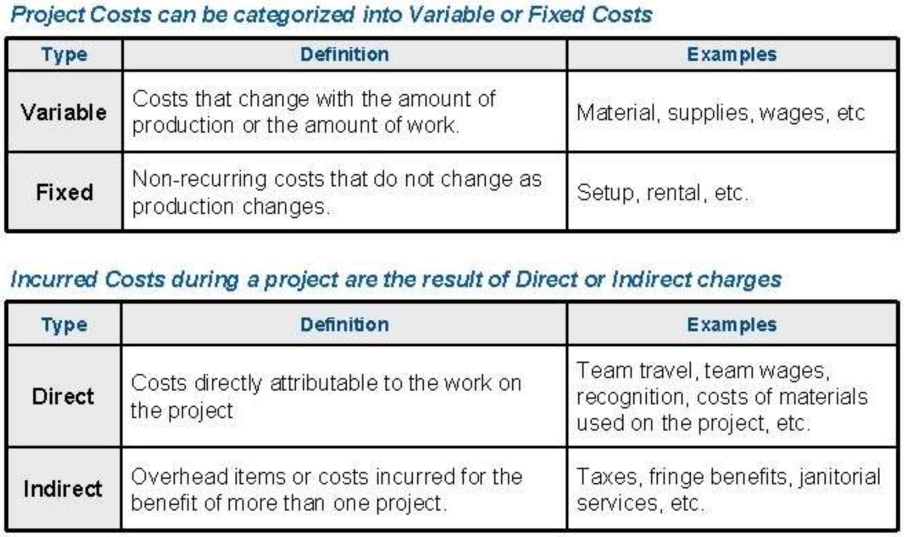
MASTER OF COMPUTER SCIENCE/
MASTER OF SCIENCE IN COMPUTER SCIENCE

MCS 4204 –
Software Project Management and Quality Assurance

Project Cost Management

UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING

Types of Costs



Project Costs can be categorized into Variable or Fixed Costs

Type	Definition	Examples
Variable	Costs that change with the amount of production or the amount of work.	Material, supplies, wages, etc
Fixed	Non-recurring costs that do not change as production changes.	Setup, rental, etc.

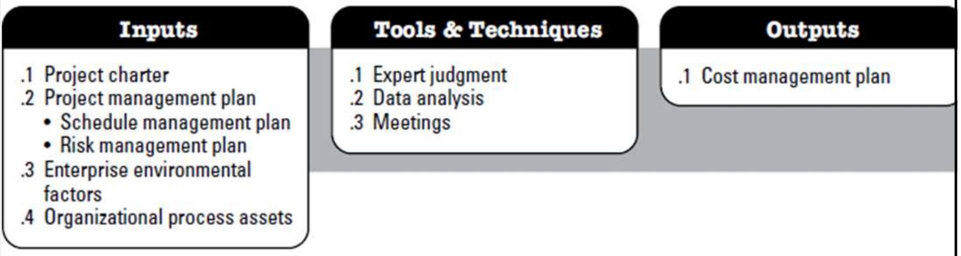
Incurred Costs during a project are the result of Direct or Indirect charges

Type	Definition	Examples
Direct	Costs directly attributable to the work on the project	Team travel, team wages, recognition, costs of materials used on the project, etc.
Indirect	Overhead items or costs incurred for the benefit of more than one project.	Taxes, fringe benefits, janitorial services, etc.

Project Cost Management

- This includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs
- It helps to complete the project within the approved budget.
- Cost Management processes:
  1. **Plan Cost Management**
  2. **Estimate Costs**
  3. **Determine Budget**
  4. **Control Costs**

1. Plan Cost Management



Inputs

.1 Project charter
.2 Project management plan
  • Schedule management plan
  • Risk management plan
.3 Enterprise environmental factors
.4 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data analysis
.3 Meetings

Outputs

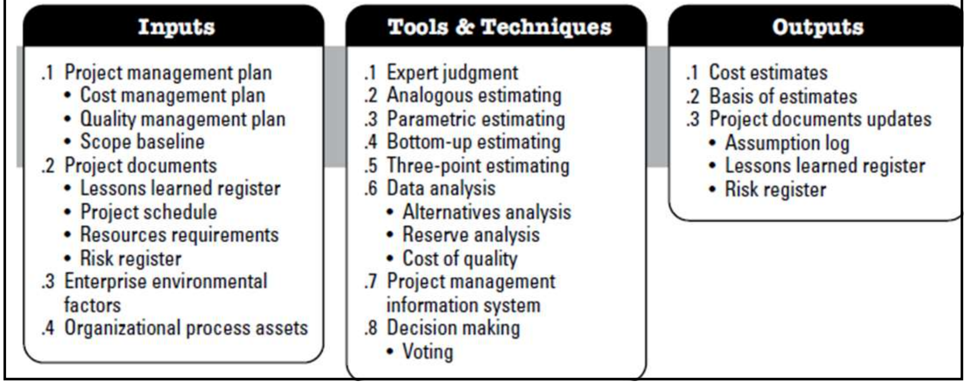
.1 Cost management plan

Cost Management Plan

- Describes how the project costs will be planned, structured, and controlled.
- Includes the cost management processes, associated tools and techniques
- Provides information such as,
  - Units of measure (days, months, Kg, Km,…)
  - Level of precision (rounding up or down: 10.44, 11 or 10)
  - Level of accuracy (+/- 1 day, -10% to + 25%)
  - Control thresholds (amount of variation before taking action to change the schedule (e.g., Bank balance of Rs. 25,000)
  - Rules of performance measurement (Earned Value Management)

2. Estimate Cost

- Estimates the cost of resources needed to complete the project work
- Determines the monetary resources required for the project
- Is performed periodically throughout the project as needed
- Accuracy increases as the project progresses



Inputs

.1 Project management plan
- Cost management plan
- Quality management plan
- Scope baseline

.2 Project documents
- Lessons learned register
- Project schedule
- Resources requirements
- Risk register

