U08784
SOFTWARE PROJECT MANAGEMENT

Lecture 5: Project Cost Management

Peter Lo

How to control cost?

- Follow the cost management plan
- Look at any organizational process asset that are available
- Manage change
  - Recording all appropriate change
  - Preventing incorrect change
  - Ensuring requested changes are agreed upon
  - Managing the actual changes when and as they occur
- Measure and measure and measure (monitoring)

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A project's success rests on two parameters, teams working within allocated budgets and timely delivery. PMP Training equips managers with the skills to utilize resources and successfully complete projects.

In a paper titled "The Essentials of Project Management" authors Lock and Grower suggest that the success of project depend primarily on three factors, Project completion within the cost budget, deliver of project on time, and good performance which is the completion of all aspects of the project as per specifications and goals. Here, the focus remains on the first two parameters, namely budget control and adherence to time limits. Of course, complete control can never be achieved because of variables that can directly or indirectly affect the project. However, the principles of management Imbibed through PMP Training can positively impact the outcome of a project.

Cost Management Plan

- The cost management plan establishes the format and conditions you'll use to plan for project costs.
- This plan is established using the WBS and its associated control accounts
- Some of the elements of this plan are:
  - Level of accuracy
  - Units of measure
  - Organizational procedures links
  - Control thresholds
  - Rules of performance measurement
  - Reporting formats
  - Process descriptions

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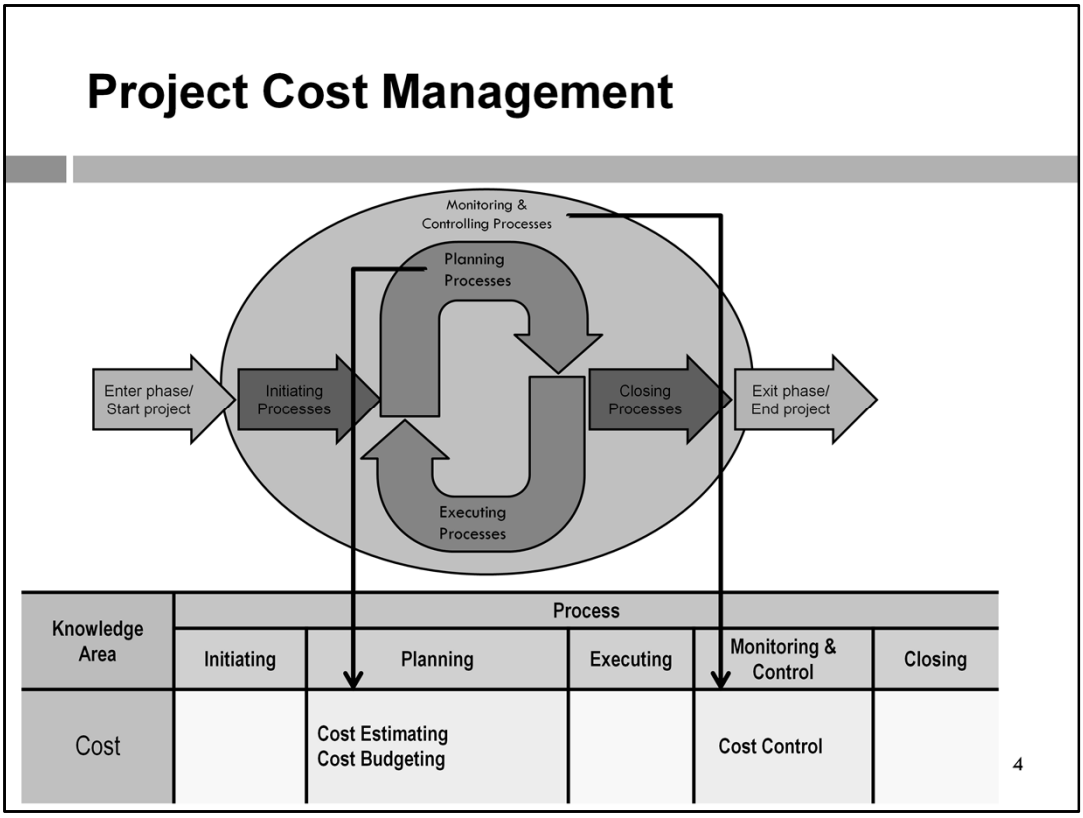
Either formal or informal, highly detailed or broadly framed can establish:

- Level of accuracy (rounding of data, $100, $1000) based on the scope and may include an amount for contingencies
- Units of measure (staff hours, staff days, weeks or lump sum) for each recourses
- Organizational procedures links (the WBS component used for the project cost accounting is called the Control Account (CA), has a unique code or account numbers linked directly to organization's accounting system
- Control thresholds (variance thresholds for monitoring cost performance, agreed upon before any action is taken, expressed as percentage)
- Rules of performance measurement
  - Define WBS points where control accounts will be performed
  - Establish the earned value measurement techniques (weighted milestone, fixed formula, percent complete, ...)
  - Specify the earned value management computation equations for determining the projected Estimate at Completion (EAC) forecasts and other tracking methodologies
- Reporting format (format and frequency of cost reports)
- Process description

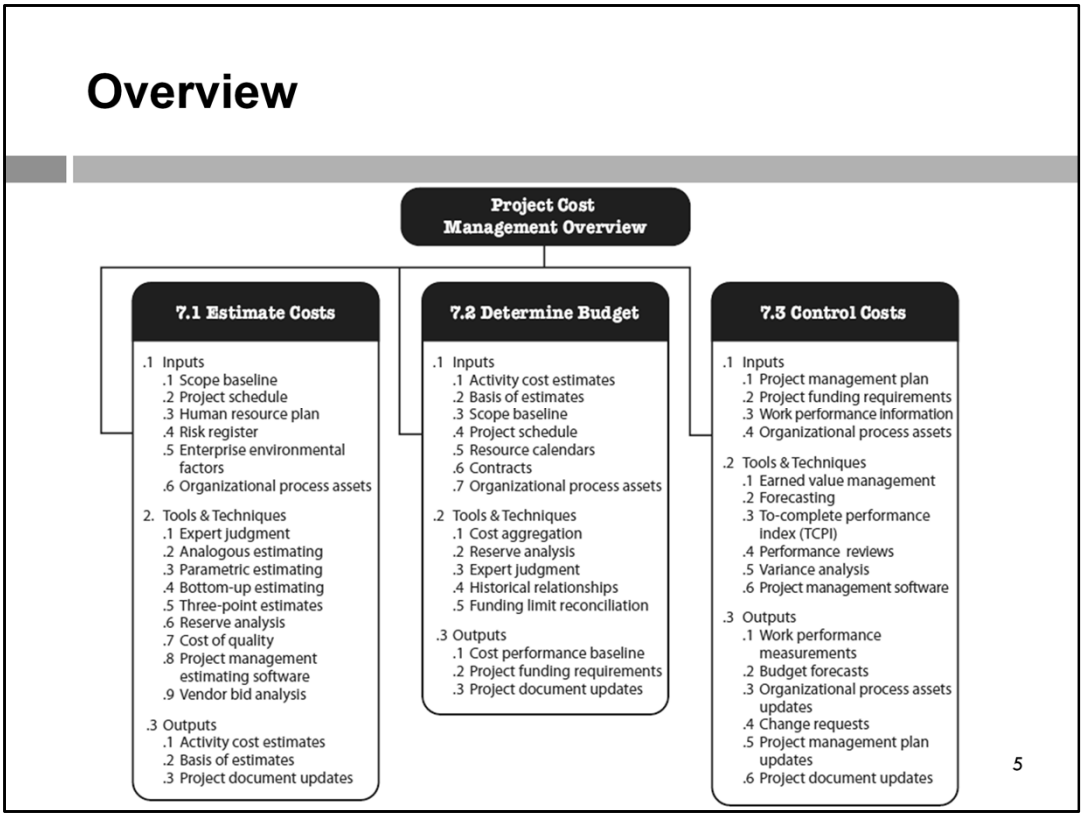
Should consider:

- stakeholder requirements (cost of an item when decision is made, order is placed, item is delivered, actual cost is incurred or recorded for project accounting)
- Effect of project decisions on the subsequent recurring cost of using, maintaining, and supporting the product, service



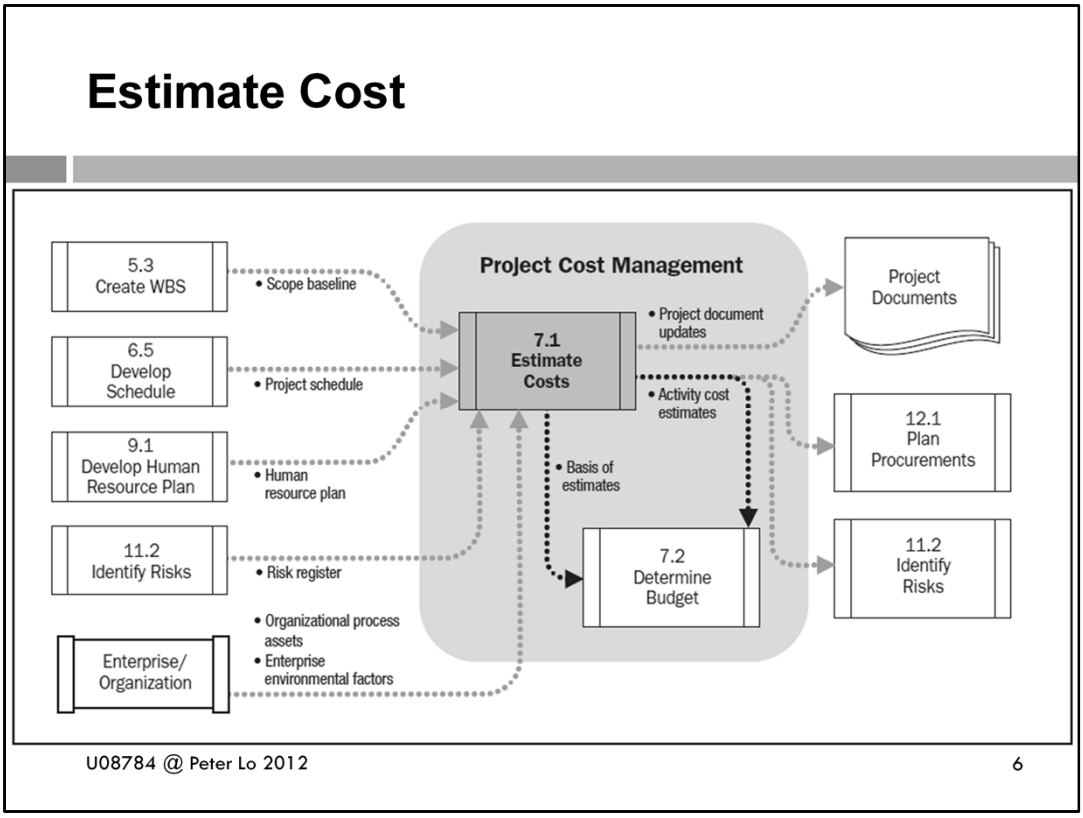
Project Cost Management

- The process involved in estimating, budgeting, and controlling cost so that the project can be completed within approved budget
- Life cycle costing
  - Looking at the cost of whole life of the product (include maintenance)
- Value analysis (value engineering)
  - Looking at less costly way to do the same work within the same scope
- Law of Diminishing Returns
  - E.g. adding twice resource to task may not get the task done in half cost/time



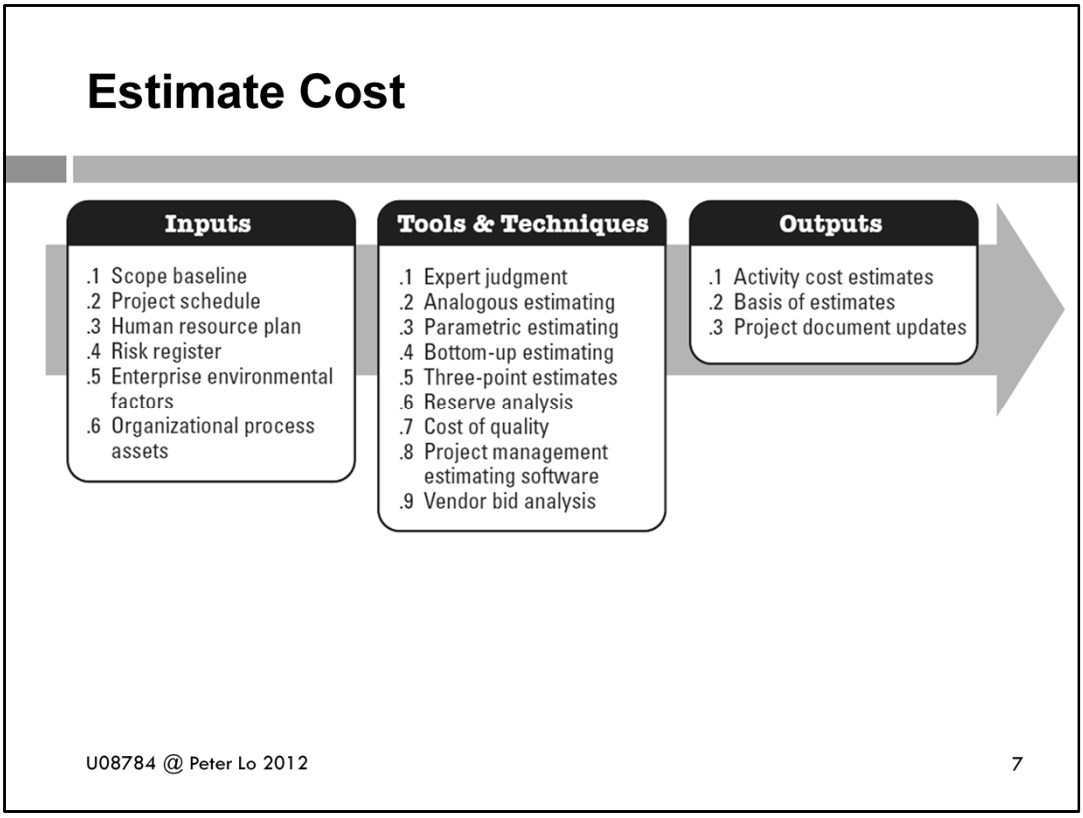
The process of developing approximation of the monetary resources needed to complete project activities

- Cost trade-offs & risk must be considered
- Cost estimates should be refined



This process develops a cost estimate for the resources (human and material) required for each schedule activity.

