



LECTURE 4

Project cost estimation

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The Importance of Project Cost Management (PCM)

- Software projects have a poor track record for meeting budget goals.
- Average cost overrun from 1995 CHAOS study was 189% of the original estimates; improved to 145% in the 2001 study.
- The 2003 CHAOS studies showed the average cost **overrun** (the additional percentage or dollar amount by which actual costs exceed estimates) was 43 percent.
- In 1995, cancelled software projects cost the U.S. over \$81 billion
- U.S. lost \$55 billion in software projects in 2002 from cancelled projects and overruns compared to \$140 billion in 1994.

Reasons for Cost Overruns

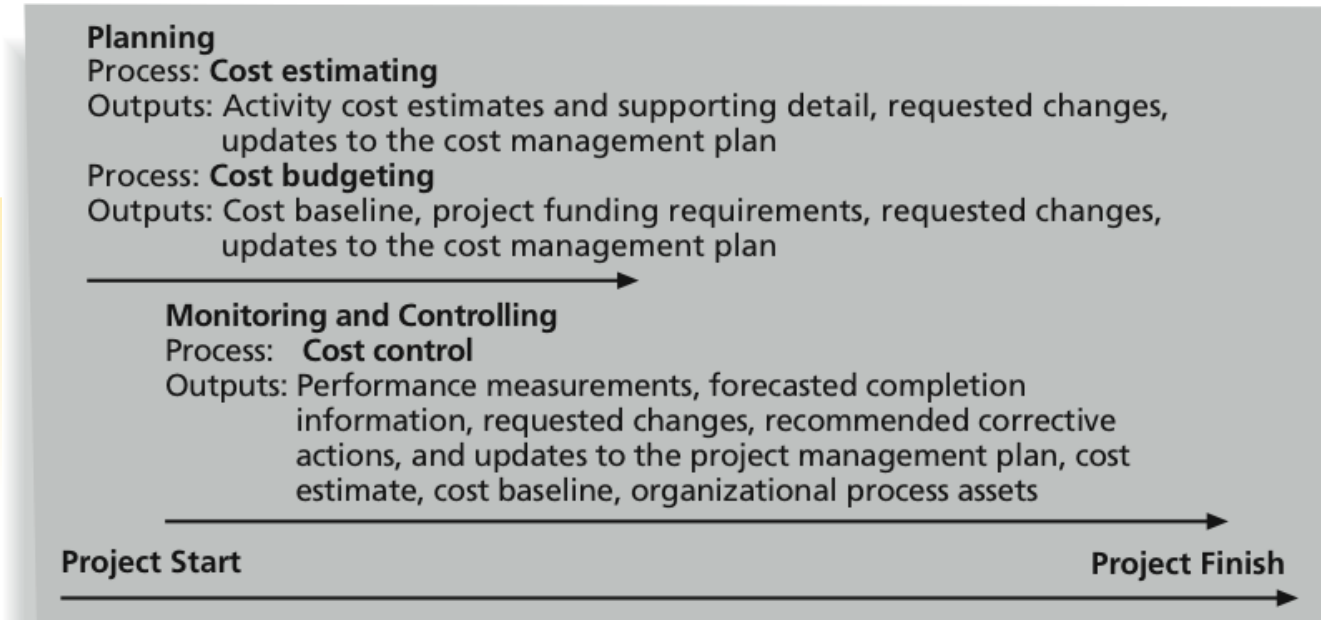
- Not emphasizing the importance of realistic project cost estimates from the outset.
 - Many of the original cost estimates for software projects are low to begin with and based on very unclear project requirements.
- Many software professionals think preparing cost estimates is a job for accountants when in fact it is a very demanding and important skill that project managers need to acquire.
- Many software projects involve new technology or business processes which involve untested products and inherent risks.

What is Cost and PCM?

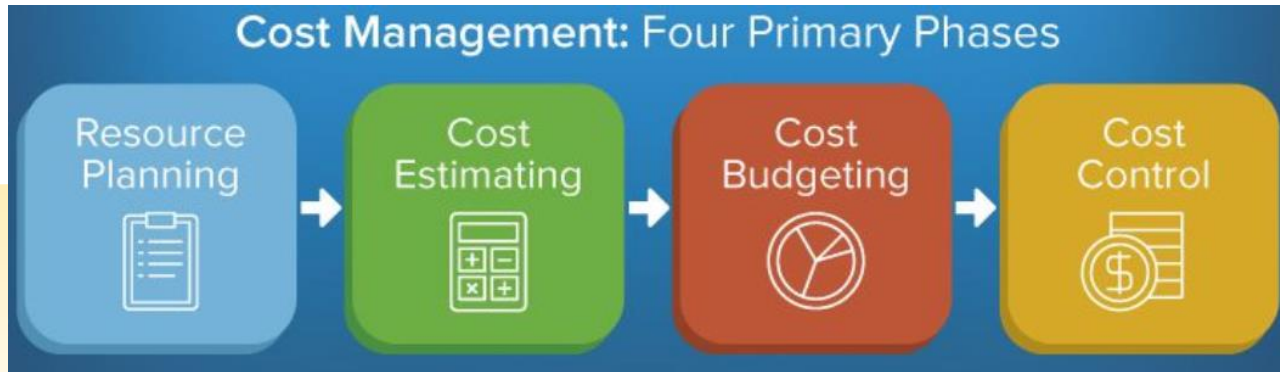
- Cost is a resource sacrificed or foregone to achieve a specific objective or something given up in exchange.
- Costs are usually measured in monetary units like dollars.
- Project Cost Management includes the processes required to ensure that the project is completed within an approved budget.
- Project managers must make sure their projects are well defined, have accurate time and cost estimates and have a realistic budget that they were involved in approving.

What is Cost and PCM?