.3 Enterprise environmental factors

.4 Organizational process assets

Tools & Techniques

.1 Expert judgment

.2 Analogous estimating

.3 Parametric estimating

.4 Bottom-up estimating

.5 Three-point estimating

.6 Data analysis
- Alternatives analysis
- Reserve analysis
- Cost of quality

.7 Project management information system

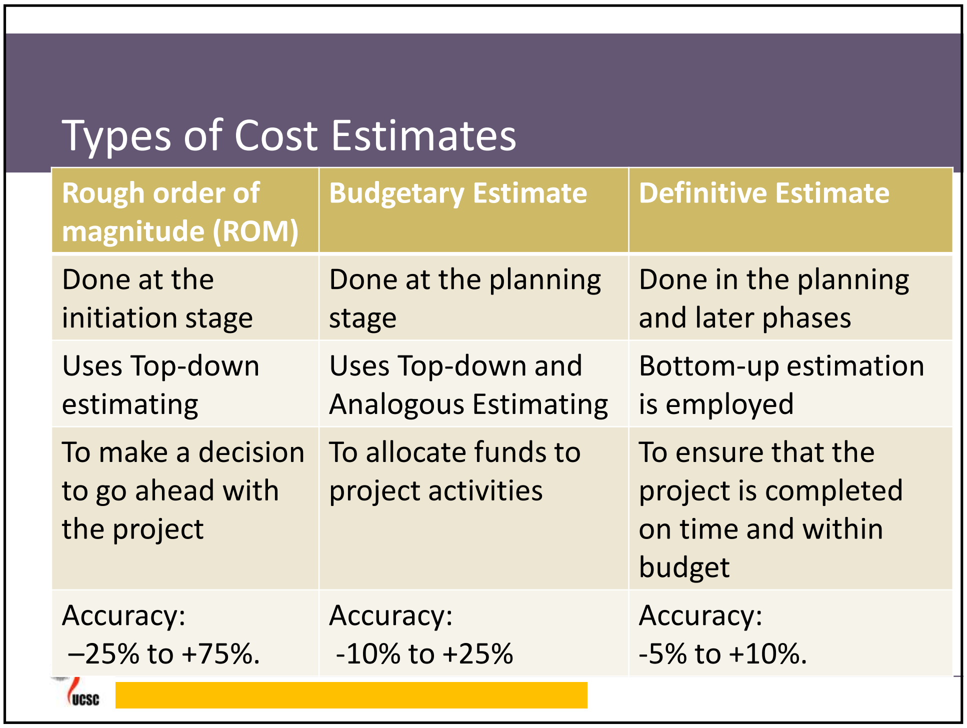
.8 Decision making
- Voting

Outputs

.1 Cost estimates

.2 Basis of estimates

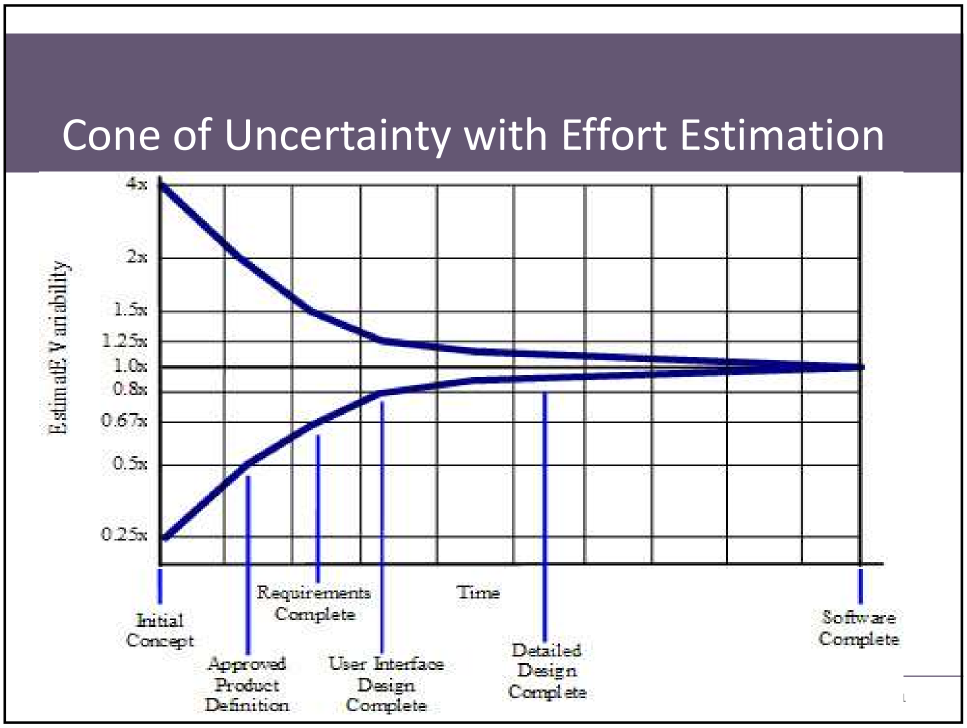
.3 Project documents updates
- Assumption log
- Lessons learned register
- Risk register



Types of Cost Estimates

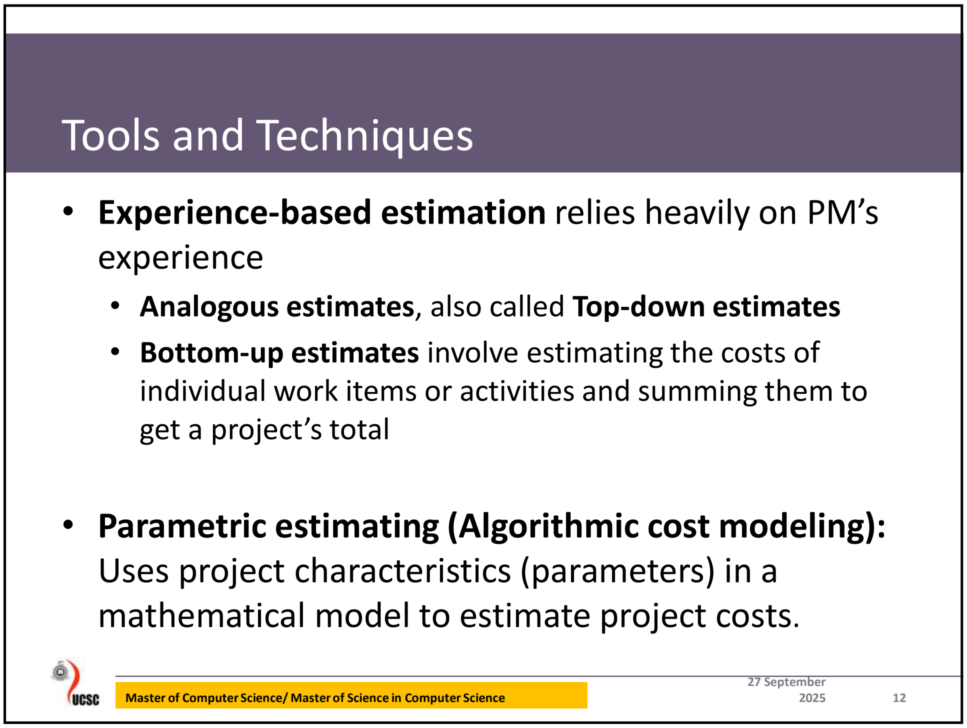
Rough order of magnitude (ROM)	Budgetary Estimate	Definitive Estimate
Done at the initiation stage	Done at the planning stage	Done in the planning and later phases
Uses Top-down estimating	Uses Top-down and Analogous Estimating	Bottom-up estimation is employed
To make a decision to go ahead with the project	To allocate funds to project activities	To ensure that the project is completed on time and within budget
Accuracy: –25% to +75%.	Accuracy: -10% to +25%	Accuracy: -5% to +10%.

9



Cone of Uncertainty with Effort Estimation

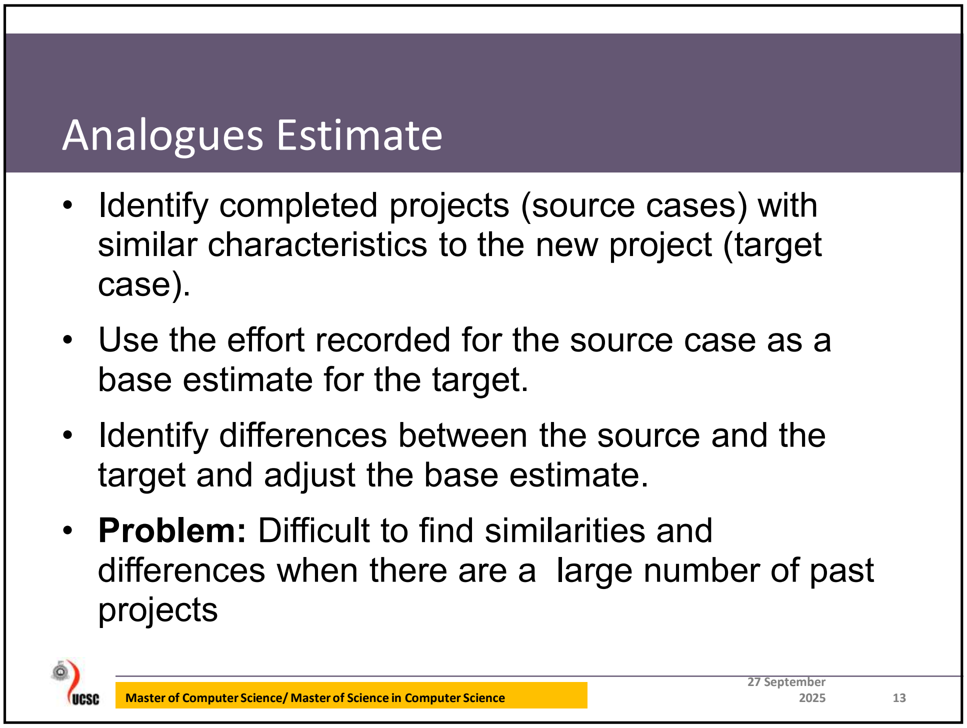
11



Tools and Techniques

- **Experience-based estimation** relies heavily on PM's experience
  - **Analogous estimates**, also called **Top-down estimates**
  - **Bottom-up estimates** involve estimating the costs of individual work items or activities and summing them to get a project's total
- **Parametric estimating (Algorithmic cost modeling):** Uses project characteristics (parameters) in a mathematical model to estimate project costs.

12

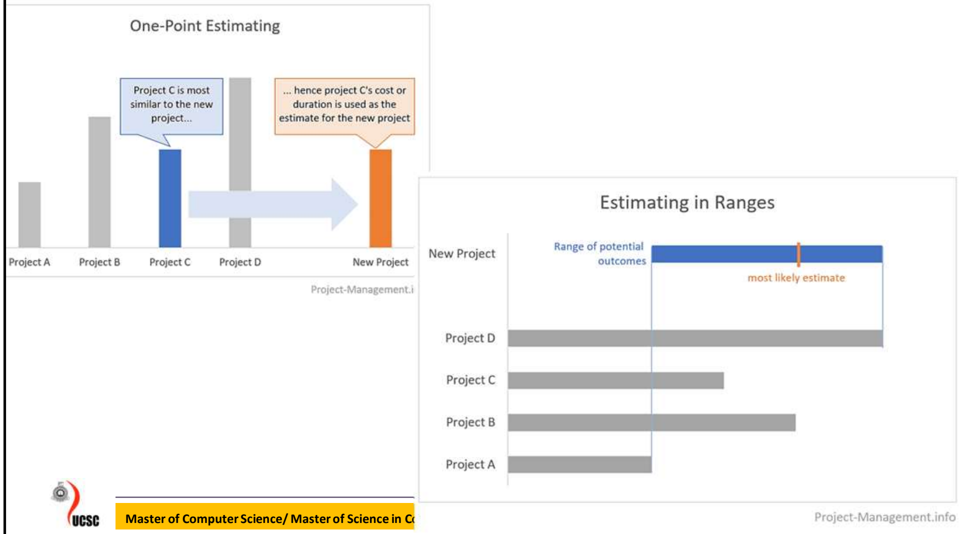


Analogues Estimate

- Identify completed projects (source cases) with similar characteristics to the new project (target case).
- Use the effort recorded for the source case as a base estimate for the target.
- Identify differences between the source and the target and adjust the base estimate.
- **Problem:** Difficult to find similarities and differences when there are a large number of past projects

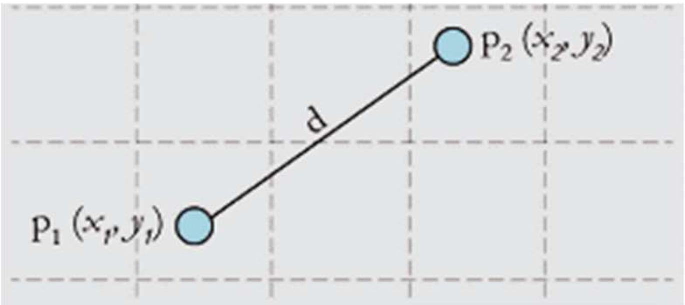
13

Analogues Estimate contd.