- Estimating schedule activity costs
- Identifying and considering various costing alternatives
- Generally expressed in units of currency
- Benefit from refinement during the course of the project to reflect the additional detail available
- Iterative process, accuracy increases as time goes by, Rough Order of Magnitude (ROM) [±50%] at the beginning, narrow down to ±10%
- Accuracy of a project estimate will increase as the project progresses - rough order of magnitude (ROM) could narrow, ROM in terms of -XX to +YY%
- Cost trade-offs and risks, make versus buy, lease, sharing the resources
- Expressed in units of some currency, staff hours, staff days
- Include labor, materials, equipment, services, facilities, inflation, contingency costs



Input
- Scope baseline
- Project Schedule
- Human Resource Plan
- Risk Register
- Enterprise Environmental Factors
- Organizational Process Assets

Tools & Techniques
- Expert Judgment
- Analogous Estimating
- Parametric Estimating
- Bottom-up Estimating
- Three-Point Estimates
- Reserve Analysis
- Cost of Quality
- Project Management Estimating Software
- Vendor Bid Analysis

Outputs
- Activity Cost Estimates
- Basis of Estimates
- Project Document Updates

Estimate Cost (Input)

- Scope Baseline
  - Scope statement, WBS
- Project Schedule
  - Type and quantity of resources, amount of their time
- Human resource plan
  - Project staffing plan, personal rates, rewards, recognitions
- Risk register
  - Risk mitigation costs
- Enterprise environmental factors
  - Market condition, published commercial information
- Organizational process assets
  - Cost estimating policies, templates, historical information, lesson learned

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Scope Baseline
- Scope statement (only direct or indirect costs as well?, contractual or legal implications: HSE, security, performance, insurance, copyright, licenses, permits)
- Work breakdown structure
- WBS dictionary (identification of the deliverables and their descriptions)

Project schedule
- Type and quantity of resources, amount of their time -> schedule activity

Human resource plan
- Project staffing plan, personal rates, rewards, recognitions

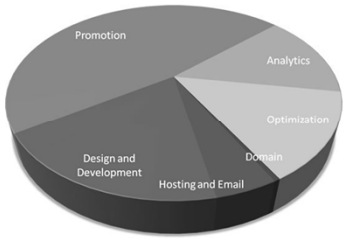
Risk register
- Risk mitigation costs -> delays, and near-term costs!

Enterprise environmental factors
- Market condition
- Published commercial information

Organizational process assets
- Cost estimating policies
- Templates
- Historical information
- Lesson learned

Types of Cost

- Variable Costs
  - Change with the amount of production/work
  - e.g. material, supplies, wages
- Fixed Costs
  - Do not change as production change
  - e.g. set-up, rental
- Direct Costs
  - Directly attributable to the work of project
  - e.g. team travel, recognition, team wages
- Indirect Costs
  - overhead or cost incurred for benefit of more than one project
  - e.g. taxes, fringe benefit, janitorial services



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Direct Costs:
- Can be traced back to a product and can be measured
- Are specifically identified by their objectives
- Include materials, labor and other direct costs
- Examples: Direct materials, Direct labor, Direct work hours, Use of equipment, Use of facilities, Number of employees, Use of materials, Consumption of services

Indirect Costs:
- Not directly identifiable
- Costs not directly related to the project product
- Belong to the core supporting business, but cannot be directly assigned to projects or individual contracts
- Include: Fringe benefits, Indirect manufacturing expenses, General indirect expenses, General and administrative expenses

Variable Costs:
- Vary as changes in the production are implemented
- Can or cannot be proportional to these production changes
- Include expenses with equipment and materials, performance bonuses, freight and sales commissions, for example
- If there's no production, there's no variable cost

Fixed Costs
- Remain constant in the total, independently of the amount of work performed
- Remain the same even when the production line pauses or is null
- Include costs like rent, depreciation, administrative team salaries and general expenses

Recurring Costs:
- Repetitive, directs or indirect, which vary depending on the production
- Examples: Daily, weekly, monthly, etc costs

Non-recurring costs
- One-time expense only
- Development, investment and other costs that are paid only once

Quality/Accuracy of Cost Estimation

Estimate	Accuracy	Phase	Duration	
Rough Order of Magnitude (ROM)	-25% ~ +75%	Initiation	3+ years	• Most difficult to estimate as very little project info is available, made during **initiating process**
Budget Estimate	-10% ~ +25%	Early Planning	1-2 years	• Used to finalize the Request for Authorization (RFA), and establish commitment, made during **planning phase**
Definitive Estimate	-5% ~ +10%	Late Planning & Execution	1 year	• **During the project** and refined

<u>12 Tips for Increasing Estimating Accuracy</u>

To remedy these shortcomings, below are 12 ideas for boosting the accuracy of your estimates:

1. Maintain an ongoing "actual hours" database of the recorded time spent on each aspect of your projects. Use the data to help estimate future projects and identify the historically accurate buffer time needed to realistically perform the work.
2. Create and use planning documents, such as specifications and project plans.
3. Perform a detailed task analysis of the work to be performed.
4. Use a "complexity factor" as a multiplier to determine whether a pending project is more or less complex than a previous one.
5. Use more than one method to arrive at an estimate, and look for a midpoint among all of them.
6. Identify a set of caveats, constraints, and assumptions to accompany your calculations, which would bound the conditions under which your estimates would be meaningful. (Anything that occurs outside of those constraints would be considered out of scope.)
7. If the proposed budget or schedule seems inadequate to do the work, propose adjusting upward or downward one or more of the four project scoping criteria: cost, schedule, quality, and features.
8. Consider simpler or more efficient ways to organize and perform the work.
9. Plan and estimate the project rollout from the very beginning so that the rollout won't become a chaotic scramble at the end. For instance, you could propose using a minimally disruptive approach, such as a pilot programme or a phased implementation.
10. In really nebulous situations, consider a phase-based approach, where the first phase focuses primarily on requirements gathering and estimating.
11. Develop contingency plans by prioritizing the deliverables right from the start into "must-have" and "nice-to-have" categories.
12. Refer to your lessons-learned database for "20:20 foresight" on new projects, and incorporate your best practices into future estimates.

Estimate Cost (Tools & Techniques)

- Expert Judgment
  - Use of knowledge gained from past project management experience.
  - In conjunction with objective estimation techniques, provides valuable information about the organizational environment and information from prior comparable projects

Cost Estimates are influenced by numerous variables such as labor rates, material costs, inflation, risk factors, and other variables.
Expert Judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects.
Expert Judgment can also be used to determine whether to combine methods of estimating and how to reconcile differences between them.
E.g. Labor rates, material costs, inflation, risk factors, ..., historical information

Estimate Cost (Tools & Techniques)

- Analogous Estimating
  - Also known as top-down estimating
  - Using actual costs of similar past project to estimate cost of current project.
  - Good when limited info is available, early phase of project
  - Can apply to scope, cost budget, duration, size, scale, weight, complexity
  - Quick but inaccurate (Less costly, less time consuming, less accurate)

Analogous Estimating is considered top-down and is less accurate than parametric. Analogous estimating uses an "analogy" – comparing a past similar project to your current project.

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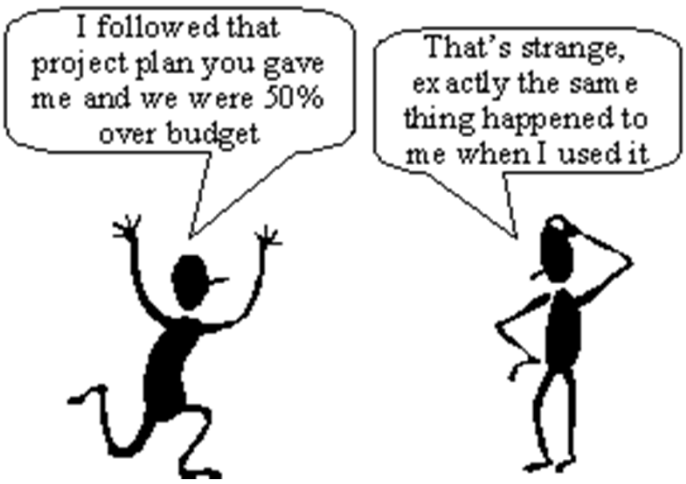
Analogous Estimating uses a similar past project to estimate the duration or cost of your current project, thus the root of the word: analogy.
Used when there is limited information regarding your current project, an analogous estimate is considered "top-down" and is generally not as accurate as other estimating techniques.
Because the project manager's, and possibly the team's, experience and judgment are applied to the estimating process, it is considered a combination of historical information and expert judgment.
For example, if it cost $7,100 to develop a website a few months ago and you are responsible for developing a new similar website, you estimate it to cost $7,100.



Estimate Cost (Tools & Techniques)

- Parametric Estimating
  - Uses a statistical relationship between historical data and other variables (e.g. LOC) to calculate an estimate for activity parameters, such as scope, cost, budget, and duration.
  - Produce higher levels of accuracy depending upon the sophistication and the underlying data built into the model.
  - An example for the cost parameter is multiplying the planned quantity of work to be performed by the historical cost per unit to obtain the estimated cost.

Parametric Estimating is more accurate, specifically when the underlying data is scalable. Parametric uses a relationship between variables (a unit cost/duration and the number of units) to develop the estimate

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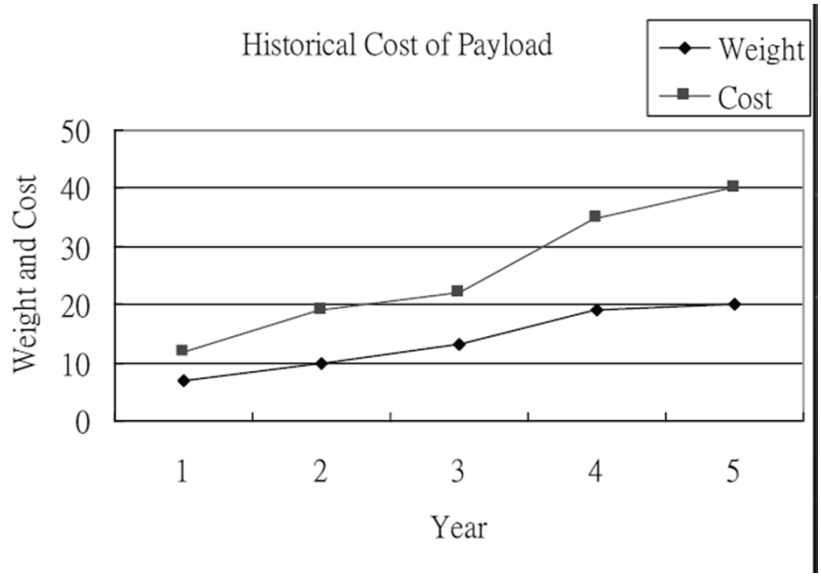
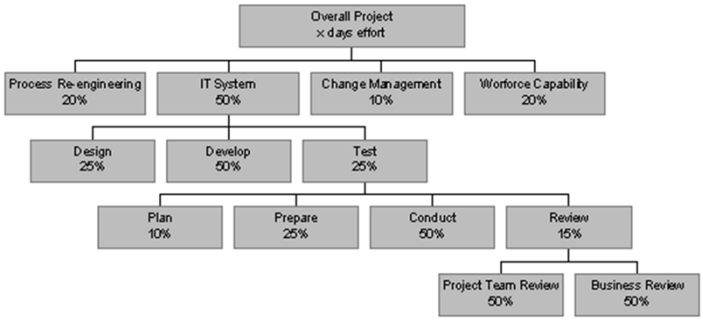
Parametric Estimating, a more accurate technique for estimating cost and duration, uses the relationship between variables to calculate the cost or duration.
Essentially, a parametric estimate is determined by identifying the unit cost or duration and the number of units required for the project or activity.
The measurement must be scalable in order to be accurate.
For example, if it took me two hours to mow my one acre yard last week and this week I'm mowing four acres, I could estimate that it will take eight hours to mow.
However, if the first one hour was spent transporting my tractor and preparing it to mow, the estimate would need to be scaled appropriately: 1 hour for transporting and then four hours to mow, for a total of five hours.