- Project Cost Management Summary:



Project Cost Management Processes



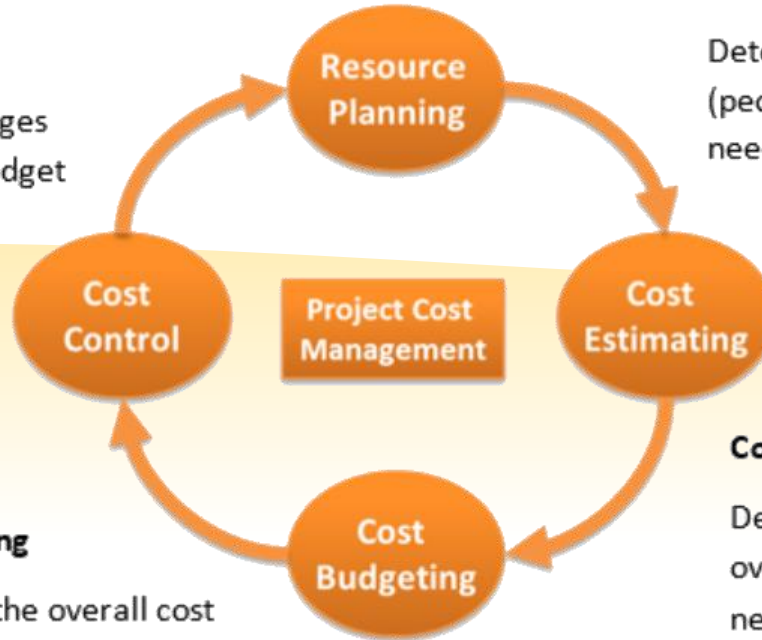
Project Cost Management Processes

Cost Control

Controlling changes to the project budget

Resource Planning

Determine the resources (people, equipment, materials) needed for project completion



Cost Budgeting

Allocation of the overall cost estimate to the project budget

Cost Estimating

Develop an approximation of overall cost of resources needed to complete the project

Basic Principles of Cost Management

- Most CEOs and boards know a lot more about finance than software, so software project managers must speak their language.
 - **Profits** are revenues minus expenses.
 - **Profits margin** is the ratio of revenues to profits
 - \$2 profit per \$100 revenue → 2% profit margin
 - **Life cycle costing** is estimating the cost of a project plus the maintenance costs of the products it produces.
 - **Cash flow analysis** is determining the estimated annual costs and benefits for a project. Benefits and costs can be tangible or intangible, direct or indirect.
 - **Sunk cost** should not be a criteria in project selection.

Basic Principles of Cost Management

- **Tangible costs** or **benefits** are those costs or benefits that an organization can easily measure in dollars.
- **Intangible costs** or **benefits** are costs or benefits that are difficult to measure in monetary terms.
- **Direct costs** are costs that can be directly related to producing the products and services of the project.
- **Indirect costs** are costs that are not directly related to the products or services of the project, but are indirectly related to performing the project.
- **Sunk cost** is money that has been spent in the past; when deciding what projects to invest in or continue, you should *not* include sunk costs.

Basic Principles of Cost Management

- **Learning curve theory** states that when many items are produced repetitively, the unit cost of those items decreases in a regular pattern as more units are produced.
- **Reserves** are dollars included in a cost estimate to mitigate cost risk by allowing for future situations that are difficult to predict.
 - **Contingency reserves** allow for future situations that may be partially planned for (sometimes called **known unknowns**) and are included in the project cost baseline.
 - **Management reserves** allow for future situations that are unpredictable (sometimes called **unknown unknowns**).

Basic Principles of Cost Management

- Cost of Software Defects.

When Defect is Detected	Typical Cost of Correction
User Requirements	\$100-\$1,000
Coding/Unit Testing	\$1,000 or more
System Testing	\$7,000 - \$8,000
Acceptance Testing	\$1,000 - \$100,000
After Implementation	Up to millions of dollars

- It is important to spend money up-front on software projects to avoid spending a lot more later.

Resource Planning

- The nature of the project and the organization will affect resource planning.
- Some questions to consider:
 - How difficult will it be to do specific tasks on the project?
 - Is there anything unique in this project's scope statement that will affect resources?
 - What is the organization's history in doing similar tasks?
 - Does the organization have or can they acquire the people, equipment, and materials that are capable and available for performing the work?