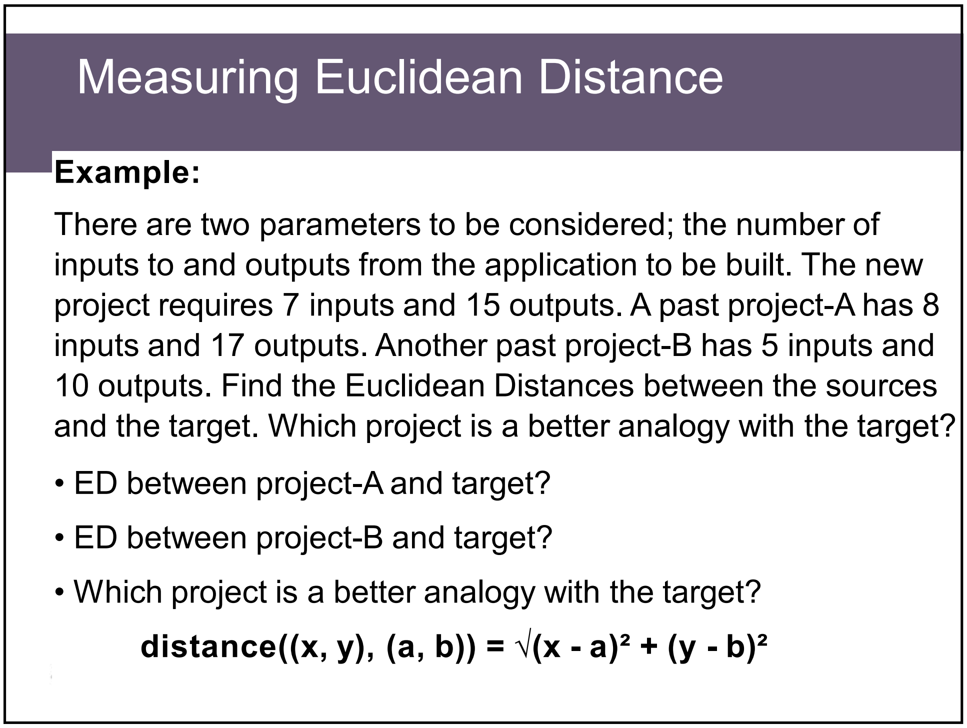


Analogy: Calculating Euclidean distance

- Identify the source case that closest matches the target by measuring the Euclidean distance between cases.
- The source case at the shortest Euclidean distance from the target is deemed to be the closest match.



$$\text{Euclidean distance (d)} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$



Measuring Euclidean Distance

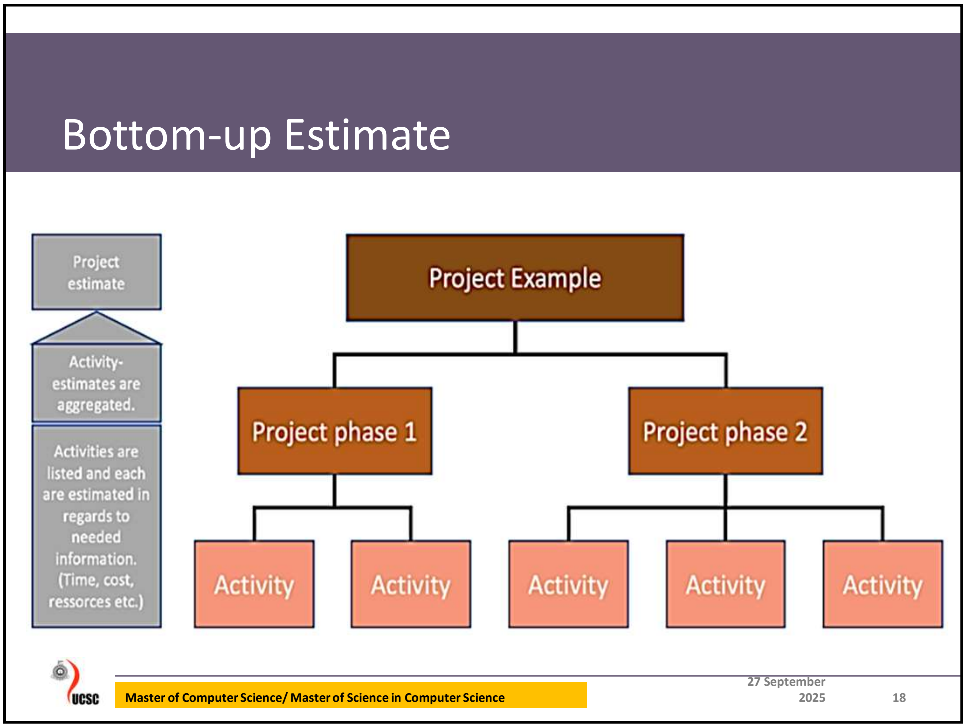
Example:

There are two parameters to be considered; the number of inputs to and outputs from the application to be built. The new project requires 7 inputs and 15 outputs. A past project-A has 8 inputs and 17 outputs. Another past project-B has 5 inputs and 10 outputs. Find the Euclidean Distances between the sources and the target. Which project is a better analogy with the target?

- ED between project-A and target?
- ED between project-B and target?
- Which project is a better analogy with the target?

$$\textbf{distance}((x, y), (a, b)) = \sqrt{}(x - a)^2 + (y - b)^2$$

16



Bottom-up Estimate

Project estimate

Activity-estimates are aggregated.

Activities are listed and each are estimated in regards to needed information. (Time, cost, ressorces etc.)

Project Example

Project phase 1

Project phase 2

Activity

Activity

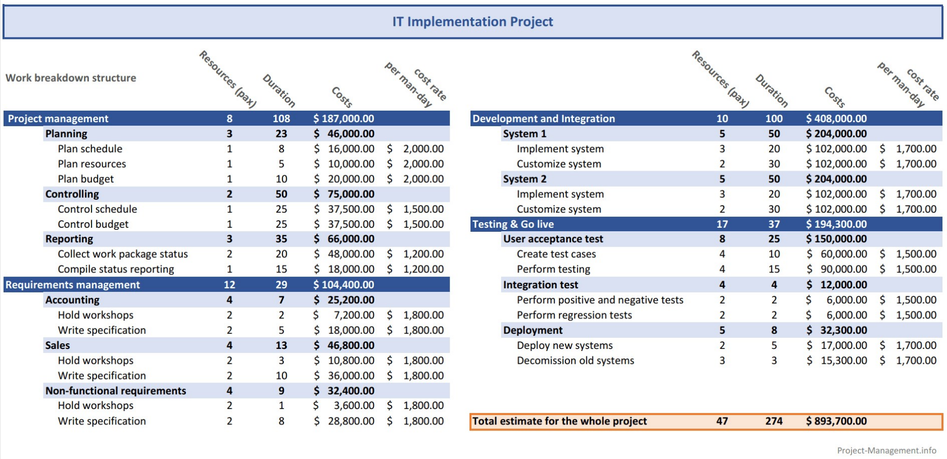
Activity

Activity

Activity

18

Example



IT Implementation Project

Work breakdown structure	Resources (pax)	Duration	Costs	cost rate per man-day
Project management	**8**	**108**	**$ 187,000.00**	
Planning	**3**	**23**	**$ 46,000.00**	
Plan schedule	1	8	$ 16,000.00	$ 2,000.00
Plan resources	1	5	$ 10,000.00	$ 2,000.00
Plan budget	1	10	$ 20,000.00	$ 2,000.00
Controlling	**2**	**50**	**$ 75,000.00**	
Control schedule	1	25	$ 37,500.00	$ 1,500.00
Control budget	1	25	$ 37,500.00	$ 1,500.00
Reporting	**3**	**35**	**$ 66,000.00**	
Collect work package status	2	20	$ 48,000.00	$ 1,200.00
Compile status reporting	1	15	$ 18,000.00	$ 1,200.00
Requirements management	**12**	**29**	**$ 104,400.00**	
Accounting	**4**	**7**	**$ 25,200.00**	
Hold workshops	2	2	$ 7,200.00	$ 1,800.00
Write specification	2	5	$ 18,000.00	$ 1,800.00
Sales	**4**	**13**	**$ 46,800.00**	
Hold workshops	2	3	$ 10,800.00	$ 1,800.00
Write specification	2	10	$ 36,000.00	$ 1,800.00
Non-functional requirements	**4**	**9**	**$ 32,400.00**	
Hold workshops	2	1	$ 3,600.00	$ 1,800.00
Write specification	2	8	$ 28,800.00	$ 1,800.00