Estimate Cost (Tools and Techniques)

- Bottom-up Estimating
  - Estimating costs of individual activities (work packages) to sum up for project cost
  - Accurate and time-consuming



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Bottom-up estimating is an extremely helpful technique in project management as it allows for the ability to get a more refined estimate of a particular component of work. In bottom-up estimating, each task is broken down into smaller components. Then, individual estimates are developed to determine what specifically is needed to meet the requirements of each of these smaller components of the work. The estimates for the smaller individual components are then aggregated to develop a larger estimate for the entire task as a whole. In doing this, the estimate for the task as a whole is typically far more accurate, as it allows for careful consideration of each of the smaller parts of the task and then combining these carefully considered estimates rather than merely making one large estimate which typically will not as thoroughly consider all of the individual components of a task. In general, the smaller the scope, the greater the accuracy

Estimate Cost (Tools and Techniques)

- Three-point Estimates
  - Use of three estimates to determine a range for an activity's cost: the best-case estimate, the most likely estimate, and the worst-case estimate

$$c_E = \frac{c_0 + 4c_M + c_P}{6}$$

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The accuracy of single-point activity cost estimates can be improved by considering estimation uncertainty and risk. This concept originated with the program evaluation and review technique (PERT).

PERT uses three estimates to define an approximate range for an activity's cost:

Most likely – The cost of the activity, based on realistic effort assessment for the required work and any predicted expenses.

Optimistic – The activity cost based on analysis of the best-case scenario for the activity.

Pessimistic – The activity cost based on analysis of the worst-case scenario for the activity.

PERT analysis calculated an expected (cE) activity cost using a weighted average of these three estimates:

- **PERT = (Optimistic + Pessimistic + 4 x Most likely) / 6**

Cost estimates based on this equation (or even on a simple average of the three points) may provide more accuracy, and the three points clarify the range of uncertainty of the cost estimates.

Estimate Cost (Tools and Techniques)

- Reserve Analysis (contingency allowances for uncertainty)
  - Reserves are intended to reduce the impact of missing cost objectives.
  - Reserves does not cover change in scope
  - Contingency reserves are included in the baseline
    - Allow for future situations that may be partially planned for (known unknowns)
  - Management reserves require a change to the project baseline
    - Allows for future situations that are impossible to predict (unknown unknowns)

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Cost estimates may include contingency reserves (sometimes called contingency allowances) to account for cost uncertainty. The contingency reserve may be a percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods.

As more precise information about the project becomes available, the contingency reserve may be used, reduced or eliminated. Contingency should be clearly identified in cost documentation.

Contingency reserves are part of the funding requirements.

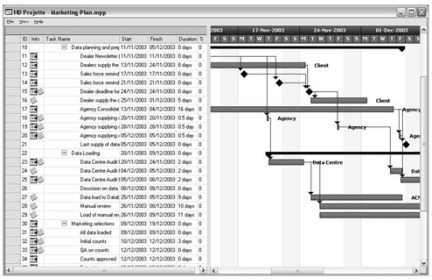
Estimate Cost (Tools and Techniques)

- Cost of Quality (COQ)
  - Quality has a cost and must be balanced against cost of non-conformance
  - Three types:
    - Prevention
    - Appraisal
    - Failure costs

Assumptions about costs of quality may be used to prepare the activity cost estimate.

Estimate Cost (Tools and Techniques)

- Project Management Estimating Software
  - Widely used to assist schedule and cost development



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Use of project management cost estimating software applications, computerized spreadsheets, simulation, and statistical tools. Such tools can allow for rapid consideration of multiple cost estimate alternatives.

Estimate Cost (Tools and Techniques)

- Vendor Bid Analysis
  - Comparison of outsourcing options

Bid Summary

	Vendor A	Vendor B	ScanMan	Vendor D
Average Rating	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
	View bid	View bid	View bid	View bid
Project Setup	$500.00	$250.00	$500.00	
Document Pickup		$100.00	$200.00	$100.00
Document Preparation		$950.00	$300.00	$300.00
Document Scanning	$3,250.00	$3,750.00	$3,000.00	$2,000.00
Hand Key Indexing	$1,000.00	$900.00	$800.00	
Output to Media	$75.00	$45.00	$150.00	
Secure Document Destruction			$90.00	$90.00
Minimum quality level (percent)	100 Percent	98 Percent	99 Percent	99 Percent
Days to complete project (30 = one month)	30 Days	45 Days	30 Days	30 Days
Total Amount	**$4,825.00**	**$5,995.00**	**$5,040.00**	**$2,490.00**

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Use to determination of what the project should cost based on a review of vendor bids/proposals.

This technique may be used in conjunction with other cost estimation techniques to ensure that cost estimates are comprehensive

Estimate Cost (Output)

- Activity Cost Estimates
  - Summary or detail
  - Labor, materials, equipment, services, facilities,
  - IT, inflation, contingency reserve

Activity Cost Estimates										
Project: Flex Pay Database								**Date:** 03/01/20xx		
WBS No.	**Resource**	**Direct Costs**	**Indirect Costs**	**Reserve**	**Estimate**	**Method**	**Assumptions/ Constraints**	**Additional Information**	**Range**	**Confidence Level**
3.1.1	Jr. Programmer for 40 hours	40 hrs @ $20.75 = $1,030	$0	$20.75	$1,050.75	Parametric	Must obtain functional manager approval to assign Jr. Programmer	N/A	$1020 - $1075	8
3.1.1	Network Specialist for 10 hours	10 hrs @ $26.90 = $269	$0	$53.80	$322.80	Parametric	Must obtain functional manager approval to assign Network Specialist	N/A	$300 - $350	7
3.1.1	Lease Network Test Equipment		12 hrs @ $42 = $504	$0	$504	Parametric	Assume test equipment will be available	Lease from Test Supply Corp.	$500 - $510	9

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Activity Cost Estimates are a valuable project management tool for determining the costs for a project. Much like how a project's work is broken down into activities and work packages, the activity cost estimate breaks the project's costs down to the activity level in order to improve the reliability and accuracy of the estimate.

The activity cost estimate considers each project activity and the costs associated with completing the activity. These costs include direct costs for project resources, indirect costs which may be passed on to the project, and the amount held in contingency reserve for the activity. A given activity may have many resources allocated to it which all must be accounted for as part of the estimate for that activity.

One characteristic of the activity cost estimate is documenting how the estimate was determined. This is usually done by either analogous or parametric estimating. Analogous estimating is done using similar past projects or activities to estimate cost. Parametric estimating is done by determining and using a unit cost calculated over a duration or quantity of units. Parametric estimating is usually more accurate and should result in a higher confidence level.

Another characteristic of the activity cost estimate is that it often uses a range for the activity's cost estimate as well as a confidence level. At different stages of project planning some activities may be more well-defined which may result in a much higher confidence level than that of an activity with more unknowns. It is important to note that like most project management documentation, the activity cost estimate should continue to be revised and improved throughout the project's lifecycle.

In general, the more information and detail that is available for an activity, the more accurate the activity cost estimate will be. Once activity cost estimates are completed for all of a project's activities, these can then be used to develop the overall project cost estimate

Standard Activity Cost Estimates Template:

Activity Cost Estimates										
Project:								**Date:**		
WBS No.	**Resource**	**Direct Costs**	**Indirect Costs**	**Reserve**	**Estimate**	**Method**	**Assumptions/ Constraints**	**Additional Information**	**Range**	**Confidence Level**
This should be the WBS number from the Work Breakdown Structure	Type of resource (labor, material, equipment, service, etc.)	Costs directly related to project work (staff salaries, supplies, training, etc.)	Costs not directly attributable to the project (utilities, rent, security, etc.)	Amount of funding held in reserves for contingencies	Estimated cost	Method used such as parametric, analogous, etc.	Any assumptions used in developing the estimate such as labor cost per hour	Information on cost of quality, interest rate, or other	Range of estimate	The degree of confidence in the estimate based on available information

Estimate Cost (Output)

- Basis of Estimates (BoE)
  - Documentation of the basis of the estimate (how it was developed)
  - Documentation of assumption made
  - Documentation of known constraints
  - The confidence level of final estimates
  - Indication of uncertainty (Range of possible estimates, e.g. 10000 ±10%)

Cost Estimating

Item	Description	Quantity	Required Units (Man-days)	Unit cost (HKD)	Estimation (HKD)
A1	To supply manpower and materials for the implementation of Phase 1				
A1.1	Operational and Functional Design	1 lot	21	3,000	63,000
A1.2	Software Design	1 lot	17	3,000	51,000
A1.3	Software Development	1 lot	65	2,000	130,000
A1.4	Documentation	1 lot	70	2,000	140,000
A1.5	Interface tests	1 lot	8	2,000	16,000
A1.6	Offsite test	1 lot	10	2,000	20,000
A1.7	Onsite test	1 lot	10	2,000	20,000
A1.8	User acceptance test (OAT support)	1 lot	52	2,000	104,000
A1.9	Observation Period, including fine tuning, benchmarking and other minor adjustments	1 lot	50	2,000	100,000
A1.10				Subtotal	644,000

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This is a companion document to Activity Cost Estimates, which details how much each project activity is expected to cost. The Basis of Estimates document indicates how these estimates were derived. It could include information such as how the estimate was developed, assumptions, constraints, range of possible values, and confidence in the estimate.

For example, in Katy's Activity Cost Estimates document, she has the activity of "Shopping for Cookie Ingredients" with the cost estimate of $17. Her Basis of Estimates document first contains how this estimate was developed. It was developed by using expert judgment to estimate the cost of the individual ingredients on the shopping list. The flour is about $4, the sugar $3, the chocolate chips are $3, the vanilla is about $2, the eggs are about $2, and the butter is around $3, which totals the $17 estimate. Next are the assumptions and constraints. She assumes that the chocolate chips that typically cost about $4 will only cost $3 because she has a coupon for one dollar off the price of the chocolate chips. She is constrained by only having $20 to spend. Last is the value range and confidence level. The range of possible values for this activity is from $12 to $20, and she is 75% sure that her estimate of $17 will be accurate.

2.2 2005 Shutdown 1/4/2005 10/10/2005 196d

Type	Material	Labor	Base Cost	Material Contingency	Labor Contingency	Total Cost	Funding Source	Cost Book
Subproject	$268,579	$397,173	$665,752	25	20	$809,923		

WBS Dictionary Warm up B4 and C1 houses. Replace half-dipoles with full-dipoles in these houses. Remove MI dipoles and C-magnetsfrom C0. Install beampipe in C0. Install LCW piping for collision hall and assembly hall. Cool down B4 and C1 houses. Warm up D3 house. Install modified QD37 for synch light monitor. Install Synch light monitor in D48 warm straight. Cool down D3 house.

Ground Rules There will be a 2 month shutdown starting ~Aug. 1, 2005 [MDC]

2.2.1 Preliminary LCW design: FY05/06 R&D 1/4/2005 4/1/2005 63d

Type	Material	Labor	Base Cost	Material Contingency	Labor Contingency	Total Cost	Funding Source	Cost Book
Subproject	$0	$9,459	$9,459	0	10	$10,405	RD	

WBS Dictionary Complete the design work for the 2005 shutdown lcw modifications.

2.2.1.1 Final LCW design 1/4/2005 4/1/2005 63d

Type	Material	Labor	Base Cost	Material Contingency	Labor Contingency	Total Cost	Funding Source	Cost Book
ASAP	$0	$9,459	$9,459	0	10	$10,405	RD	

WBS Dictionary Remaining system design for 2005 LCW modifications and extensions.