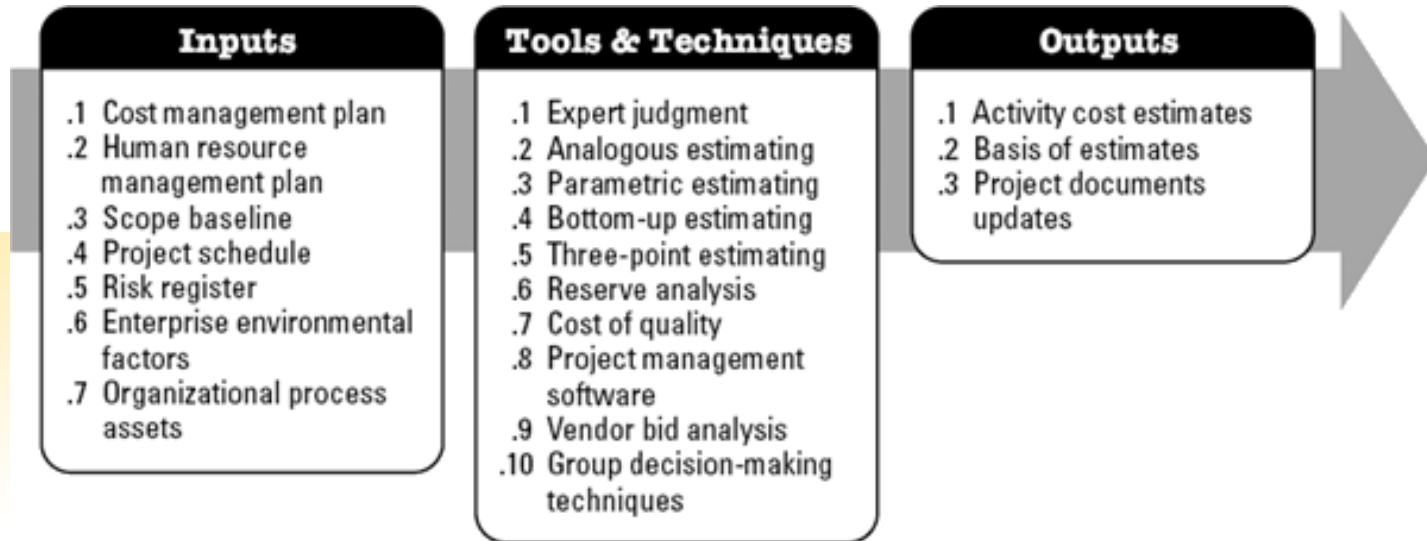
Resource Planning

RESOURCE USAGE	i	Resource Name ▼	Work ▼	Details	June 6/1	6/8	6/15	6/22
	1	▷ Mary Smith	163.33 hrs	Work	5.33h	22h	30h	20h
	2	▷ John Taylor	44.67 hrs	Work	34.67h	10h		
	3	▷ Malcolm Green	9.33 hrs	Work	1.33h	6h	2h	
	4	▷ Brent Brown	4.67 hrs	Work	2.67h	2h		
	5	▷ Scott Grey	24 hrs	Work		8h	8h	8h
	6	▷ Karen White	16 hrs	Work		8h	0h	8h
	7	▷ Mark Foster	4 hrs	Work			4h	
	8	▷ Amy Johnson	42 hrs	Work		2h	36h	4h
	9	▷ Bob Seer	26 hrs	Work		2h	8h	16h
	10	▷ Larry Nelson	16 hrs	Work			4h	12h
	11	▷ Tasha McCoy	56 hrs	Work	8h	32h	16h	
	12	▷ Lee Brown	2 hrs	Work		2h		
	13	▷ Troy Smith	24 hrs	Work		12h	12h	

Cost Estimating

- An important output of project cost management is a cost estimate.
- After developing a good resource requirements list, PMs and their teams must develop several estimates of the costs for these resources.
- Project managers must take cost estimates seriously if they want to complete projects within budget constraints.
- It's important to know the types of cost estimates, how to prepare cost estimates, and typical problems associated with software cost estimates.

Cost Estimating



Estimate Costs: Inputs, Tools & Techniques, and Outputs

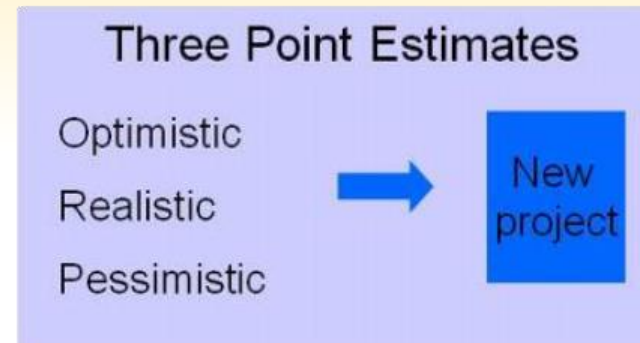
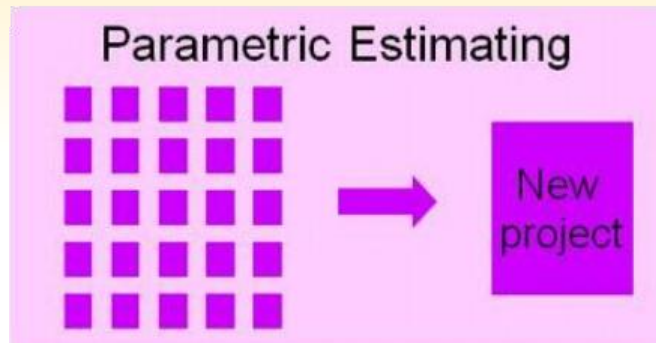
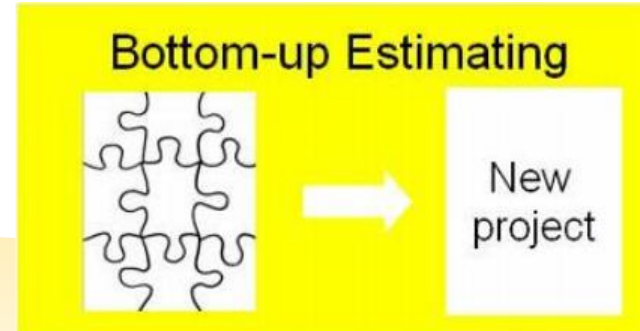
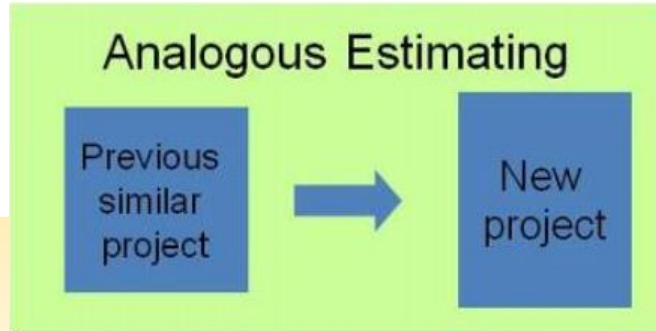
Cost Estimating

- There are several types of cost estimates and tools and techniques to help create them.
- It is also important to develop a cost management plan that describes how cost variances will be managed on the project.
- Types of cost estimate:

Type of Estimate	When Done	Why Done	How Accurate
Rough order of magnitude (ROM)	Very early in the project life cycle, often 3–5 years before project completion	Provides estimate of cost for selection decisions	–50% to +100%
Budgetary	Early, 1–2 years out	Puts dollars in the budget plans	–10% to +25%
Definitive	Later in the project, less than 1 year out	Provides details for purchases, estimates actual costs	–5% to +10%

Cost Estimation Techniques

- There are 4 basic techniques for cost estimates.