	Resources (pax)	Duration	Costs	cost rate per man-day
Development and Integration	**10**	**100**	**$ 408,000.00**	
System 1	**5**	**50**	**$ 204,000.00**	
Implement system	3	20	$ 102,000.00	$ 1,700.00
Customize system	2	30	$ 102,000.00	$ 1,700.00
System 2	**5**	**50**	**$ 204,000.00**	
Implement system	3	20	$ 102,000.00	$ 1,700.00
Customize system	2	30	$ 102,000.00	$ 1,700.00
Testing & Go live	**17**	**37**	**$ 194,300.00**	
User acceptance test	**8**	**25**	**$ 150,000.00**	
Create test cases	4	10	$ 60,000.00	$ 1,500.00
Perform testing	4	15	$ 90,000.00	$ 1,500.00
Integration test	**4**	**4**	**$ 12,000.00**	
Perform positive and negative tests	2	2	$ 6,000.00	$ 1,500.00
Perform regression tests	2	2	$ 6,000.00	$ 1,500.00
Deployment	**5**	**8**	**$ 32,300.00**	
Deploy new systems	2	5	$ 17,000.00	$ 1,700.00
Decomission old systems	3	3	$ 15,300.00	$ 1,700.00
Total estimate for the whole project	**47**	**274**	**$ 893,700.00**	

Project-Management.info

Parametric Estimate

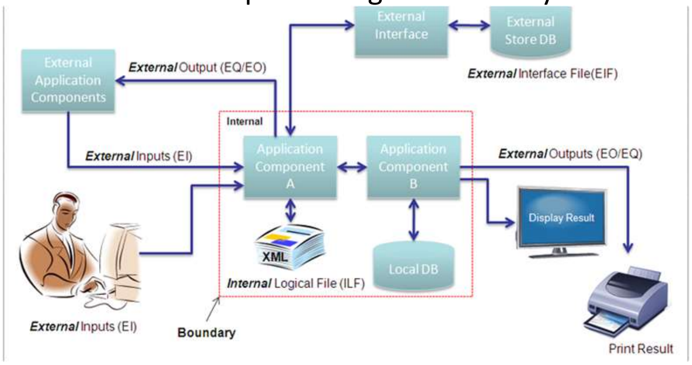
- Lines of Code (LOC)
- Function Point Analysis (Story Point/ Usecase Points)
- COCOMO (Constructive Cost Model)
- DM techniques
  - K-mean, K Nearest Neighbours, Support Vector Machine (SVM), CBR (Case-Based Reasoning)…etc
- Artificial Neural Network based techniques

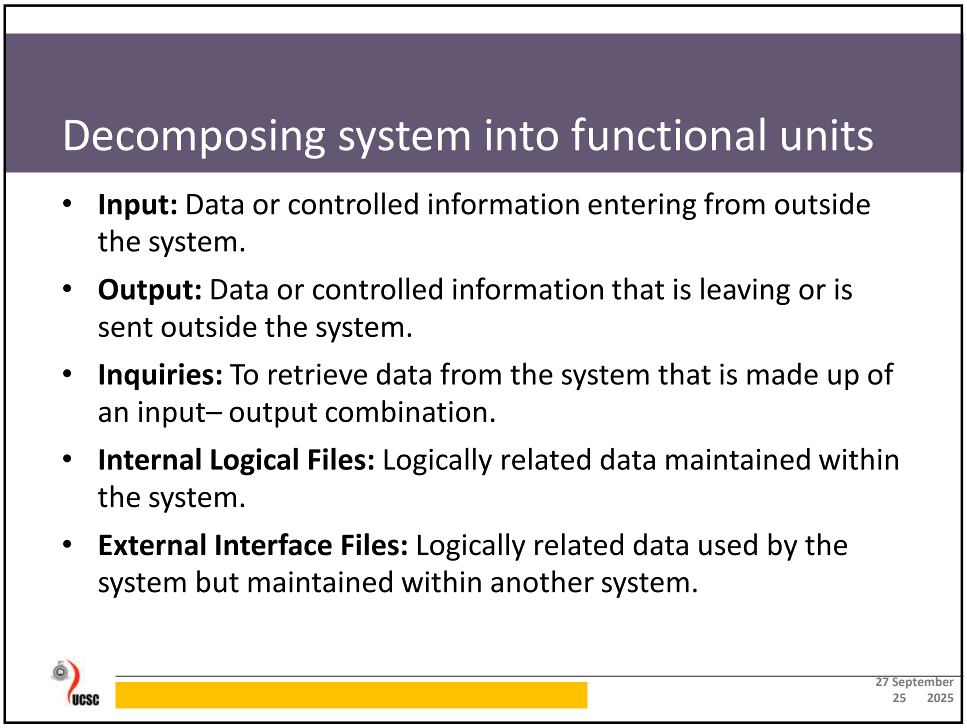
Lines of code

- Unit: KLOC (Thousands of lines of code)
- Physical SLOC – The count of lines in the program's source code including comment and blank (in case there are less than 25% of blank) lines.
- Logical LOC - The number of "statements“ (Specific to computer languages- e.g., for C-like programming languages: The number of statement-terminating semicolons).
- Automatically count the lines of code
  - cloc - a command-line-based tool to count the blank lines, comment lines, actual code lines written in many programming languages
  - VisualExpert - a static code analyzer to find cross references, understand complex code, detect security, quality or performance issues and fix bugs

Function Point Analysis (FPA)

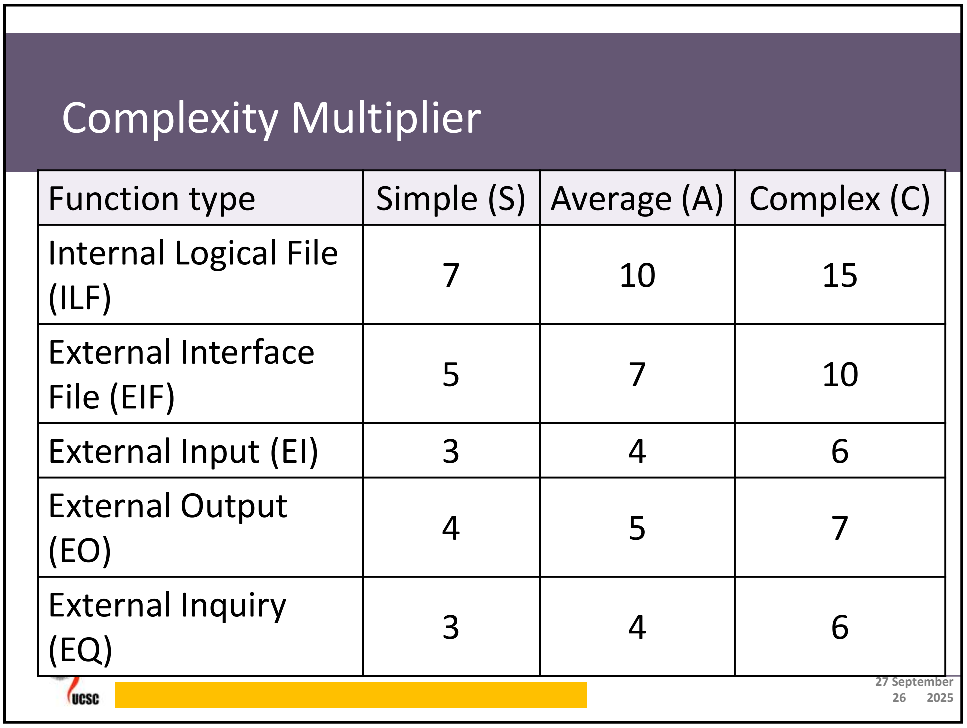
- Quantifies the size and complexity of software in terms of functions.
- Depends on the information processing functionality of the program.