BOE Labor Based on engineering judgement for reviewing cooling requirements and existing system and working with a drafter to complete a layout drawing. [JR]

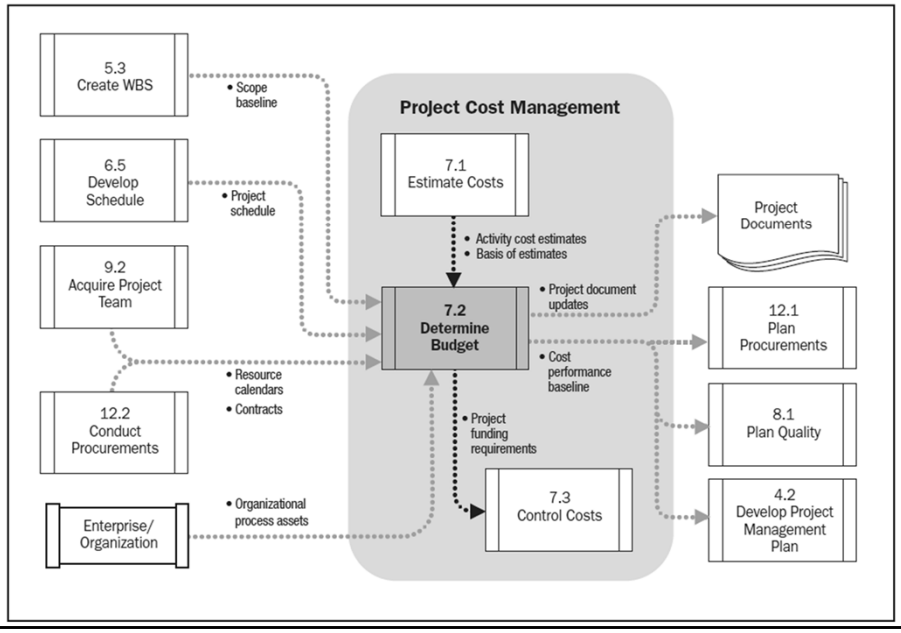
Labor Resources (hours)

BTEV.FNAL.BD.DSGRDR	20
BTEV.FNAL.BD.ME	100

Estimate Cost (Output)

- Project Document Updates
  - Project documents that may be updated include, but are not limited to the risk register

Determine Budget



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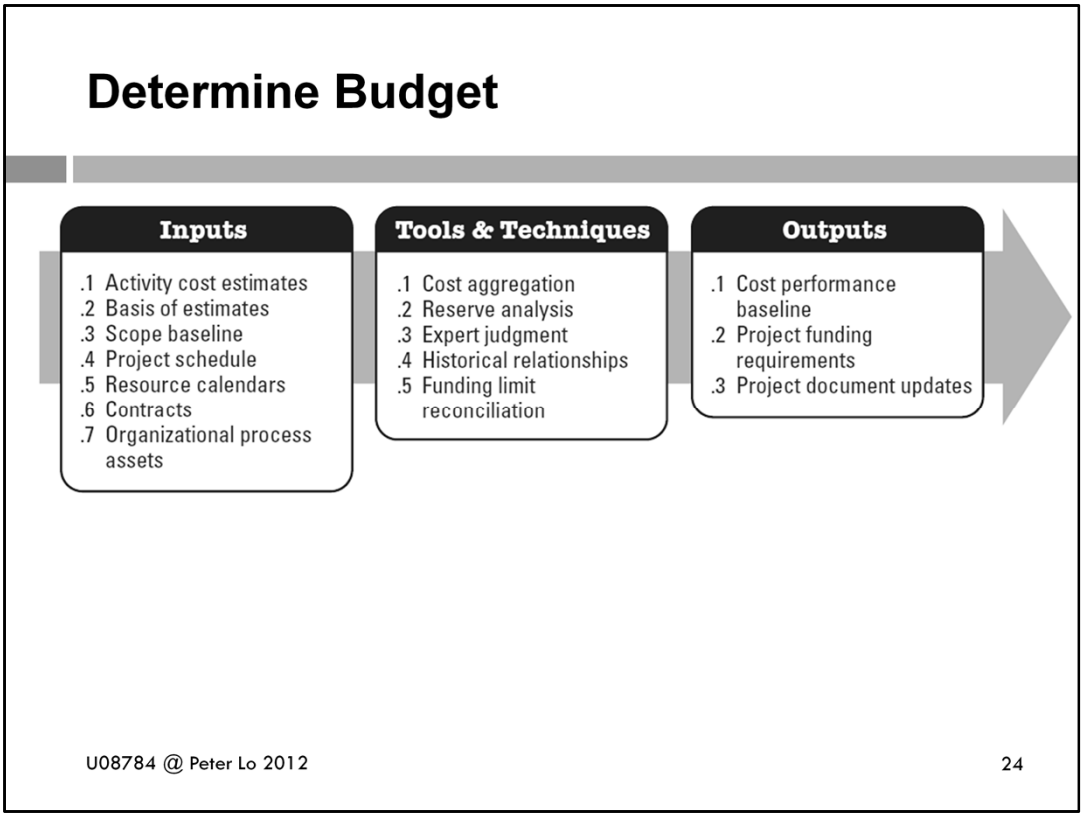
- The process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline
- Project budget constitute the funds authorized to execute the project
- Project cost performance is measured against the authorized budget
- Involves aggregating the estimated costs of individual schedule activities
- Establish a total cost baseline for measuring project performance
- Cost estimation prepared prior to the detailed budget requests and work authorization



Input

- Activity Cost Estimates
- Basis of Estimates
- Scope Baseline
- Project Schedule
- Resource Calendars
- Contracts
- Organizational Process Assets

Tools & Techniques

- Cost Aggregation
- Reserve Analysis
- Expert Judgment
- Historical Relationship
- Funding Limit Reconciliation

Outputs

- Cost Performance Baseline
- Project Funding Requirements
- Project Document Updates

Determine Budget (Input)

- Activity Cost Estimates
- Basis of Estimates
- Scope Baseline
  - Scope estimate
  - Work breakdown structure
  - WBS dictionary
- Project Schedule
- Resource Calendars
- Contracts
- Organizational Process Assets
  - Formal/informal cost budgeting-related policies, procedures, guidelines
  - Cost budgeting tools
  - Reporting methods

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The purpose of this process is to add up the estimated costs of the project activities in order to create the budget. These cost estimates and their explanations are found in Activity Cost Estimates and Basis of Estimates, which were outputs of the Estimate Costs process. Cost Aggregation is the fancy term for simply adding up these estimated costs. Additionally, there are a few other documents that are good to reference when developing the budget—the Scope Baseline, Project Schedule, Resource Calendars, and Contracts. The Scope Baseline should be referenced for mention of funding constraints. Assuring that the budget is within these funding constraints is called Funding Limit Aggregation. The Project Schedule and Resource Calendars are used as a basis for knowing how much to budget for different calendar periods of the project. For example, costs may be low for the first couple months, but according to the calendar, in the third month a substantial amount of material may need to be purchased and specialized labor hired, so more funds will be budgeted for that time. Contracts associated with the project should also be examined for agreed-upon costs.

Determine Budget (Tools and Techniques)

- Cost Aggregation
  - The accumulation of single costs following the structure of the WBS (and the distribution of payments with respect to the schedule base line)

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Schedule activity cost estimates are aggregated by work packages in accordance with the WBS

It is important to aggregate, or sum up if you will, such costs to the work package level. This is important because all costs are measured in the first place, and then managed and controlled at work package level throughout the project.

There may be other levels within the project where costs need to be aggregated, and these may include accounting node points within the WBS, internal or external accounting departments, and of course at the total project level.

Determine Budget (Tools and Techniques)

- Reserve Analysis
  - **Contingency Reserves** – Cost Baseline the cost impacts of the remaining risk
  - **Management Reserves** – Cost Budget extra fund to cover unforeseen risk or changes to the project

Reserves & Risk Management are important while Estimating!

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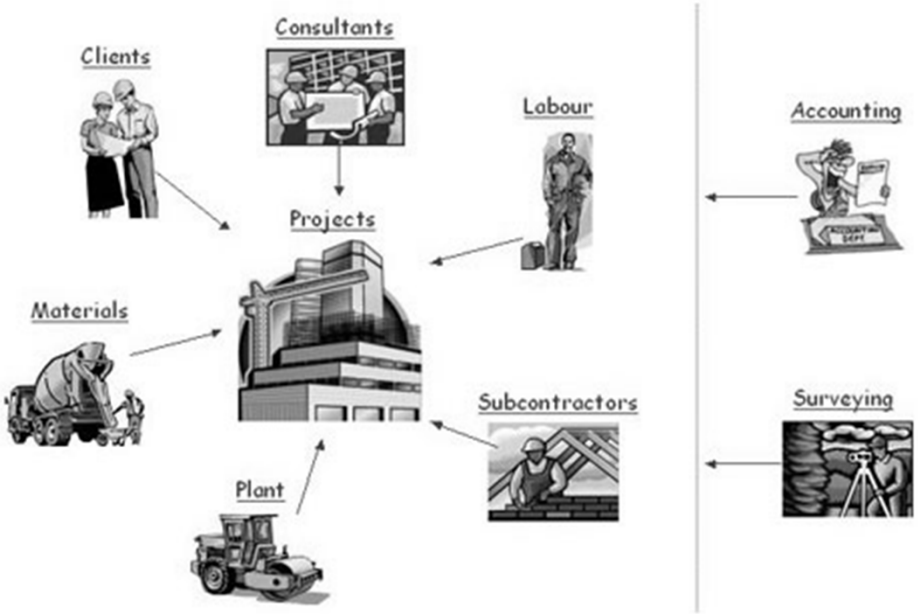
In terms of the project management scope of work and work flow, the concept of reserve analysis actually refers to a specific technique that is often implemented by the project management team and/or the project management team leader or leaders for the purposes of helping to better maintain and manage the projects that they may have under their guise at that respective time.

Specifically speaking, the technique of reserve analysis is a particular analytical technique that is used for the purposes of making a complete and thorough determination of the entirety of the specific and exact features and or in many cases relationships of all of the individual project related components that currently exist as part of the previously determined project management plan. The purpose of the execution and implementation of a reserve analysis is the establishment of an estimated reserve that can be used for the purposes of establishing a schedule duration, any and all estimated costs, the budget, as well as the complete funds assigned or allocated to the project.

Determine Budget (Tools and Techniques)

- Expert Judgment
  - Other units within organization
  - Consultants
  - Stakeholders, customers
  - Professional and technical association
  - Industry groups



Determine Budget (Tools and Techniques)

- Historical Relationships (Analogous and Parametric models)
  - 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:
    - The historical information used to develop the information was accurate
    - The parameters in the model are readily quantifiable
    - The model is scalable (works well for small as well as large projects

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Analogous estimating uses a similar past project to estimate the duration or cost of your current project, thus the root of the word: analogy. Used when there is limited information regarding your current project, an analogous estimate is considered "top-down" and is generally not as accurate as other estimating techniques. Because the project manager's, and possibly the team's, experience and judgment are applied to the estimating process, it is considered a combination of historical information and expert judgment.

Parametric estimating, a more accurate technique for estimating cost and duration, uses the relationship between variables to calculate the cost or duration. Essentially, a parametric estimate is determined by identifying the unit cost or duration and the number of units required for the project or activity. The measurement must be scalable in order to be accurate.

Similarities between analogous and parametric estimating:

- Can be used for both duration and cost estimating
- Essentially a combination of historical information (leveraging past projects/activities) and expert judgment

Differences between analogous and parametric estimating:

- Analogous is considered top-down and is less accurate than parametric. Analogous estimating uses an "analogy" – comparing a past similar project to your current project.
- Parametric is more accurate, specifically when the underlying data is scalable. Parametric uses a relationship between variables (a unit cost/duration and the number of units) to develop the estimate.

Determine Budget (Tools and Techniques)

- Fund Limit Reconciliation
  - Funding limits set by the customer or performing organization
  - Accomplished by placing imposed date constraints for some work packages and milestones

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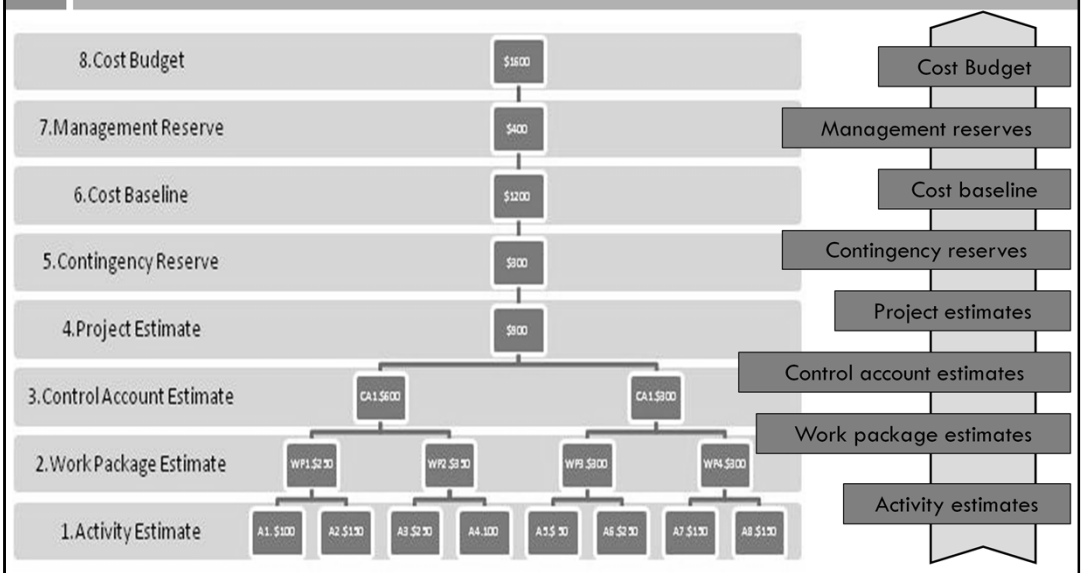
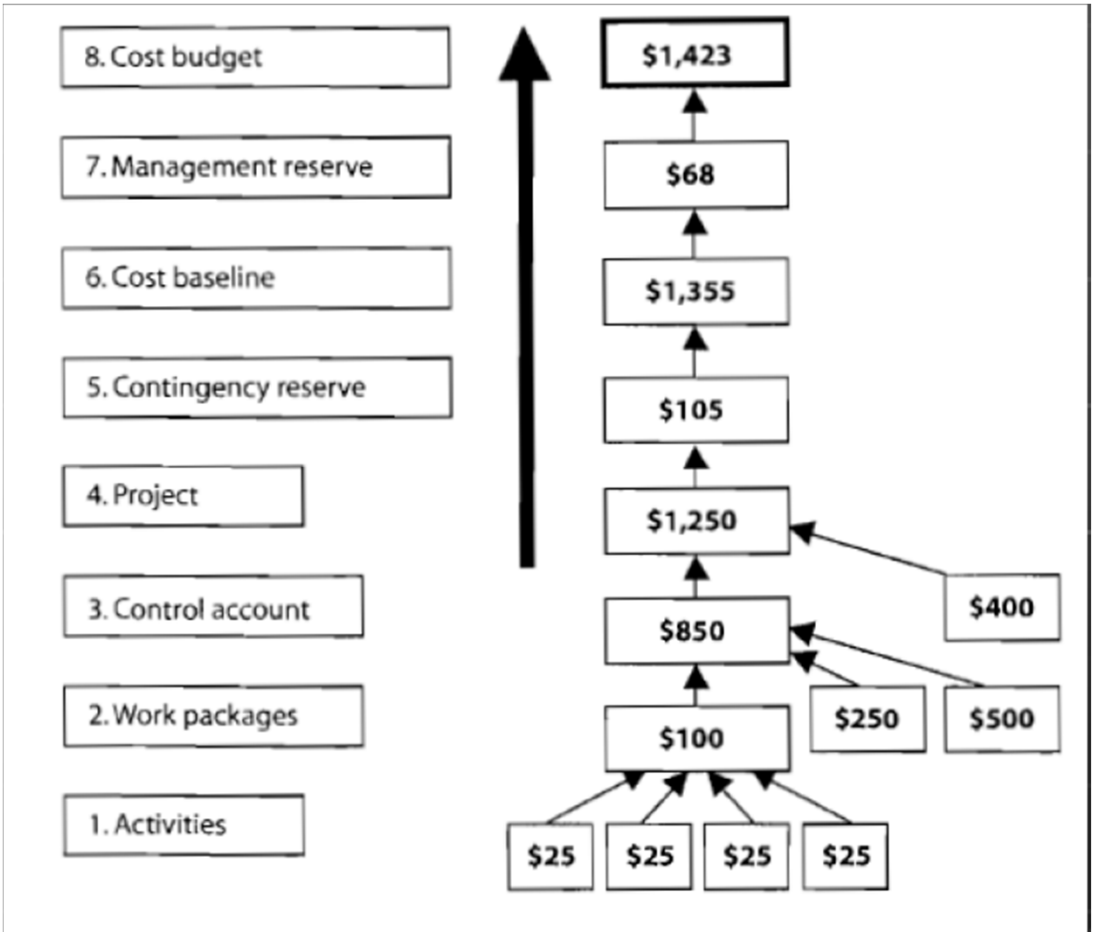
Funding Limit Reconciliation – Customer/sponsor will set limits on disbursement of funds for the project. Funding Limit Reconciliation will necessitate the scheduling of work to be adjusted to smooth or regulate those expenditures. It is accomplished by placing imposed date constraints for some work packages and compressing the schedule to reduce the estimated cost of the project. Conciliation happens for the cash flow of the project and with any cost constraint of the project.
Reconciliation needed before proposed cost baseline and cost budget become final. Such reconciliation is part of integration management