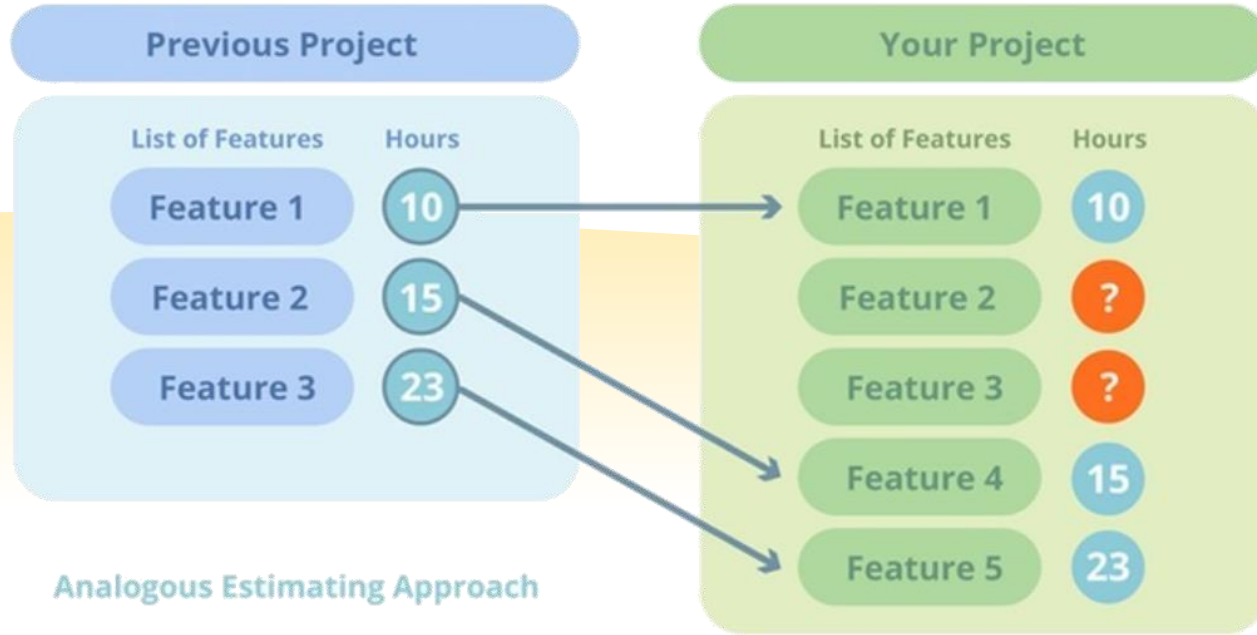


Cost Estimation Techniques

- **Analogous or top-down estimates:** use the actual cost of a previous, similar project as the basis for estimating the cost of the current project.
 - How similar the current and previous project are determines the accuracy of the estimate.
 - Using a different language or hardware can skew the estimate.

Cost Estimation Techniques

- Analogous or top-down estimates:

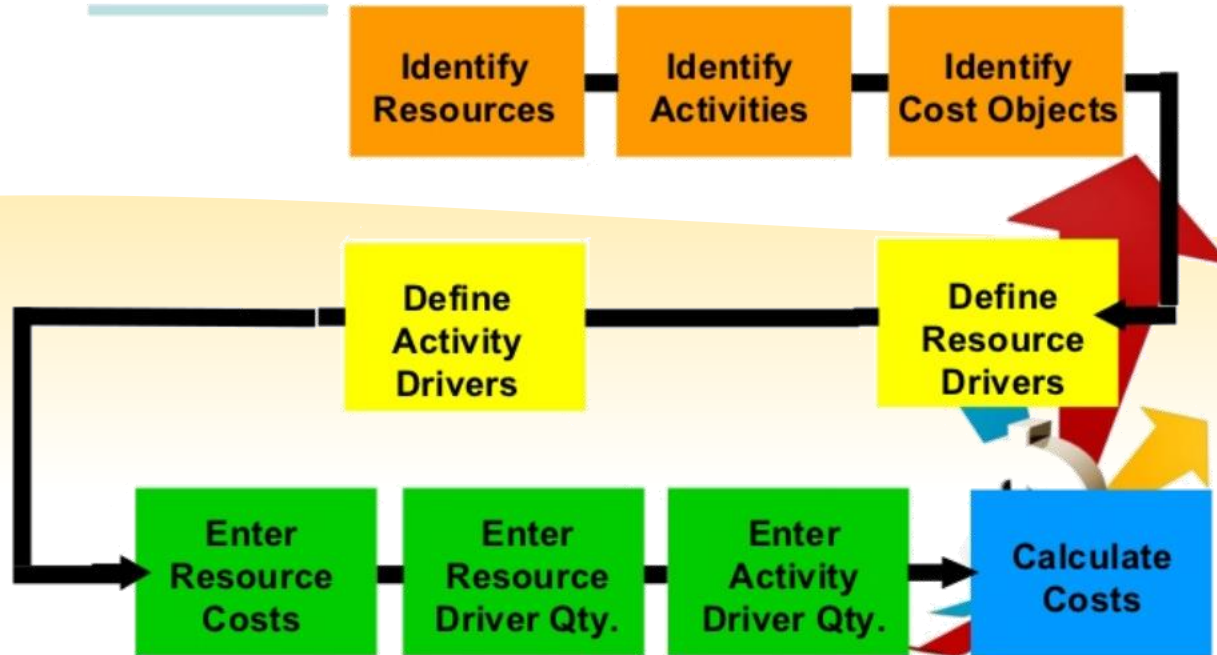


Cost Estimation Techniques

- **Bottom-up estimates** or **Activity Based Costing** : involve estimating individual work items or activities and summing them to get a project total.
 - The smaller the work items, the better the estimate but these estimates are usually time intensive and expensive to develop.