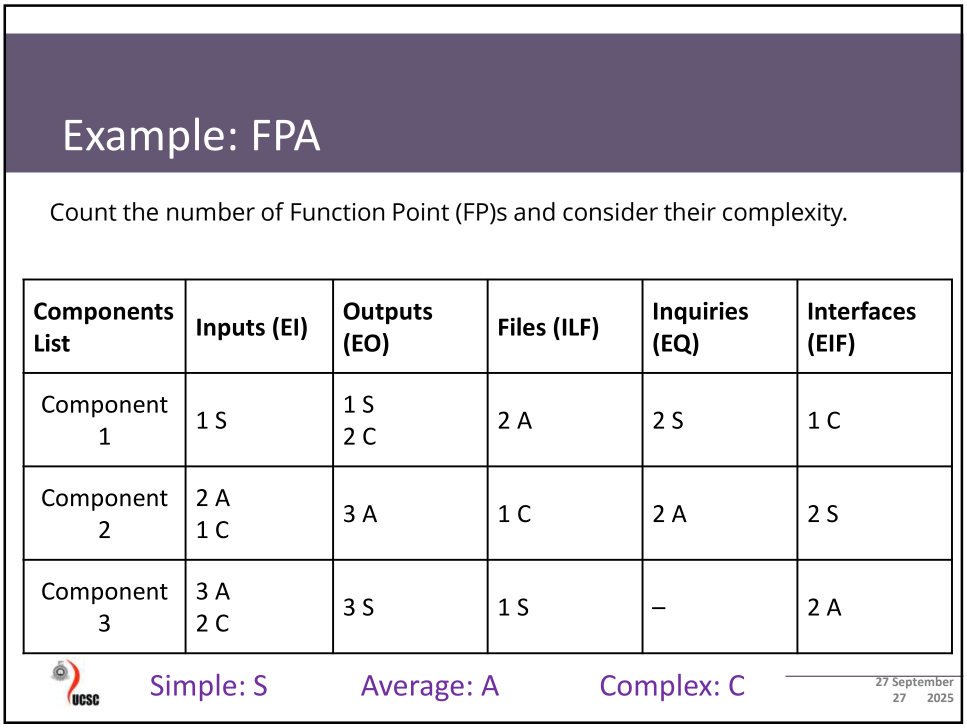
Decomposing system into functional units

- **Input:** Data or controlled information entering from outside the system.
- **Output:** Data or controlled information that is leaving or is sent outside the system.
- **Inquiries:** To retrieve data from the system that is made up of an input– output combination.
- **Internal Logical Files:** Logically related data maintained within the system.
- **External Interface Files:** Logically related data used by the system but maintained within another system.



Complexity Multiplier

Function type	Simple (S)	Average (A)	Complex (C)
Internal Logical File (ILF)	7	10	15
External Interface File (EIF)	5	7	10
External Input (EI)	3	4	6
External Output (EO)	4	5	7
External Inquiry (EQ)	3	4	6

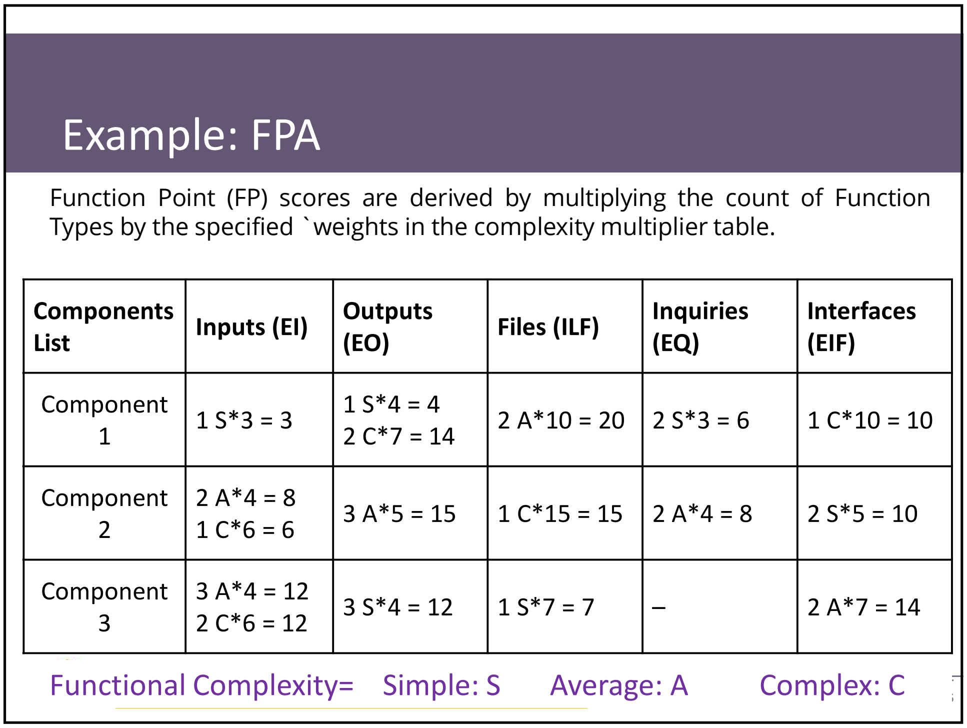


Example: FPA

Count the number of Function Point (FP)s and consider their complexity.

Components List	Inputs (EI)	Outputs (EO)	Files (ILF)	Inquiries (EQ)	Interfaces (EIF)
Component 1	1 S	1 S 2 C	2 A	2 S	1 C
Component 2	2 A 1 C	3 A	1 C	2 A	2 S
Component 3	3 A 2 C	3 S	1 S	–	2 A

Simple: S Average: A Complex: C



Example: FPA

Function Point (FP) scores are derived by multiplying the count of Function Types by the specified `weights in the complexity multiplier table.

Components List	Inputs (EI)	Outputs (EO)	Files (ILF)	Inquiries (EQ)	Interfaces (EIF)
Component 1	1 S*3 = 3	1 S*4 = 4 2 C*7 = 14	2 A*10 = 20	2 S*3 = 6	1 C*10 = 10
Component 2	2 A*4 = 8 1 C*6 = 6	3 A*5 = 15	1 C*15 = 15	2 A*4 = 8	2 S*5 = 10
Component 3	3 A*4 = 12 2 C*6 = 12	3 S*4 = 12	1 S*7 = 7	–	2 A*7 = 14

Functional Complexity= Simple: S Average: A Complex: C

Unadjusted and Adjusted FPs

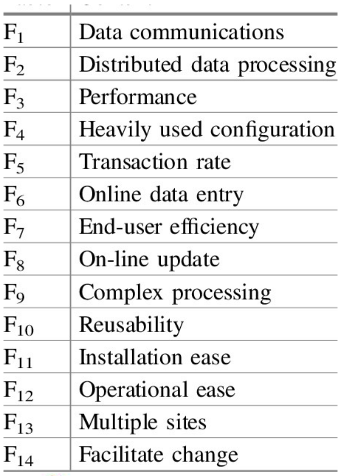
- **Unadjusted Function Points (UFP) =**

(n × EI) + (n × EO) + (n × EQ) + (n × ILF) + (n × EIF)

What is the UPF of the previously discussed example?

- Consider **the degree of influence/functional complexity** of each General System Characteristics (GSC) factor on the system.

General System Characteristics (GSC) and Value Adjustment Factor (VAF)



F_1	Data communications
F_2	Distributed data processing
F_3	Performance
F_4	Heavily used configuration
F_5	Transaction rate
F_6	Online data entry
F_7	End-user efficiency
F_8	On-line update
F_9	Complex processing
F_{10}	Reusability
F_{11}	Installation ease
F_{12}	Operational ease
F_{13}	Multiple sites
F_{14}	Facilitate change

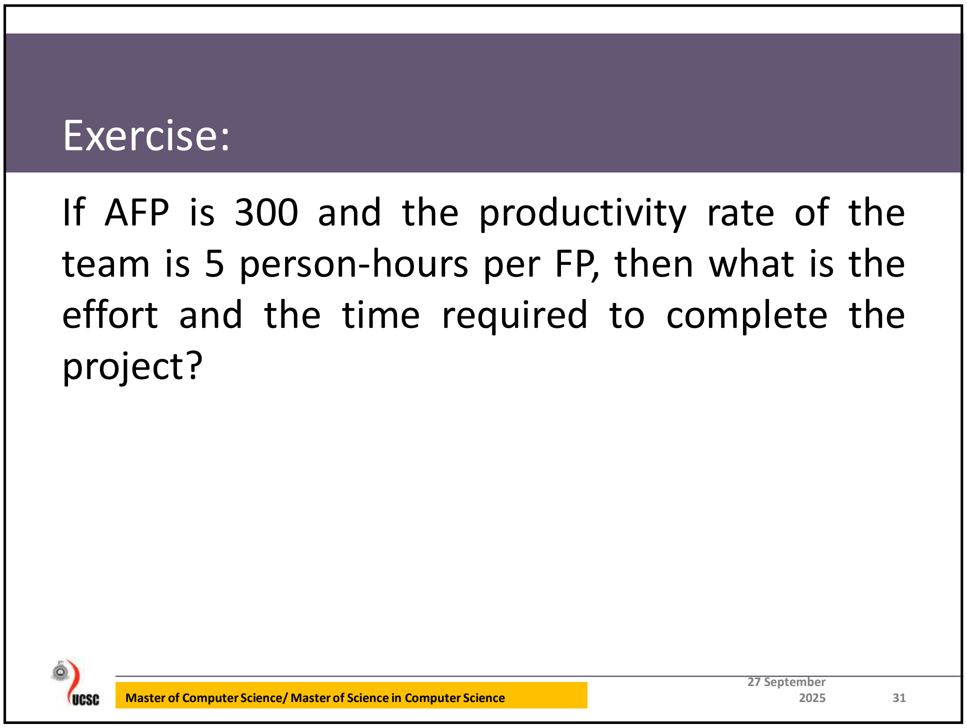
1. Assign a value within 0 (no influence) to 5 (strong influence) to each factor
2. Calculate the Total Degree of Influence (TDI)- **∑Influence of GSC**

