- ☐ **Forecasting**
  Forecasting involves predicting future performance based on historical work performance information and expert judgment. EVM provides forecasting formulas.

- **To-complete performance index (TCPI)**
  TCPI is a formula that provides the level of performance that must be achieved to meet either the budget at completion (BAC) or the estimate at completion (EAC).
- **Performance reviews**
  Performance reviews are assessments that analyze the project's historical cost performance. It can include earned value measurements, variance analysis, and trend analysis.
- **Variance analysis**
  Variance analysis compares expected cost performance to what is actually occurring, and determines the causes of any variance uncovered. Variance analysis also makes a determination whether requests for preventative or corrective actions will be made.
- **Project management software**
  Automated tools can help in monitoring, tracking, and reporting on earned value measurements.

Outputs

- **Work performance measurements**
  This includes work performance information that specifically provides mathematical measurements of performance that is communicated to stakeholders. It may also report on earned value values for WBS components or control accounts within the WBS.
- **Budget forecasts**
  Forecasts on the project's expected completion cost and variances is documented and provided to stakeholders throughout the project.
- **Organizational process assets updates**
  Updates to the organizational or institutional knowledge base occurs as part of cost control, including lessons learned, corrective actions taken and the reasons, and the causes of financial variances.
- **Change requests**
  Changes to the cost baseline or any component of the project management plan may be needed as part of this process.
- **Project management plan updates**
  Approved changes will impact the project management plan. The most likely component subject to change is the cost performance baseline.
- **Project document updates**
  Lessons learned, basis of estimates, and activity cost estimates are project documents likely to undergo revisions.

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Chapter summary

The Project Cost Management knowledge area provides processes to estimate activity costs, develop the project funding requirements and cost baseline, and monitor and control project costs. The project cost management plan establishes how project costs will be planned for, estimated, structured, reported on, and managed.

The Estimate Costs process uses the scope baseline, schedule, human resource plan, and the risk register as the basis for establishing anticipated costs for every scheduled activity. This process will result in cost estimates for activities and a basis of estimates document that is supporting detail for the estimates. There are many factors that influence cost estimates. Risks are the primary factor, but total cost of ownership (life-cycle costing), cost of quality, and marketplace conditions are other factors. To help determine cost estimates, commercial databases, historical information, project files from other projects, project team expertise, and lessons learned from other projects can be referenced.

Applicable to both the Estimate Costs and Determine Budget processes, reserve analysis uses different techniques to plan for "known unknowns" (risks) that may cause cost variances. The three types of reserves are budget reserve, contingency reserve, and management reserve. Budget reserves are allocated specifically to an activity, while contingency reserves are allocated specifically to a potential identified risk. Management reserves are usually held for large scope changes or extraordinary risk events, and are disbursed only by upper management to re-fund the project should those events occur.

The Determine Budget process establishes the project funding requirements and the cost performance baseline. The project funding requirements is the total financial need of the project and the project cost baseline is the project budget based on calendar period. The cost baseline comes into existence when the project budget is approved, and the baseline is shown as an S-curve.

The Control Costs process is about proactively managing project costs, variance analysis, forecasting, and reporting on project cost performance. Any requested changes that affect costs will be directed through the cost change control system, which establishes the procedures for logging, reviewing, approving or denying change requests. Approved changes will result in updates to the cost performance baseline.

Earned Value Management is an important part of cost monitoring, reporting, and forecasting. EVM provides formulas for monitoring project cost and schedule performance. It's important to establish regular intervals where EVM measurements will be taken, and we'll need to know all the EVM formulas for our PMP examination.