Cost Estimation Techniques

- Bottom-up estimates or Activity Based Costing:

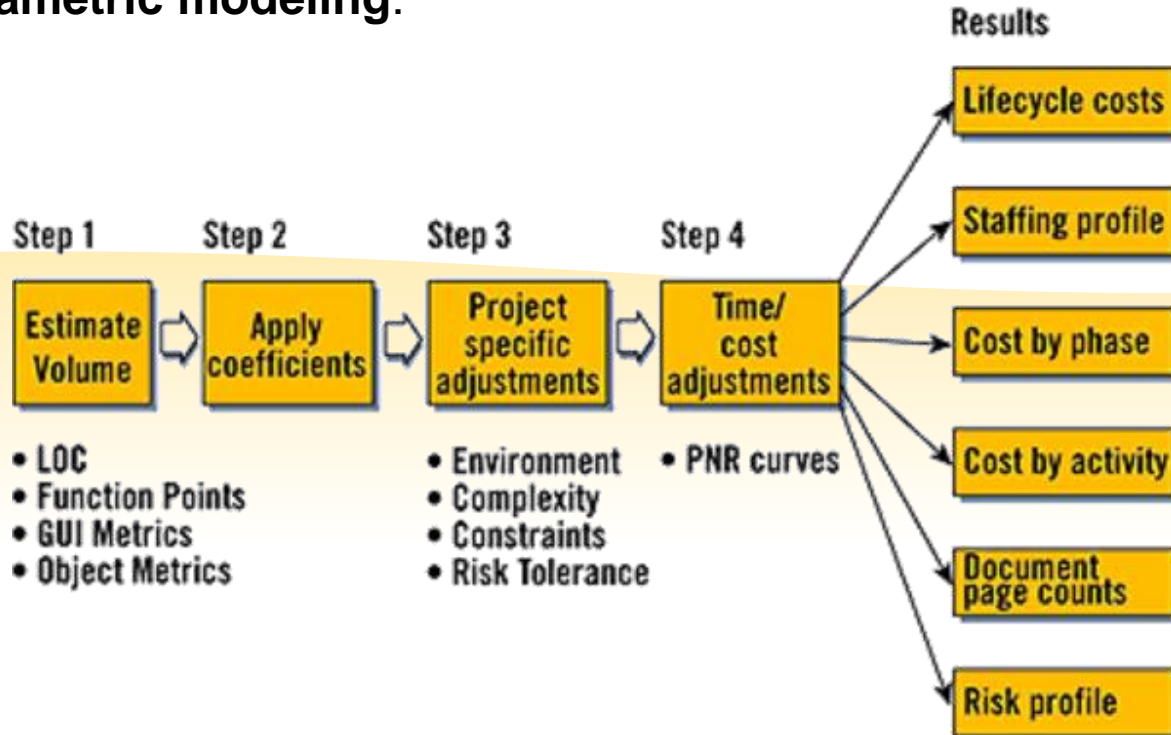


Cost Estimation Techniques

- **Parametric modeling:** uses project characteristics (parameters) in a mathematical model to estimate project costs..
 - For example, a model might provide an estimate of \$50 per line of code for a software development project based on the programming language, level of expertise of the programmers, size and complexity of the data involved, etc
 - Some models may be simpler such as a \$10,000 ballpark estimate per workstation in a large office automation project based on history of similar projects during the same time period.

Cost Estimation Techniques

- Parametric modeling:



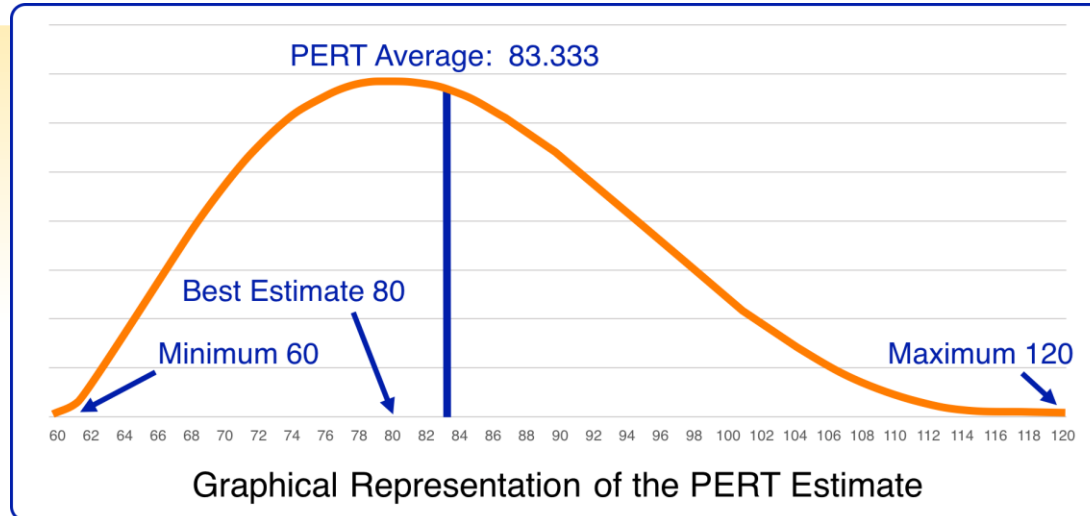
Cost Estimation Techniques

- **Three Point Estimates:** 3-Points is a technique that involves people that are professional in the task we are estimating by this technique. In three-point estimation, three figures are produced initially for every distribution that is required, based on prior experience or best-guesses:
 - The first is a most likely (M)/best guess (BG) which is the average amount of work the task might take if the team member performed it 100 times.
 - The second estimate is the pessimistic (P) estimate which is the amount of work the task might take if the negative factors they identified do occur.
 - The third estimate is the optimistic (O) estimate which is the amount of work the task might take if the positive risks they identified do occur.