   VAF can vary in range from 0.65 (when all GSCs have no influence) to 1.35 (when all GSCs have strong influence)

3. Calculate the VAF considering the total influence of GSC

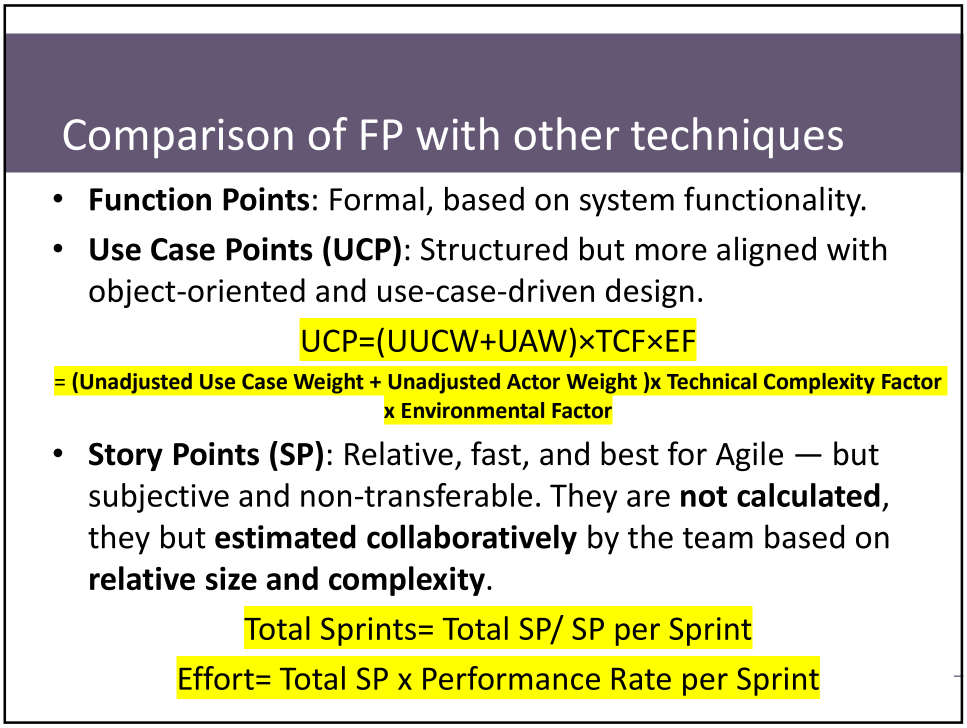
VAF = 0.65 + TDI* 0.01

Adjusted Functional Point (AFP) = UFP * VAF



Exercise:

If AFP is 300 and the productivity rate of the team is 5 person-hours per FP, then what is the effort and the time required to complete the project?



Comparison of FP with other techniques

- **Function Points**: Formal, based on system functionality.
- **Use Case Points (UCP)**: Structured but more aligned with object-oriented and use-case-driven design.

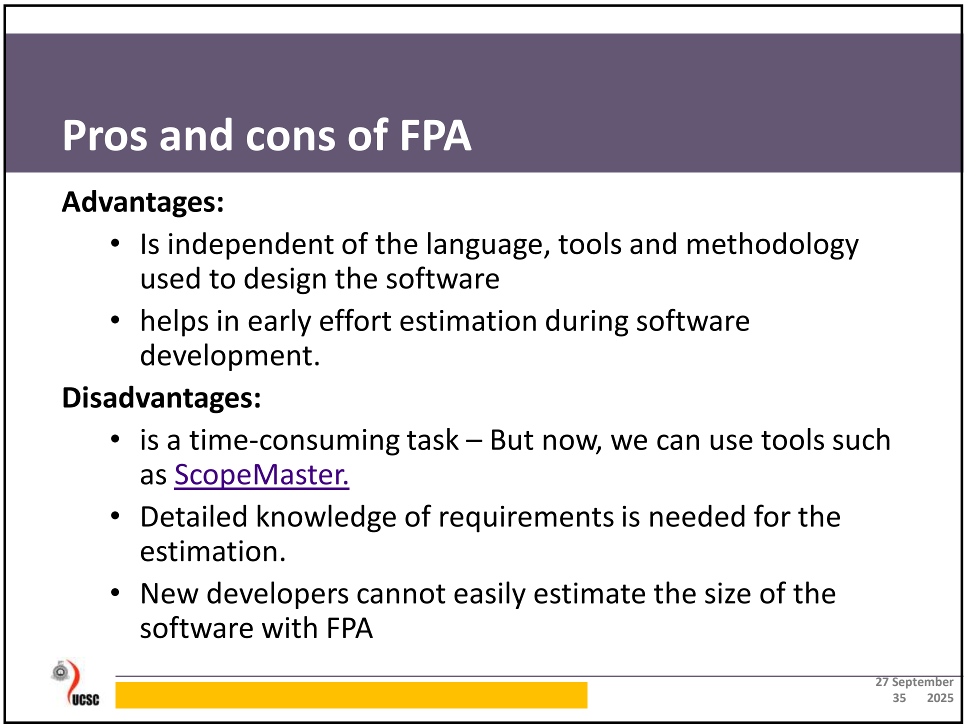
$$UCP=(UUCW+UAW)\times TCF\times EF$$

= (Unadjusted Use Case Weight + Unadjusted Actor Weight)x Technical Complexity Factor x Environmental Factor

- **Story Points (SP)**: Relative, fast, and best for Agile — but subjective and non-transferable. They are **not calculated**, they but **estimated collaboratively** by the team based on **relative size and complexity**.

Total Sprints= Total SP/ SP per Sprint

Effort= Total SP x Performance Rate per Sprint



Pros and cons of FPA

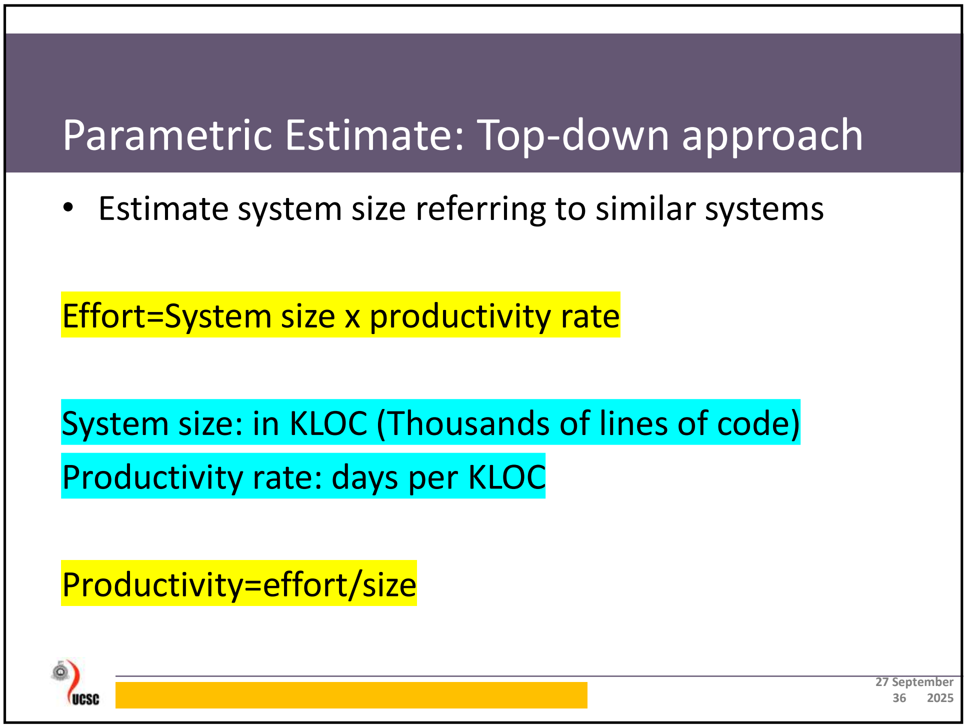
Advantages:

- Is independent of the language, tools and methodology used to design the software
- helps in early effort estimation during software development.