Determine Budget





Determine Budget (Output)

- Cost Performance Baseline
  - Authorized time-phased Budget at Completion (BAC) used to measure, monitor and control overall cost performance (S shape curve)
- Project Funding Requirement
  - Funding usually occurs in incremental amounts that are not continuous, and, therefore, appears as a step function
- Project document updates
  - Risk register
  - Cost estimates
  - Project schedule

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Cost Performance Baseline

The cost performance baseline is an authorized time-phased budget at completion (BAC) used to measure, monitor, and control overall cost performance on the project. It is developed as a summation of the approved budgets by time period and is typically displayed in the form of an S-curve, as is illustrated in the Figure. In the earned value management technique the cost performance baseline is referred to as the performance measurement baseline (PMB).

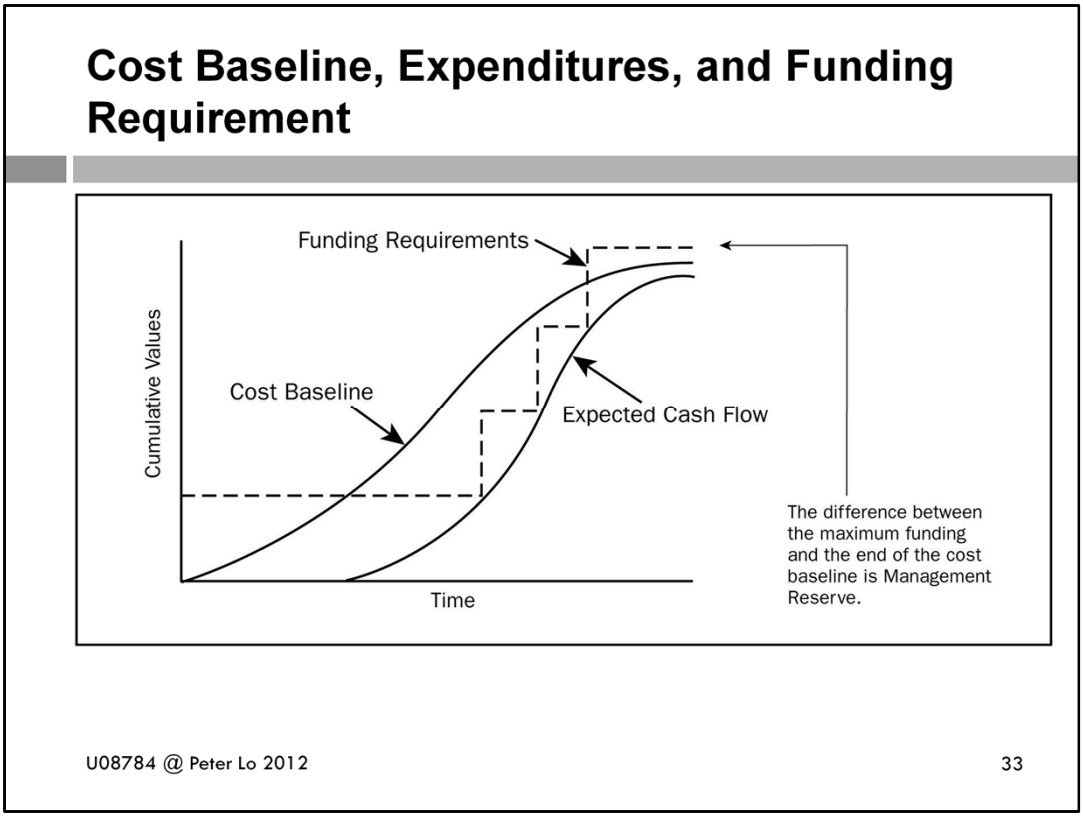
Project Funding Requirements

Total funding requirements and periodic funding requirements (e.g., quarterly, annually) are derived from the cost baseline. The cost baseline will include projected expenditures plus anticipated liabilities. Funding often occurs in incremental amounts that are not continuous. The total funds required are those included in the cost baseline, plus management reserves, if any.

Project Document Updates

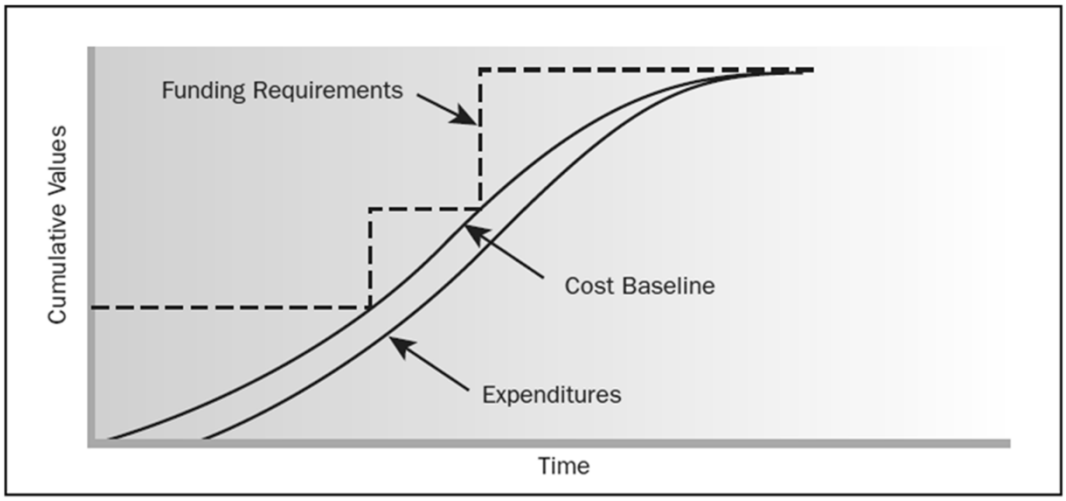
Project documents that may be updated include but are not limited to:

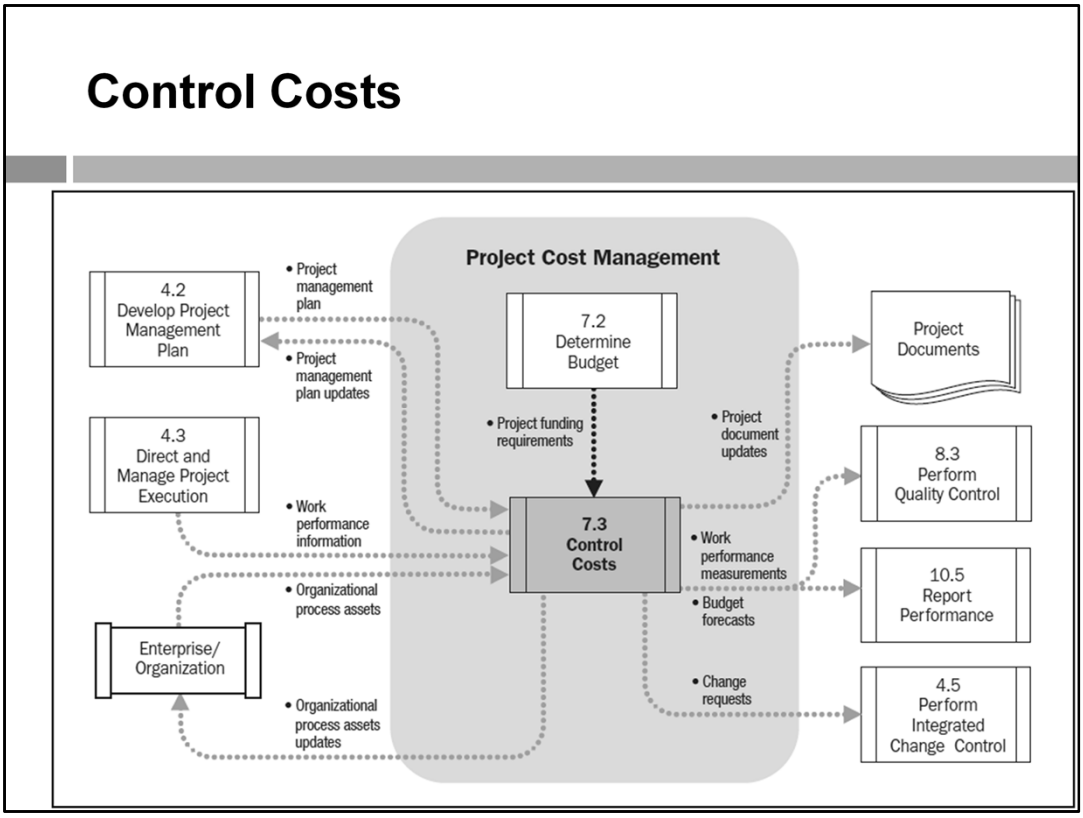
- Risk register
- Cost estimates
- Project schedule.



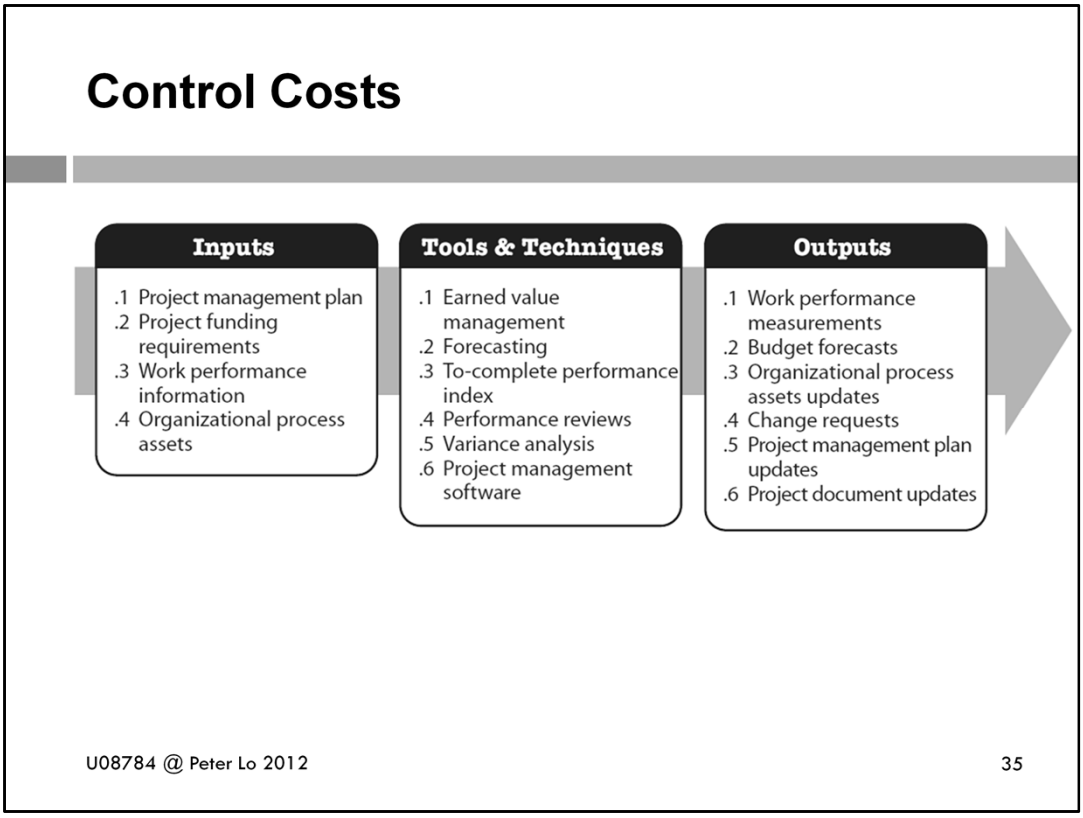
The Cost Performance Baseline is an "authorized time-phased budget-at-completion (BAC) used to measure, monitor, and control overall cost performance on the project. All the minor budgets are added together to create the overall Cost Performance Baseline, which is displayed as a graph of cumulative funds to be spent over time. The periods of time are on the x-axis and the funds are on the y-axis. The periods of time could be days, months, years, etc. Because spending is generally less at the beginning and end of the project, the line on the graph representing cumulative funds tends to be in an S-shaped curve.