Cost Estimation Techniques

- **Three Point Estimates:** also called Program Evaluation and Review Technique (PERT)

$$E = \frac{(O + 4M + P)}{6}$$



Cost Estimation Tools

A Summary Comparison of Cost-Planning Tools					
Situation	Cost-Planning Map	Analogous Estimate	Parametric Estimate	Bottom-up Estimate	Cost Baseline
Provide cost-planning methodology	✓				
Show the amount of estimated funds		✓	✓	✓	✓
Show time-phasing of estimated funds					✓
Organizations with stream of small projects	✓	✓	✓	✓	
Organizations with large projects	✓	✓	✓	✓	✓
Based on past experience		✓	✓		
Higher accuracy required				✓	✓

Cost Estimation Tools

Lower accuracy required		✓	✓		
A few hours to prepare		✓			
Medium time to prepare			✓		
Longer time to prepare	✓		✓	✓	✓
Need estimate for project screening, forecasting			✓	✓	
Need estimate for budget authorization				✓	
Need estimate for cost proposal/change orders				✓	✓
Make decisions very early in project life cycle		✓			
Estimate in project definition/early design			✓		
Before execution, design substantially complete				✓	

Cost Estimation Tools

- There are five tools with clearly designed purposes.
- For two tools, the **cost-planning map** and **cost baseline**, the purposes are so distinct that they do not compete with other tools for use in cost planning.
- While the **cost-planning map** strives to establish a systematic methodology for cost planning, the **cost baseline** aims at providing a time-phased budget.
- The remaining three tools may be used in combination or a single tool can be chosen for a particular application. That calls for matching the project situation with the tool that favors the situation.

Cost Management Plan

- A **cost management plan** is a document that describes how the organization will manage cost variances on the project.
- A large percentage of total project costs are often labor costs, so project managers must develop and track estimates for labor.
- A large percentage of the costs of many software projects are human resource costs.

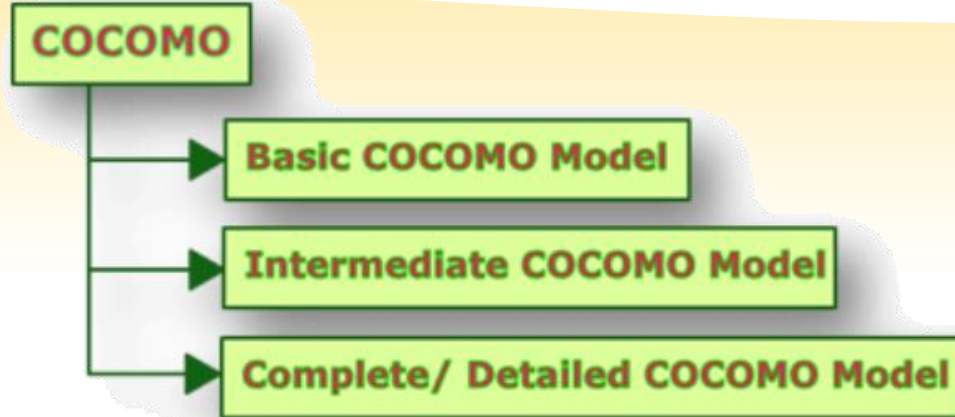
Cost Management Plan

- Example: Maximum Departmental Headcounts by Year

DEPARTMENT	1994	1995	1996	1997	1998	TOTALS
Information Systems	24	31	35	13	13	116
Marketing Systems	3	3	3	3	3	15
Reservations	12	29	33	9	7	90
Contractors	2	3	1	0	0	6
Totals	41	66	72	25	23	227

Constructive Cost Model (COCOMO)

- Barry Boehm helped develop the COCOMO models for estimating software development costs.
- According to him, software cost estimation should be done through three stages:



Constructive Cost Model (COCOMO)

Surveyor Pro Project Cost Estimate Created October 5

	# Units/Hrs.	Cost/Unit/Hr.	Subtotals	WBS Level 2 Totals	% of Total
WBS Items					
1. Project Management				\$306,300	20%
Project manager	960	\$100	\$96,000		
Project team members	1920	\$75	\$144,000		
Contractors (10% of software development and testing)			\$66,300		
2. Hardware				\$76,000	5%
2.1 Handheld devices	100	\$600	\$60,000		
2.2 Servers	4	\$4,000	\$16,000		
3. Software				\$614,000	40%
3.1 Licensed software	100	\$200	\$20,000		
3.2 Software development*			\$594,000		
4. Testing (10% of total hardware and software costs)			\$69,000	\$69,000	5%
5. Training and Support				\$202,400	13%
Trainee cost	100	\$500	\$50,000		
Travel cost	12	\$700	\$8,400		
Project team members	1920	\$75	\$144,000		
Subtotal			\$1,267,700		
6. Reserves (20% of total estimate)			\$253,540	\$253,540	17%
Total project cost estimate				\$1,521,240	

*See software development estimate.