Disadvantages:

- is a time-consuming task – But now, we can use tools such as ScopeMaster.
- Detailed knowledge of requirements is needed for the estimation.
- New developers cannot easily estimate the size of the software with FPA

35



Parametric Estimate: Top-down approach

- Estimate system size referring to similar systems

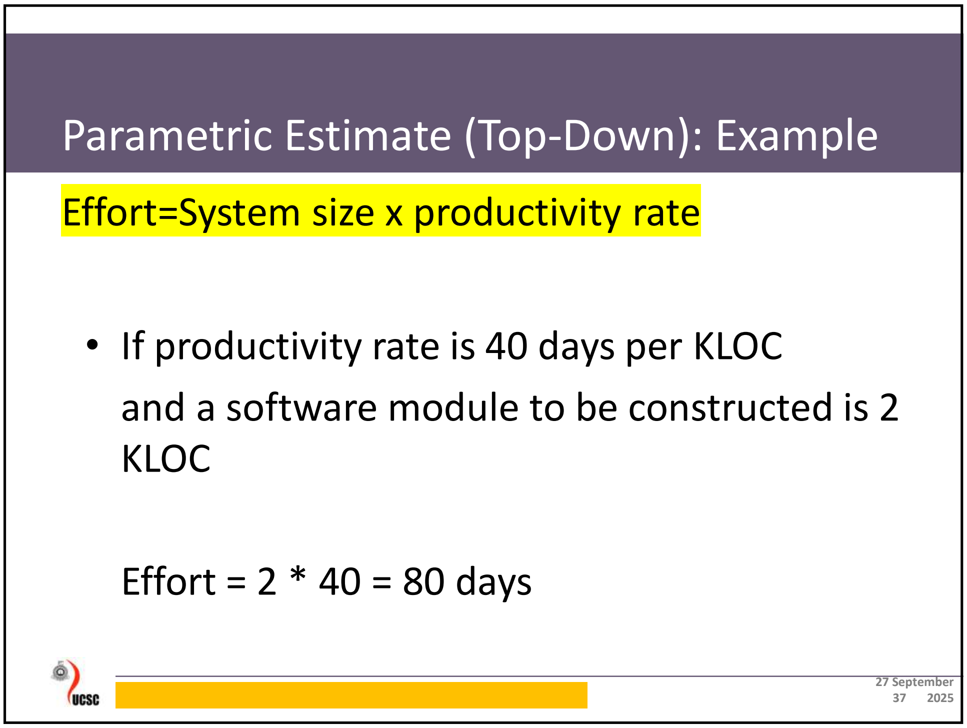
Effort=System size x productivity rate

System size: in KLOC (Thousands of lines of code)

Productivity rate: days per KLOC

Productivity=effort/size

36



Parametric Estimate (Top-Down): Example

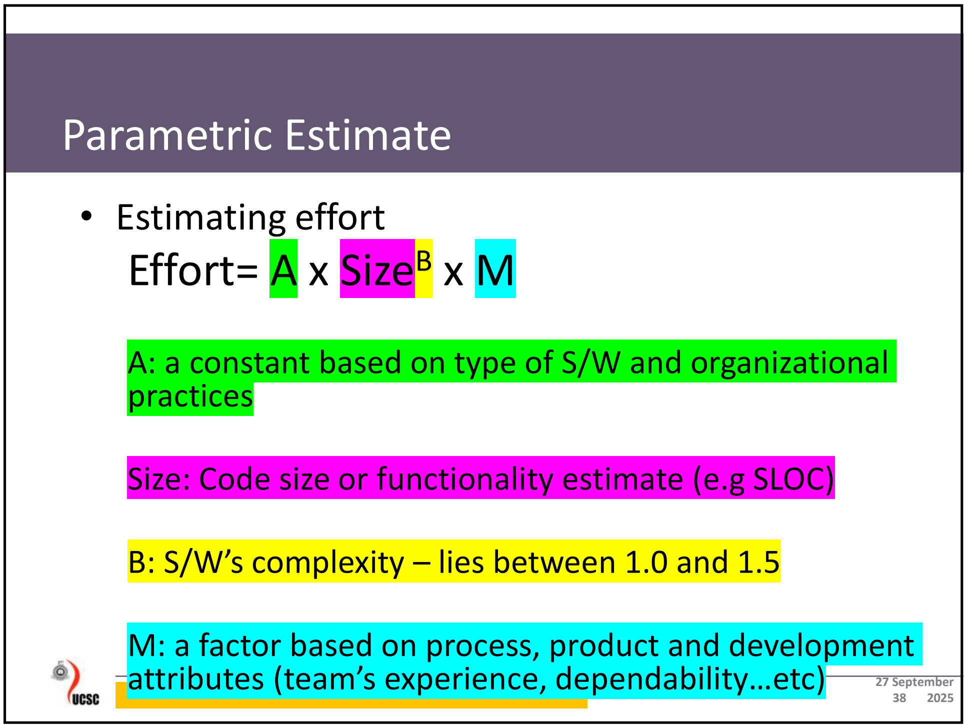
Effort=System size x productivity rate

- If productivity rate is 40 days per KLOC and a software module to be constructed is 2 KLOC

Effort = 2 * 40 = 80 days

27 September 2025 37

37



Parametric Estimate

- Estimating effort

Effort= A x Size^B x M

A: a constant based on type of S/W and organizational practices

Size: Code size or functionality estimate (e.g SLOC)

B: S/W's complexity – lies between 1.0 and 1.5

M: a factor based on process, product and development attributes (team's experience, dependability…etc)

27 September 2025 38

38

COCOMO (Constructive Cost Model)

- A regression model based on the number of LOC
- Used to predict the efforts based on the software product’s size and complexity
- Basic COCOMO model:

$$effort = c \times size^{k}$$

- Effort - in pm – number of ‘person months’
- Size – in kdsi (thousands (k) of delivered source code instructions)

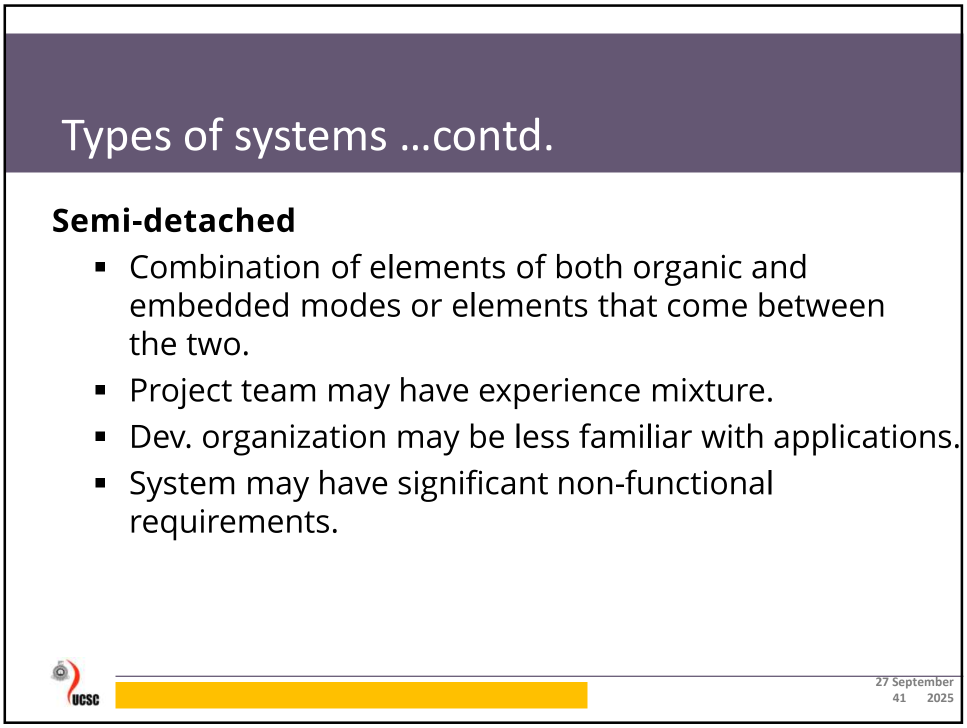
Types of systems categorised by COCOMO

Organic mode

- Relatively small teams.
- Develop software in a highly familiar in-house environment.
- Well-understood applications.
- Less difficult non-functional constraints.

Embedded mode

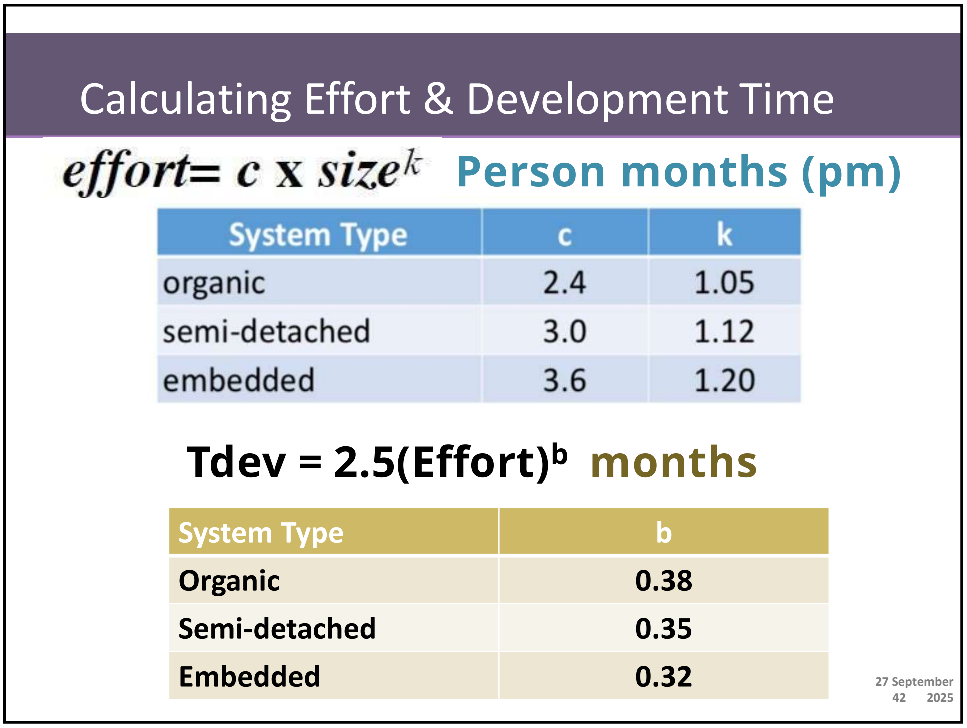
- The product needs to be operated within very high constraints.
- Changes to the system are very costly.
- Includes both hardware and software.
- Highly complex and requires creativity and experience.