The Cost Performance Baseline, also called the Performance Measurement Baseline (PMB), is one of the project baselines that are incorporated into the Project Management Plan. It is developed in the PMBOK's Determine Budget process which adds up the estimated costs of the project activities in order to create the budget. The Cost Performance Baseline is then used an input to the Plan Quality and Plan Procurements processes. Also see the earlier posting of Determine Budget Process .





- The process of monitoring the status of the project to update the project budget and managing changes to the cost baselines
- Involves recording actual cost spent
- Approval to increase the budget through Integrated Change Control Process
- Includes
  - Influencing the factors that create changes to authorized cost baselines
  - Recording all changes against the cost baseline
  - Ensuring requested changes are agreed upon
  - Ensuring change requests are acted in a timely manner
  - Managing the actual changes
  - Assuring that potential cost overruns do not exceed the authorized funding
  - Ensuring the cost expenditures do not exceed the authorized funding
  - Monitoring cost performance to detect variances from the cost baseline
  - Monitoring work performance versus funds expended
  - Preventing unapproved changes in cost or resources
  - Informing appropriate stakeholders of approved changes and associated costs
  - Bringing expected cost overruns within accepted limits
  - Preventing incorrect, inappropriate, or unapproved changes from being included in the reported cost or resource usage



Inputs:
- Project Management Plan
- Project Funding Requirements
- Work Performance Information
- Organizational Process Assets

Tools & Techniques
- Earned Value Management
- Forecasting
- To-complete Performance Index
- Performance Reviews
- Variance Analysis
- Project Management Software

Outputs
- Work Performance Measurements
- Budget Forecast
- Organizational Process Assets Update
- Change Request
- Project Management Plan Updates
- Project Document Updates

Control Costs (Input)

- Project Management Plan
  - Cost Performance Balance – To check with the actual results to see if change (corrective, preventive actions) is necessary
  - Cost Management Plan – How the project should be managed and controlled
- Project Funding Requirements
- Work performance information
  - Which deliverables have started, finished, how much progress
  - Costs have been authorized, incurred, and estimate for future
- Organizational Process Assets
  - Formal/informal cost control-related policies, procedures, and guidelines
  - Cost control tools
  - Monitoring and reporting methods

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The Control Costs process is one of the three Cost knowledge area processes, and one of the ten Monitoring and Controlling processes. The primary purpose of this process is to monitor the budget and manage any changes made to the cost baseline. The Cost Performance Baseline and Cost Management Plan can be found in the Project Management Plan, which is used to guide this process. Project Funding Requirements and Work Performance Information are additional inputs.

Control Costs (Tools & Techniques)

- Earned Value Management
- Forecasting
- To-complete Performance Index
- Performance Reviews
- Variance Analysis
- Project Management Software

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There are many tools available to manage costs, such as Earned Value Management, Forecasting, To-Complete Performance Index, Performance Reviews, Variance Analysis, and Project Management Software. The tools enable the project manager to calculate how close spending matches the budget, and how much more funding is needed. This results in Work Performance Measurements and Budget Forecasts that can be used to plan the remainder of the project. As Change Requests are approved through the Perform Integrated Change Control process and implemented, there may be updates to the Organizational Process Assets, Project Management Plan, and Project Documents.

Earned Value Management

- **Earned Value Analysis (EVA)** is a method of performance measurement. Many project managers manage their project performance by comparing planned to actual results. With this method, one could easily be on time but overspend according to the plan

Performance Measures		Schedule		
		SV > 0 & SPI > 1.0	SV = 0 & SPI = 1.0	SV < 0 & SPI < 1.0
Cost	CV > 0 & CPI > 1.0	Ahead of Schedule Under Budget	On Schedule Under Budget	Behind Schedule Under Budget
	CV = 0 & CPI = 1.0	Ahead of Schedule On Budget	On Schedule On Budget	Behind Schedule On Budget
	CV < 0 & CPI < 1.0	Ahead of Schedule Over Budget	On Schedule Over Budget	Behind Schedule Over Budget

EVM – Hints to remember

- EV comes first in every formula
- If it's variance, the formula is EV – something
- If it's index, EV / something
- If it relates to cost, use Actual Cost
- If it relates to schedule, use PV
- Negative numbers are bad, positive is good

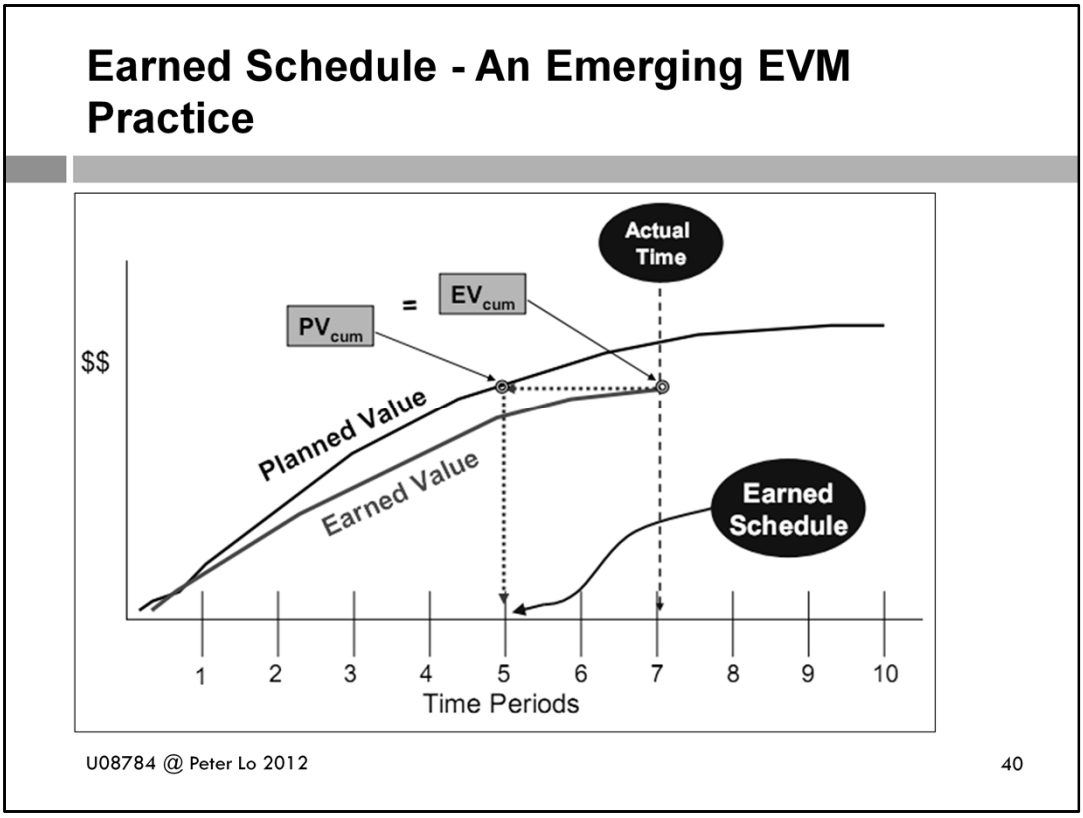
Earned Value Technique

Example:	At the 3 month checkpoint:
Project Budget: $400K	Spent: $200K
Project Schedule: 4 months	Work completed: $100K

Terms and Formulas	Definition	Example
Earned Value (EV)	As of today, what is the estimated value of the work actually accomplished?	$100K
Actual Cost (AC)	As of today, what is the actual cost incurred for the work accomplished?	$200K
Planned Value (PV)	As of today, what is the estimated value of work planned to be done?	$300K
Cost Variance (CV) = EV - AC	Negative is over budget Positive is under budget	$100K – $200K = ($100K)
Schedule Variance (SV) = EV - PV	Negative is behind schedule Positive is ahead schedule	$100K - $300K = ($200K)
Cost Performance Index (CPI) = EV/AC	We are getting $__ worth of work out of every $1 spent. Are funds being used efficiently?	$100K/$200K = 0.5 i.e. 50%
Schedule Performance Index (SPI) = EV/PV	We are (only) progressing at __ percent of the rate originally planed	$100K/$300K = 0.33 i.e 33%
Revised Total Duration	Baseline Duration/Schedule Performance Index	4/0.33 = 12 months

- Earned value (EV)
  - The value of work performed expressed in terms of approved budget
  - Authorized work that has been completed + the corresponding authorized budget
  - Is related to PV baseline (PMB)
  - EV cannot be greater than authorized PV
- Actual cost (AC)
  - Total cost actually incurred for accomplishing work performed
  - Same definition (direct hours only, direct costs only, all costs including indirect costs) as PV and EV
  - Has no upper limit
- Planned value (PV)
  - Authorized budget assigned for completion of an activity or WBS component
  - Detailed authorized work + the corresponding budget
  - Total PV is called Performance Measurement Baseline (PMB)
  - Total PV for the project is called Budget at Completion (BAC)
- Cost variance (CV)
  - Measure of cost performance
  - CV=EV-AC
  - CV at the end of project is the difference between BAC and the actual amount spent
  - Any negative CV is often non-recoverable
- Schedule variance (SV)
  - Measure of schedule performance
  - SV=EV – PV
  - SV at the end of project is zero
- Cost performance index (CPI)
  - A measure of value of work completed versus the actual cost
  - CPI=EV/AC
  - CPI < 1 ---> cost overrun for work completed
  - CPI > 1 ---> cost under run for work completed
- Schedule performance index (SPI)
  - A measure of progress achieved versus progress planned
  - SPI= EV/PV
  - Sometimes used with cost performance index (CPI)

- SPI < 1 ---> less work completed than planned
- SPI > 1 ---> more work completed than planned



SPI ($)

- At project start SPI is reliable
- At some point SPI accuracy diminishes
- Toward the project end it is useless (SPI = 1 at project end)
- Does not not show weeks/months of schedule variance

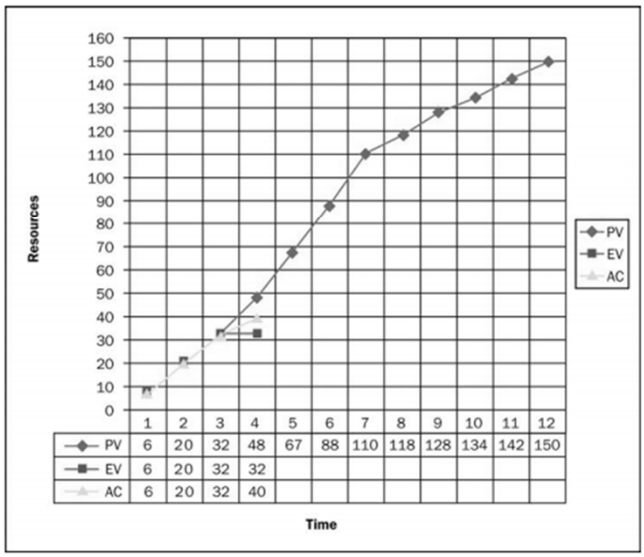
SPI (time)

- Time based schedule measures
- Create a SPI that is accurate to the of the project

SV(t) = ES – AT
SPI(t) = ES / AT

ES = Earned Schedule (Planned time)
AT = Actual time

Earned Value Management



	1	2	3	4	5	6	7	8	9	10	11	12
PV	6	20	32	48	67	88	110	118	128	134	142	150
EV	6	20	32	32								
AC	6	20	32	40								

Cumulative Planned Value, Earned Value, and Actual Cost for Project EZ
(As of April 30)

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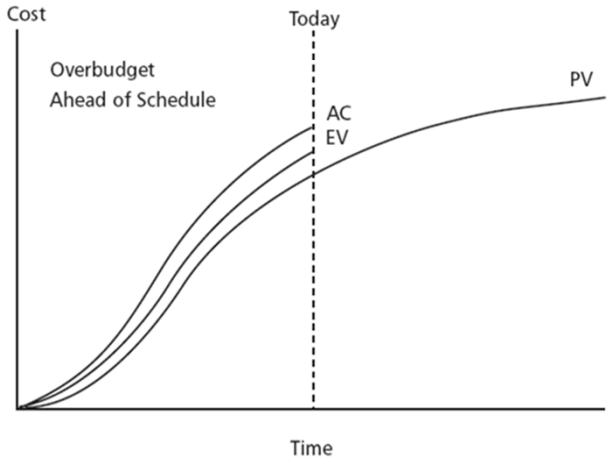
EV can be calculated by (%progress) x (planned man-days)