Constructive Cost Model (COCOMO)

Surveyor Pro Software Development Estimate Created October 5

1. Labor Estimate	# Units/Hrs.	Cost/Unit/Hr.	Subtotals	Calculations
Contractor labor estimate	3000	\$150	\$450,000	$3000 * 150$
Project team member estimate	1920	\$75	\$144,000	$1920 * 75$
Total labor estimate			\$594,000	Sum above two values
2. Function point estimate	Quantity	Conversion Factor	Function Points	Calculations
External inputs	10	4	40	$10 * 4$
External interface files	3	7	21	$3 * 7$
External outputs	4	5	20	$4 * 5$
External queries	6	4	24	$6 * 4$
Logical internal tables	7	10	70	$7 * 10$
Total function points			175	Sum above function point values
Java 2 language equivalency value			46	Assumed value from reference
Source lines of code (SLOC) estimate			8,050	$175 * 46$
Productivity \times KSLOC ^{Penalty} (in months)			29.28	$3.13 * 8.05^{1.072}$ (see reference)
Total labor hours (27 hours/function point)*			4,725	$27 * 175$
Cost/labor hour (\$120/hour)			\$120	Assumed value from budget expert
Total function point estimate			\$567,000	$4,725 * 120$

* Based on historical data

Typical Problems with Software Cost Estimates

- Developing an estimate for a large software project is a complex task requiring a significant amount of effort. Remember that estimates are done at various stages of the project.
- Many people doing estimates have little experience doing them. Try to provide training and mentoring.
- People have a bias toward underestimation. Review estimates and ask important questions to make sure estimates are not biased.
- Management wants a number for a bid, not a real estimate. Project managers must negotiate with project sponsors to create realistic cost estimates.

Cost Budgeting

- Cost budgeting involves allocating the project cost estimate to individual work items and providing a cost baseline.
- The WBS is a required input to the cost budgeting process since it defines the work items.
- An important goal is to produce a **cost baseline**
 - A time-phased budget that project managers use to measure and monitor cost performance.
 - Estimating costs for each major project activity over time provides management with a foundation for project cost control.
 - Cost budgeting also provides info for project funding requirements – at what point(s) in time will the money be needed.

Cost Budgeting

- For example, in the Business Systems Replacement project, there was a total purchased cost estimate for FY97 of \$600,000 and another \$1.2 million for Information Services and Technology. These amounts were allocated to appropriate budgets:

Surveyor Pro Project Cost Baseline Created October 10, 2008*

WBS Items	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1. Project Management													
Project manager	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	96,000
Project team members	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	144,000
Contractors		6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	66,300
2. Hardware													
2.1 Handheld devices				30,000	30,000								60,000
2.2 Servers				8,000	8,000								16,000
3. Software													
3.1 Licensed software				10,000	10,000								20,000
3.2 Software development		60,000	60,000	80,000	127,000	127,000	90,000	50,000					594,000
4. Testing			6,000	8,000	12,000	15,000	15,000	13,000					69,000
5. Training and Support													
Trainee cost									50,000				50,000
Travel cost									8,400				8,400
Project team members							24,000	24,000		24,000	24,000	24,000	144,000
6. Reserves				10,000	10,000	30,000	30,000	60,000	40,000	40,000	30,000	3,540	253,540
Totals	20,000	86,027	92,027	172,027	223,027	198,027	185,027	173,027	148,427	90,027	80,027	53,567	1,521,240

Cost Control

- Project cost control includes:
 - Monitoring cost performance.
 - Ensuring that only appropriate project changes are included in a revised cost baseline.
 - Informing project stakeholders of authorized changes to the project that will affect costs.
- Many organizations around the globe have problems with cost control.

Cost Control

- Performance review meetings can be a powerful tool to help control project costs.
 - Knowing you have to report on your progress is an incentive for people to perform better.
- Performance measurement is another important tool for cost control.
 - There are many general accounting approaches for measuring cost performance but **earned value management** is a tool unique to project management

Earned Value Management (EVM)

- EVM is a project performance measurement technique that integrates scope, time, and cost data.
- Given a baseline (original plan plus approved changes), you can determine how well the project is meeting its goals
- You must enter actual information periodically to use EVM:
 - Was a WBS item completed or approximately how much of the work was completed
 - Actual start and end dates
 - Actual cost
- More and more organizations around the world are using EVM to help control project costs.

Earned Value Management (EVM)

- Example figure shows a sample form for collecting information:

WBS#: 6.8.1.2			Description: Design Interface Process - Customer Information		Revision:	Revision Date:
Assignments			Forecast			
			Hours per day		Effort (in hours)	
					Calculated	
Responsible: SMC	Role: PA	Availability: 6	Optimistic: 20	Plan 30 Hrs		
			Most Likely: 30	Effort: _____		
Involved: _____	Role: _____	Availability: _____	Pessimistic: 40	Plan 5 Days		
Involved: _____	Role: _____	Availability: _____		Duration : _____		
Involved: _____	Role: _____	Availability: _____	Delay (Days): _____			
Description			Assumptions			
Develop an operational process design for the Customer Information interface from the Invoicing System to Oracle Receivables. This task will accept as input the business/functional requirements developed during the tactical analysis phase and produce as output a physical operational design, which provides the specifications, required for code development.			- All business rules and issues will be resolved prior to this task. - The ERD & data model for Oracle Receivables & any Oracle extension required will be completed and available prior to this task. - The ERD for the Invoicing System will be completed and available prior to this task. - Few iterations of the review/modify cycle will be required.			
Results / Deliverables			Dependencies			
Process Design Document - Technical - Operation/Physical DFD - Process Specifications - Interface Data Map			Predecessor's (WBS#):		Successors (WBS#):	
			4.7			

Earned Value Management (EVM)

- Earned Value Management Terms:
 - The **planned value (PV)**, formerly called the budgeted cost of work scheduled (BCWS), also called the budget, is that portion of the approved total cost estimate planned to be spent on an activity during a given period.
 - **Actual cost (AC)**, formerly called actual cost of work performed (ACWP), is the total of direct and indirect costs incurred in accomplishing work on an activity during a given period.
 - The **earned value (EV)**, formerly called the budgeted cost of work performed (BCWP), is an estimate of the value of the physical work actually completed.