Earned Value (EV): EV = Actual % Complete x BAC	Estimate at Completion (EAC): EAC = BAC / CPI
Planned Value (PV): PV = Planned % Complete x BAC	Estimate to Completion (ETC): ETC = EAC – AC
Cost Variance (CV): CV = EV – Actual Cost (AC)	Variance at Completion (VAR): VAC = BAC - EAC
Schedule Variance (SV): SV = EV - PV	To-complete (TCPI) for BAC: TCPI=(BAC – EV) / (BAC – AC)
Cost Performance Index (CPI): CPI = EV / AC	To-complete (TCPI) for EAC: TCPI=(BAC – EV) / (EAC – AC)
Schedule Performance Index (SPI): SPI = EV / PV	

Exam summary

☐ The PMBOK's sequencing is scope development, schedule development, and then budget development.

☐ The Estimate Costs process establishes anticipated costs for all scheduled activities.

☐ The primary inputs to the Estimate Costs process are the scope statement, work breakdown structure, WBS dictionary, schedule, human resource plan, and the risk register.

☐ Direct costs can be attributed specifically to the project.

☐ Indirect costs are incurred by the project, but the goods or services are used by other projects or the organization for activities beyond the project.

☐ Fixed costs are static throughout the project.

☐ Variable costs can fluctuate throughout the project.

☐ Reserve analysis plans for cost variances by establishing reserve funds.

☐ Contingency reserves are set aside for project risks.

☐ Management reserves are set aside for potential large scope changes or for projects with extraordinary risks.

☐ The outputs of the Estimate Costs process are the activity cost estimates and their supporting detail, called the basis of estimates.

☐ The Determine Budget process establishes the cost performance baseline and the project funding requirements.

☐ The project funding requirements is the total financial need of the project, including reserves.

☐ The project cost baseline is the time-phased budget for the project.

☐ The project cost baseline is usually shown as an S-curve.

☐ Funding limit reconciliation matches the project's need for funds with the organization's ability to allocate to funds.

☐ Control Costs manages, forecasts, and analyzes project costs.

☐ The cost change control system is part of the overall project change control system, which is part of Integrated Change Control.

☐ Costs already incurred by the project are sunk costs.

☐ The primary inputs to the Control Costs process are the cost baseline, project funding requirements, performance reports, and work performance information.

☐ The primary outputs are performance measurements and forecasted completion information.

☐ Earned value analysis is a technique for determining variances and making forecasts about project performance.

☐ Budget at completion is the total budgeted cost of the project.

☐ Actual cost is the expenses incurred by the project up to a specific point in time.

☐ Planned value is how much work, expressed in monetary value, was expected to be completed up to a specific point in time.

☐ The formula for PV is: PV = Planned % Complete x BAC

☐ Earned value is how much work, expressed in monetary value, has been completed up to a specific point in time.

☐ The formula for EV is: EV = Actual % Complete x BAC

☐ Cost variance compares actual cost and earned value, showing how actual costs compare to the value of work completed.

☐ The formula for CV is: CV = EV – AC

☐ Schedule variance compares the value of the actual work completed to the value of the planned work.

☐ The formula for SV is: SV = EV – AC

☐ The cost performance index shows much work is being completed on the project for every unit of cost spent.

☐ The formula for CPI is: CPI = EV / AC

☐ Cumulative CPI uses aggregated EV and AC measurements to provide an overall CPI for the project.

☐ The schedule performance index shows how actual work is comparing to the scheduled work.

☐ The formula for SPI is: SPI = EV / PV

☐ The estimate at completion forecasts the final project cost based on current cost performance.

☐ The most common EAC formula is: EAC = BAC / CPI

☐ The estimate to complete is how much more money will be required to the finish the project.

☐ The most common formula for ETC is: ETC = EAC – AC

☐ The variance at completion is the difference between the original project budget and the estimate at completion.

☐ The formula for VAR is: VAR = BAC - EAC.

☐ The to-complete performance index tells us what level of performance must be achieved to meet the budget at completion or estimate at completion.

☐ The formula for TCPI to meet the BAC is: (BAC – EV) / (BAC – AC)

☐ The formula for TCPI to meet EAC is: (BAC – EV) / (EAC – AC)