Task	Budget	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		6	6										
1	12												
			8	12	16	12							
2	48												
						7	21						
3	28												
								18					
4	18												
								4	8	10	6		
5	28												
												8	8
6	16												
Σ	150	6	14	12	16	19	21	22	8	10	6	8	8
CUM	-	6	20	32	48	67	88	110	118	128	134	142	150
PV	48	6	14	12	16	19	21	22	8	10	6	8	8
CUM		6	20	32	48	67	88	110	118	128	134	142	150
EV	32	6	14	12	0	0	0	0	0	0	0	0	0
CUM		6	20	32	32								
AC	40	6	14	12	8	0	0	0	0	0	0	0	0
CUM		6	20	32	40								

Work Plan and Status for Project EZ (As of April 30)

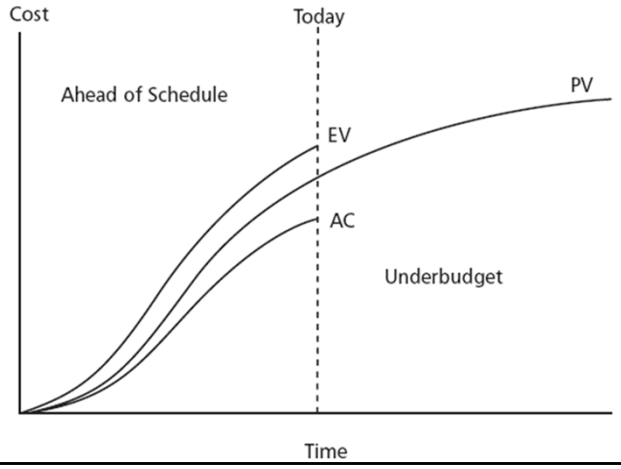
Earned Value Example

- EV higher than PV means the project is ahead of schedule AC is higher than PV and EV, means more money is spent to complete the job than planned, and spending more money to accomplish work than the EV of that work.



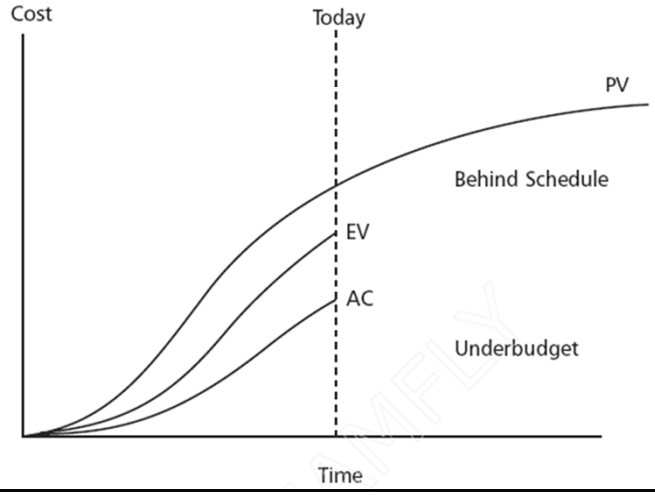
Earned Value Example

- EV higher than PV means the project is ahead of schedule AC is lower than EV, means we are spending less money then the earned value of the work. Possible some work does not done as planned and quality is suffering



Earned Value Example

- EV is less than PV, project is behind schedule. AC less than EV, work is accomplished with less cost than planned. Project is understaffed but people is doing a better-than average job.



Earned Value Analysis

Acronym	Term	Interpretation
PV BCWS	Planned Value Budget Cost of Work Scheduled	Estimated value of work to be done
EV BCWP	Earned Value Budget Cost of Work Perform	Estimated value of work actually accomplished
AC ACWP	Actual Cost Actual Cost of Work Perform	Actual cost incurred for the work accomplished
BAC	Budget at Completion	ALL budget of total project effort
EAC	Estimate at Completion	The currently expect the total project to cost
ETC	Estimate to Completion	How much more we expect to cost to finish the project
VAC	Variance at Completion	How much over or under budget we expect at end of project

BCWP – ACWP = Cost Variance
BCWP – BCWS = Schedule Variance
BCWP / ACWP = Cost Performance Index
BCWP / BCWS = Schedule Performance Index

BCWS - budgeted cost of work scheduled
ACWP - actual cost of work performed
BCWP - budgeted cost of work performed

Budget at Completion (BAC)

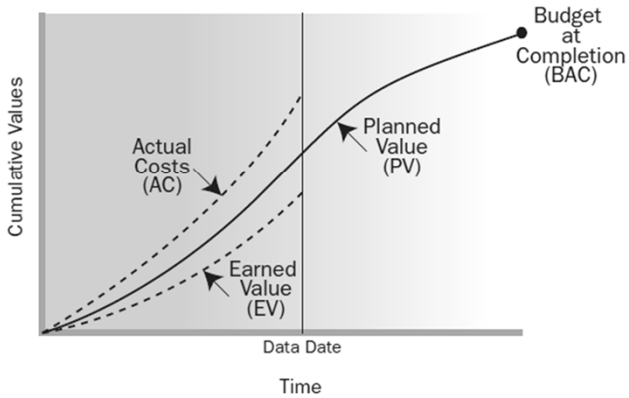


Figure 7-9. Earned Value, Planned Value, and Actual Costs

Forecasting Formula

Terms and Formulas	Definition
Budget at completion (BAC)	How much did we BUDGET for the TOTAL project effort?
Estimate at Completion (EAC) = BAC / CPI	What do we currently expect the TOTAL project cost (a forecast)?
Estimate to Complete (ETC) = EAC - AC	From this point on, how much MORE do we expect it to cost to finish the project (a forecast)?
Variance at Completion (VAC) = BAC – EAC	As of today, how much over or under budget do we expect to be at the end of the project?

EAC is an important **forecasting** value.

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Estimate to complete (ETC) is the remaining budget required to complete the project if work continue at present performance rate

- ETC = EAC - AC

Forecasting EAC

- Estimate at Completion (EAC)
  - It estimate the project cost at the completion of the project
  - It is BAC adjusted for current performance to date, cost-wise
  - If the project continue to perform in its current level, the EAC will be the final project cost

Assumption	Example Formula
Future cost performance will be the same as all past cost performance	$EAC = AC + [(BAC - EV) / CPI] = BAC / CPI$
Future cost performance will be the same as the last three measurement periods (i, j, k)	$EAC = AC + [(BAC - EV) / ((EV_i + EV_j + EV_k) / (AC_i + AC_j + AC_k))]$
Future cost performance will be influenced additionally by past schedule performance	$EAC = AC + [(BAC - EV) / (CPI \times SPI)]$
Future cost performance will be influenced jointly in some proportion by both indices	$EAC = AC + [(BAC - EV) / (.8\ CPI + .2\ SPI)]$

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There are many ways to calculate EAC, depending on the assumption made.
Simple EAC calculation (EAC = BAC/CPI) assume that the cumulative CPI adequately reflects past performance that will continue to the end of the project.

- AC+(BAC-EV)
  - Used when current variances are thought to be atypical of the future
- AC+[(BAC-EV)/(Cumulative CPI + Cumulative SPI)]
  - It assumes poor cost performance and **need to hit a firm completion date**.

Estimate at Completion (EAC)

- A pessimistic value (expects mistake make are continue remain in the project) of EAC can be calculated
  - EAC = AC + Remain PV / CPI
  - Remain PV is different between the work must be done (BAC) and the work completed (EV)
  - Remain PV = BAC – EV
  - And CPI = EV / AC (AC = EV / CPI)
  - By substitution:
    - EAC = AC + (BAC – EV) / CPI
    - EAC = EV / CPI + (BAC – EV) / CPI
    - EAC = (EV + BAC – EV) / CPI
    - EAC = BAC / CPI
- An optimistic value (expects no mistake will be make in remaining project) of EAC can be calculated
    - EAC = AC + Remain PV
    - EAC = AC + BAC - EV

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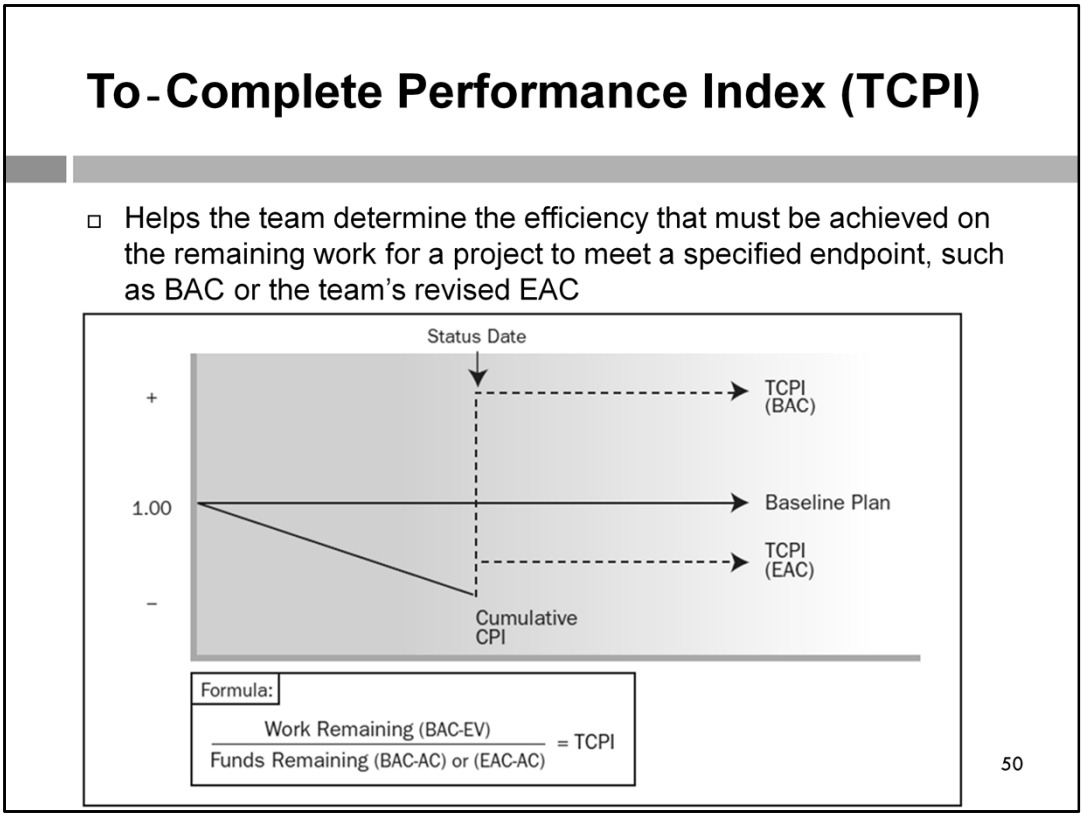
Estimate at Completion (EAC)
- Generated, updated, reissued based on work performance
- Based on actual costs incurred + an estimate to complete (ETC) the remaining work
- Most common EAC forecasting is manual bottom-up summation
- Burden: doing EAC takes energy. EAC=AC+ (bottom-up ETC)

Statistical EAC based on EVM method
- EAC forecast for ETC work performed at the budgeted rate. EAC=AC+BAC-EV
- EAC forecasted for ETC work performed at the present CPI. EAC=BAC/(cumulative CPI)
- EAC forecast for ET work considering both SPI and CPI factors. Variation of this method weigh the CPI and SPI differently (80/20, 50/50, ...). EAC= AC +[(BACEV)/(cumulative CPI x cumulative SPI)]



Calculated projection of cost performance that must be achieved on the remaining work to meet a specific goal

If the BAC cannot be achievable, the PM can seek for approval for using EAC as the final completion

TCPI Based on BAC and EAC

- TCPI based on BAC
  - Based on the work remain divided by the fund remain
  - (BAC – EV) / (BAC – AC)
- TCPI based on EAC
  - Based on the work remain divided by the new approved funding
  - (BAC – EV) / (EAC – AC)

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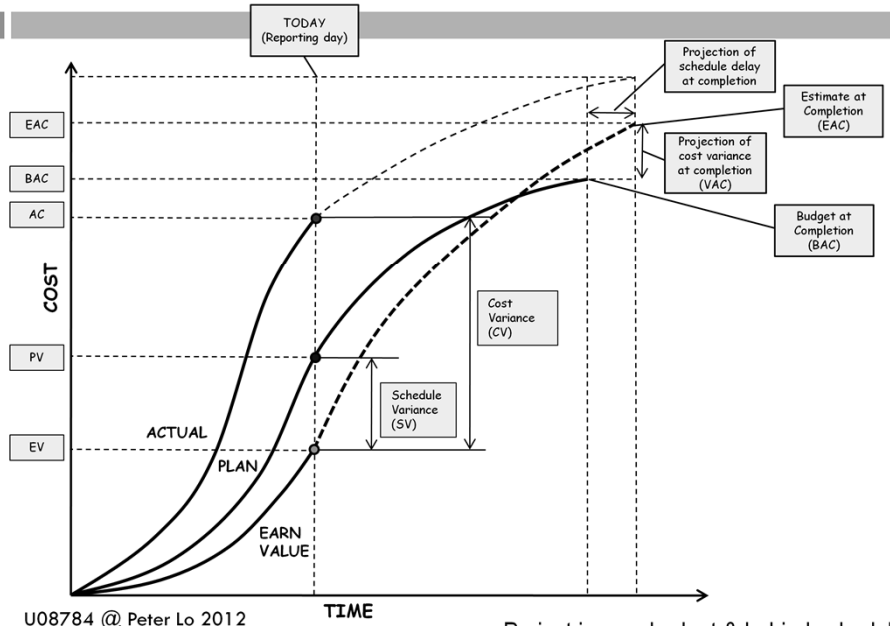
To-Complete Performance Index (TCPI), the calculated projection of cost performance that must be achieved on the remaining work to meet a specific goal such as BAC or EAC.