Earned Value Management (EVM)

- **Rate of performance (RP)** is the ratio of actual work completed to the percentage of work planned to have been completed at a given time during the life of the project or activity.
 - ✓ Brenda Taylor, Senior Project Manager in South Africa, suggests using this approach for estimating earned value.
 - ✓ For example, suppose the server installation was halfway completed by the end of week 1. The rate of performance would be 50 percent ($50/100$) because by the end of week 1, the planned schedule reflects that the task should be 100 percent complete and only 50 percent of that work has been completed.

Earned Value Management (EVM)

- Earned Value Calculations:

Earned value calculations for one activity after Week 1

Activity	Week 1
Earned value (EV)	5,000
Planned value (PV)	10,000
Actual cost (AC)	15,000
Cost variance (CV)	-10,000
Schedule variance (SV)	-5,000
Cost performance index (CPI)	33%
Schedule performance index (SPI)	50%

Earned Value Management (EVM)

- Earned Value Formulas:

Earned value formulas

Term	Formula
Earned value (EV)	$EV = PV \text{ to date} \times RP$
Cost variance (CV)	$CV = EV - AC$
Schedule variance (SV)	$SV = EV - PV$
Cost performance index (CPI)	$CPI = EV/AC$
Schedule performance index (SPI)	$SPI = EV/PV$
Estimate at completion (EAC)	$EAC = BAC/CPI$
Estimated time to complete	Original time estimate/SPI

Earned Value Management (EVM)

- The earned value calculations are carried out as follows:

$$EV = 10,000 * 50\% = 5,000$$

$$CV = 5,000 - 15,000 = -10,000$$

$$SV = 5,000 - 10,000 = -5,000$$

$$CPI = 5,000/15,000 = 33\%$$

$$SPI = 5,000/10,000 = 50\%$$

Earned Value Management (EVM)

- Rules of Thumb for Earned Value Numbers:
 - **Negative numbers** for cost and schedule variance indicate problems in those areas. The project is costing more than planned or taking longer than planned.
 - If CV is negative it means that performing the work cost more than planned
 - A negative SV means that it took longer than planned to perform the work

Earned Value Management (EVM)

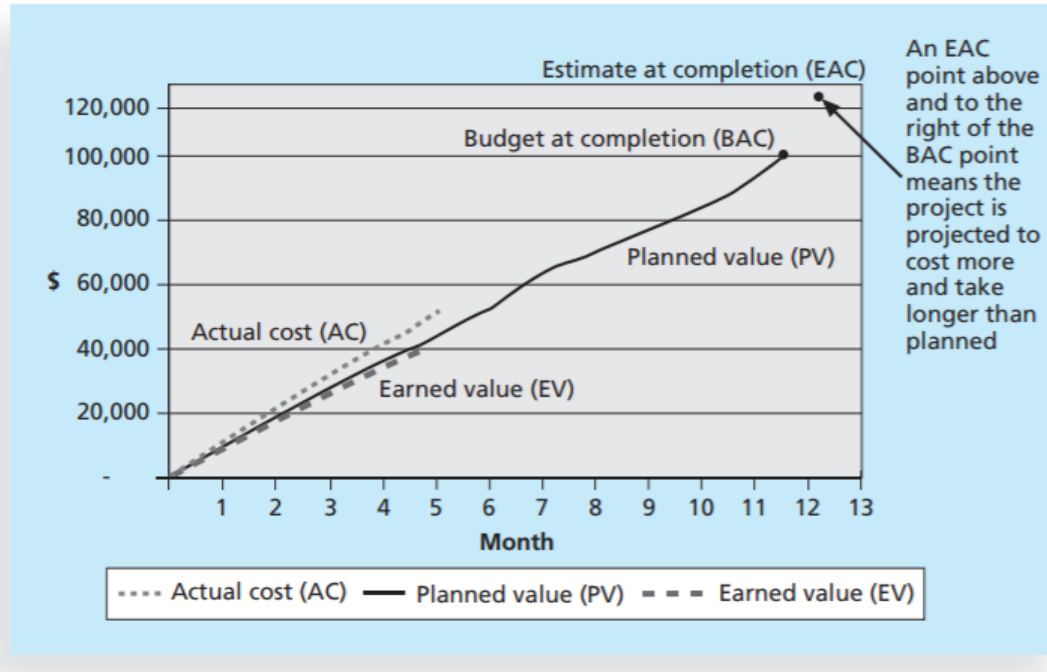
- Rules of Thumb for Earned Value Numbers:
 - **CPI** can be used to estimate the projected cost of completing the project based on performance to date (EAC)
 - $= 1$: the planned and actual costs are the same.
 - < 1 : over budget.
 - > 1 : under budget.

Earned Value Management (EVM)

- Rules of Thumb for Earned Value Numbers:
 - **SPI** can be used to estimate the projected time to complete the project
 - = 1: on schedule.
 - < 1: behind schedule.
 - > 1: ahead of schedule.

Earned Value Management (EVM)

- Example: Earned Value Chart for Project after Five Months



Project Portfolio Management

- Many organizations collect and control an entire suite of projects or investments as one set of interrelated activities in a portfolio.
- Project portfolio management has five levels:
 1. Put all your projects in one database.
 2. Prioritize the projects in your database.
 3. Divide your projects into two or three budgets based on type of investment.
 4. Automate the repository.
 5. Apply modern portfolio theory, including risk-return tools that map project risk on a curve.

Project Portfolio Management



Using Software to Assist in Cost Management

- Spreadsheets are a common tool for resource planning, cost estimating, cost budgeting, and cost control.
- Many companies use more sophisticated and centralized financial applications software for cost information.
- Project management software has many cost-related features, especially enterprise PM software.

THANK YOU !