- TCPI based on BAC=(BAC-EV)/(BAC-AC)
- If cumulative CPI falls below the baseline plan, all future work of the project will need to immediately be performed in the range of the TCPI (BAC) to stay within the authorized BAC.
- Reaching the goal depends on risks, schedule, technical performance, ...
- If not, EAC is computed and once approved, it is the new goal
- TCPI based on EAC=(BAC-EV)/(EAC-AC)

Performance Reviews

- Compare cost performance over time, schedule activities or work packages overrunning and under running the budget, and the estimated funds needed to complete work in progress in EVM:
  - Variance Analysis – compares actual project (cost or schedule) performance to planned or expected performance
  - Trend Analysis – examines project performance over time to determine if performance is improving or deteriorating. Graphical comparison of BAC versus EAC and completion dates
  - Earned Value Performance – compares the baseline plan to actual schedule and cost performance

Performance Analysis Graph



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Project is over budget & behind schedule

53 **53**

Variance Analysis

- Comparing actual project performance to planned or expected performance
- Trend analysis examining project performance over time to determine if performance is improving or deteriorating

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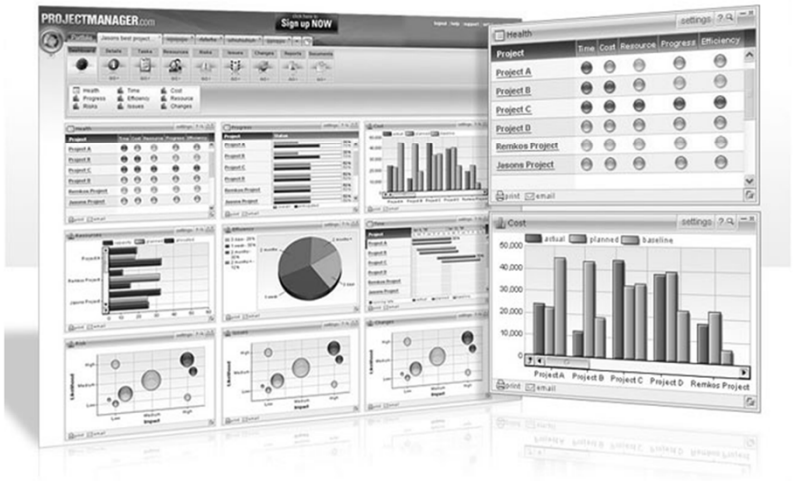
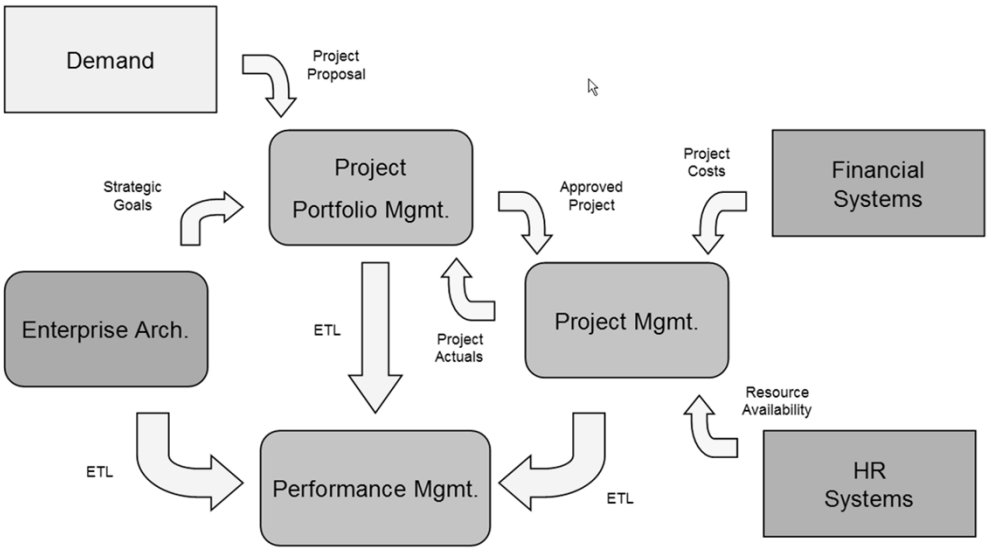
Cost performance measurements (CV, CPI) are used to assess the magnitude of variation to the original cost baseline
Cause and degree of variance WRT the cost performance baseline? --> corrective/preventive action?
High acceptable variance range at start, lower as the project gets closer to complete

Project Management Software

- Monitoring PV, EV, and AC



Software Project Management Context Diagram



Reporting Work Complete

- Progress/performance report (output from communication area)
  - Where work cannot be measured, estimate could be done by a guess
- Percent complete:
  - 50/50 Rule
    - 50% of earned value is credited as earned value when the activity begins
    - Remaining 50 percent of the earned value is not credit until all of the worked completed
  - 20/80 Rule
  - 0/100 Rule

  } Encourage project team to begin working on activities

Activity is considered X percent complete when it begins and get credit for the last Y percent only when it is complete

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There is frequently difficulty in reporting work complete on the project. Many people tend to report that the percent that is complete on an activity is the same as the percent of the time that has elapsed. Thus, if 50 percent of the time to do an activity in the project has passed but only 25 percent of the work is actually done, misleading reports could result.

There are several approaches to solving this problem. The "50-50 rule" is one such approach. In this approach to earned value data collection, 50 percent of the earned value is credited as earned value when the activity begins. The remaining 50 percent of the earned value is not credited until all of the work is completed.

The 50-50 rule encourages the project team to begin working on activities in the project, since they get 50 percent of the earned value for just starting an activity. As time goes by, the actual cost of work performed accumulates, and the project team is motivated to complete the work on the activity so that the additional 50 percent of the earned value can be credited. This creates an incentive to start work and another incentive to finish work that has been started. This solves the problem of reporting percent complete, and there should be few arguments about whether work has actually begun or has been completed on a project activity.

There are many variations of the 50-50 rule. Popular variations include the 20-80 rule and the 0-100 rule. These allow differing percentages of the earned value of the work to be claimed at the start and completion of the work.

Examples: EV is higher than the PV. This means that the project is ahead of schedule. More activities have been completed than were planned to be completed at this time. This can be good. The AC is higher than the PV as well. It is also higher than the EV. This means that we are spending

Control Costs (Output)

- Work Performance Measurements
- Budget Forecast
- Organizational Process Assets Update
- Change Request
- Project Management Plan Updates
- Project Document Updates

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- Work Performance Measurements
  - Calculated CV, SV, CPI, and SPI values for WBS components, work packages and control accounts are documented and communicated to stakeholders
- Budget Forecasts
  - Calculated EAC value or bottom-up EAC value is documented and communicated to stakeholders
- Organizational Process Assets Updates
  - Cause of variance
  - Corrective actions chosen and the reasons
  - Other types of lessons learned from project cost control
- Change Requests
  - Through the Perform Integrated Change Control Process)
- Project Management Plan Updates
  - Cost performance baseline (scope, activity resources, cost estimates. Sometimes new cost baseline should be prepared as cost variance is severe)
  - Cost management plan
- Project Document Plan
  - Cost estimates
  - Basis of estimates

Financial Tools

- Opportunity Cost
  - The opportunity cost given up by selecting one project over another
- Depreciation
  - Straight line depreciation
  - Accelerated depreciation
- Internal Rate of Return (IRR)
  - The return, which can be earned on the capital invested in the project, i.e. the discount rate that gives an NPV of zero on a given payback period. This is equivalent to the yield on the investment
- Benefit Cost Ratio
  - Compare the benefit to cost, >1 means benefit is greater than cost. A benefit cost ratio is 1.7 means payback is 1.7 times the cost
- Present Value (PV)
  - Present value means the value today of future cash flow

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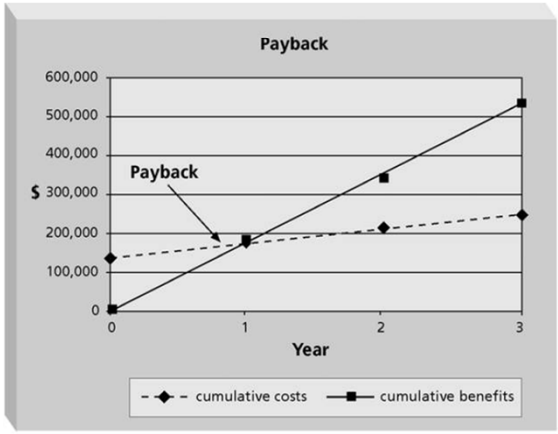
- Opportunity Cost
  - The opportunity cost given up by selecting one project over another
- Depreciation
  - Straight line depreciation
    - The same depreciation is taken each year
  - Accelerated depreciation
    - Double declining balance
    - Sum of the year digits
- Net present value (NPV)
  - The difference between the present value of cash flows generated by a project and its capital cost. It is calculated as part of the process of assessing and appraising investments
- Internal rate of return (IRR)
  - The return, which can be earned on the capital invested in the project, i.e. the discount rate that gives an NPV of zero on a given payback period. This is equivalent to the yield on the investment
- Benefit Cost Ratio
  - Compare the benefit to cost, >1 means benefit is greater than cost. A benefit cost ratio is 1.7 means payback is 1.7 times the cost
- Present Value (PV)
  - Present value means the value today of future cash flow
    - PV = FV / (1+r)n
    - FV = Future value
    - r = Interest rate
    - n = number of time periods

Payback Analysis

- The **Payback Period** is the amount of time it will take to recoup, in the form of net cash inflows, the total dollars invested in a project.
- Formula

$$= \frac{\text{Cost of Project}}{\text{Annual Cash Inflows}}$$



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Payback occurs when the cumulative discounted benefits and costs are greater than zero. Many organizations want IT projects to have a fairly short payback period.

Item	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*
Hardware purchase	500,000				
Hardware maintenance	50,000	50,000	50,000	50,000	50,000
Software purchase	180,000				
Software support	20,000	20,000	20,000	20,000	20,000
Cumulative total costs	750,000	820,000	890,000	960,000	1,030,000
Staff savings per year	220,000	220,000	220,000	220,000	220,000
Cumulative savings	220,000	440,000	660,000	880,000	1,100,000
Cumulative savings less costs	–530,000	–380,000	–230,000	–80,000	+70,000

Return on Investment

- **Return on Investment** (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.
- Many organizations have a required rate of return or minimum acceptable rate of return on investment for projects.

$$ROI = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

In the previous example,

ROI = 14,000/500,000 = 2.8%

Net Present Value

- **Net Present Value** (NPV) is the difference between the present value of cash inflows and the present value of cash outflows.
- NPV is used in capital budgeting to analyze the profitability of an investment or project.
- NPV analysis is sensitive to the reliability of future cash inflows that an investment or project will yield.
- Formula:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

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Year	Cash-flow for year	Discount Factor * at 20%	Discounted Cash Flow
1	–530,000	1.000	–530,000
2	+150,000	0.833	124,950
3	+150,000	0.694	104,100
4	+150,000	0.579	86,850
5	+150,000	0.482	72,300
		Net present value:	**–141,000**

*Discount factor = $1/(1+R)^T$ where R = Interest rate, T = No. of year

Discount factor = $1/(1+r)^t$

r is the interest rate (e.g. 10% is 0.10)

t is the number of years

In the case of 20% rate and one year, Discount factor = 1/(1+0.20) = 0.9091

In the case of 20% rate and two years, Discount factor = 1/(1.20 x 1.20) =0.8294

Sample Budget for an IT Project

BUDGET FOR: NEW CUSTOMER CONTACT SYSTEM									
Expenditure code and heading		Monthly figures							Totals
		Mar	Apr	May	Jun	Jul	Aug	Sep	
A	Direct labour	50	50	70	90	120	70	30	480
B	Subcontract work		30	30	60	60	30		210
C	Hardware	100				200			300
D	Software	30				60			90
E	Telecommunications	10				60			70
F	Travel	3	3	1	1	3	2	1	14
G	Accommodation and subsistence	2	2	1	1	2	2	1	11
H	Project-specific training	10							10
I	Support services					2	6	5	13
J	Consultancy support	2	2	2	2	6	2	1	17
Contingency (10%) – items B–J only		*16*	*4*	*3*	*6*	*39*	*4*	*1*	*74*
Monthly totals:		207	87	104	154	513	112	38	1289

Reference

- Ch. 7, PMBOK Guide, 4th Edition
- Ch. 5, Software Project Management, 4th Edition
- Ch. 9-10, Project Management for Information Systems, 5th Edition