Types of systems …contd.

Semi-detached

- Combination of elements of both organic and embedded modes or elements that come between the two.
- Project team may have experience mixture.
- Dev. organization may be less familiar with applications.
- System may have significant non-functional requirements.



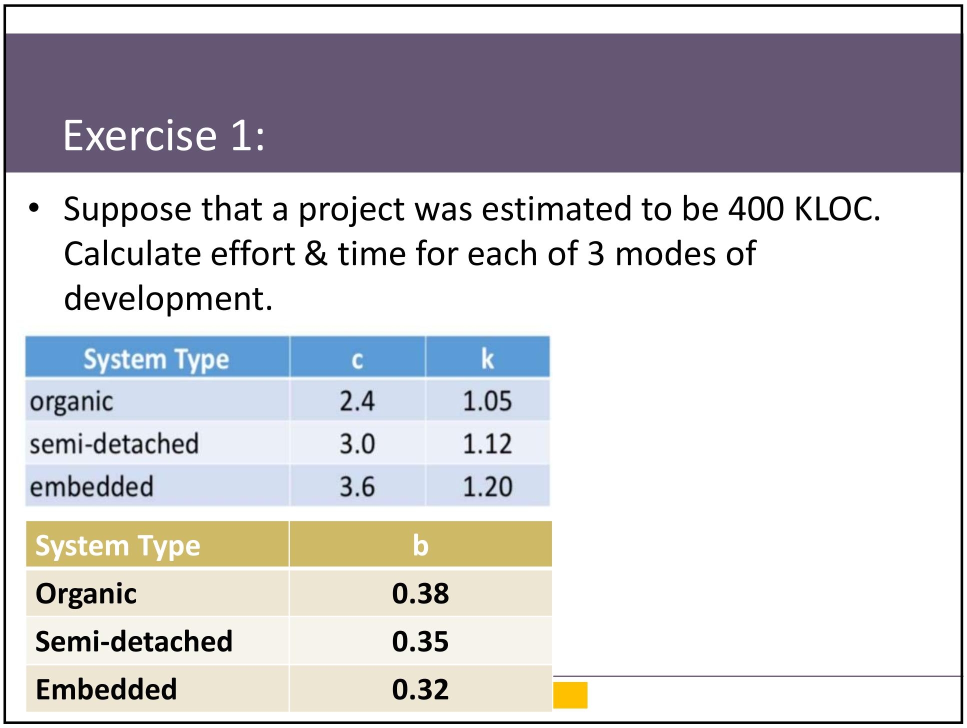
Calculating Effort & Development Time

$effort = c \times size^{k}$ **Person months (pm)**

System Type	c	k
organic	2.4	1.05
semi-detached	3.0	1.12
embedded	3.6	1.20

$\mathbf{Tdev = 2.5(Effort)^{b}}$ **months**

System Type	b
Organic	**0.38**
Semi-detached	**0.35**
Embedded	**0.32**



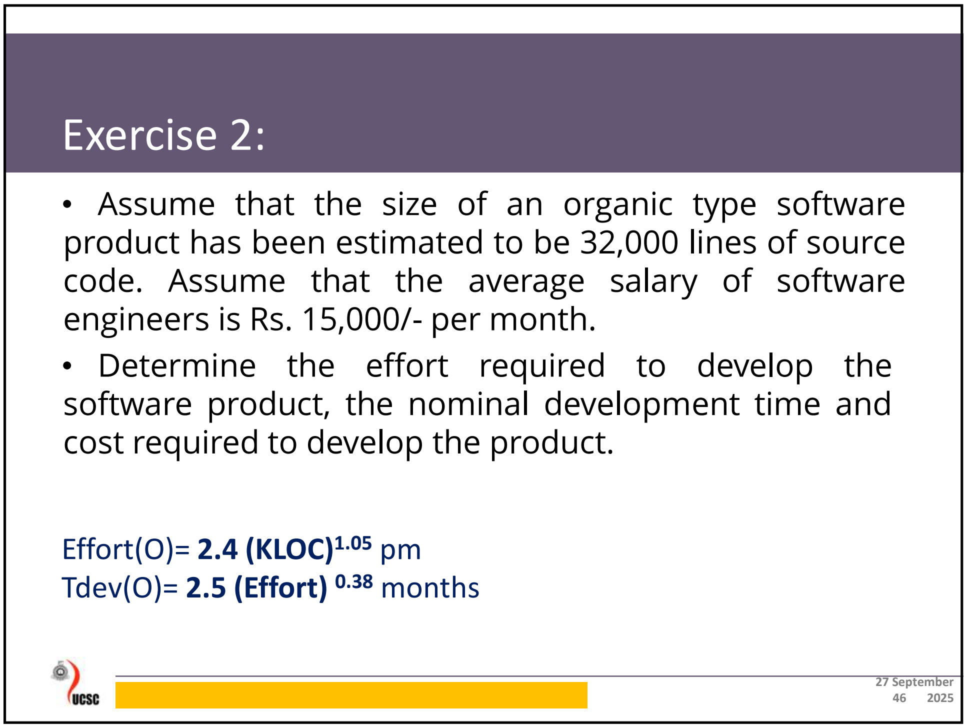
Exercise 1:

- Suppose that a project was estimated to be 400 KLOC. Calculate effort & time for each of 3 modes of development.

System Type	c	k
organic	2.4	1.05
semi-detached	3.0	1.12
embedded	3.6	1.20

System Type	b
Organic	**0.38**
Semi-detached	**0.35**
Embedded	**0.32**

43



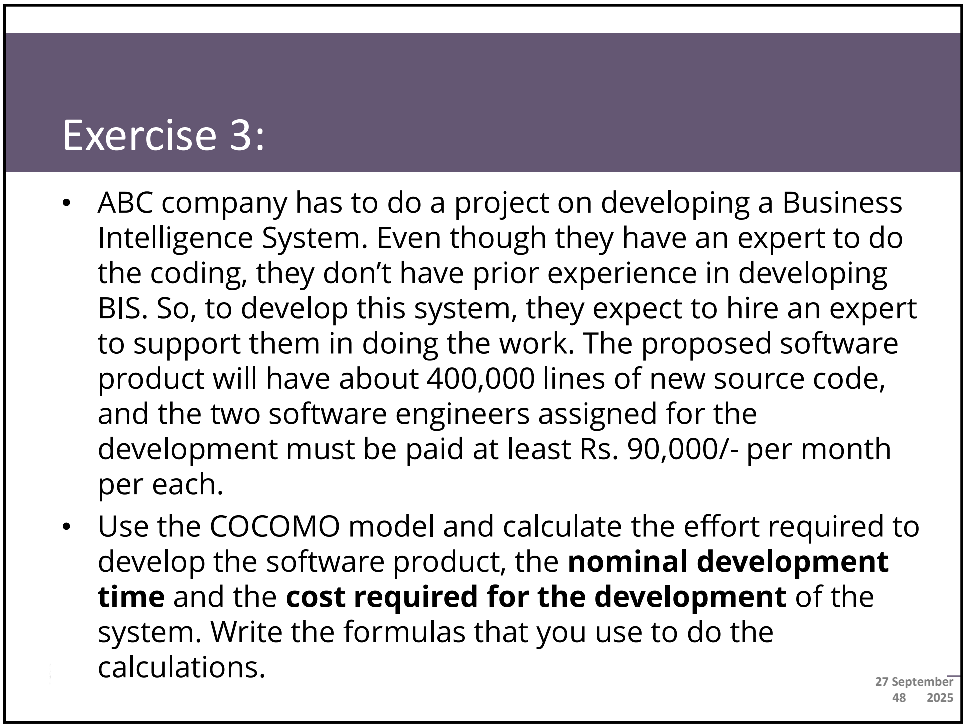
Exercise 2:

- Assume that the size of an organic type software product has been estimated to be 32,000 lines of source code. Assume that the average salary of software engineers is Rs. 15,000/- per month.
- Determine the effort required to develop the software product, the nominal development time and cost required to develop the product.

Effort(O)= **2.4 (KLOC)**$^{\mathbf{1.05}}$ pm

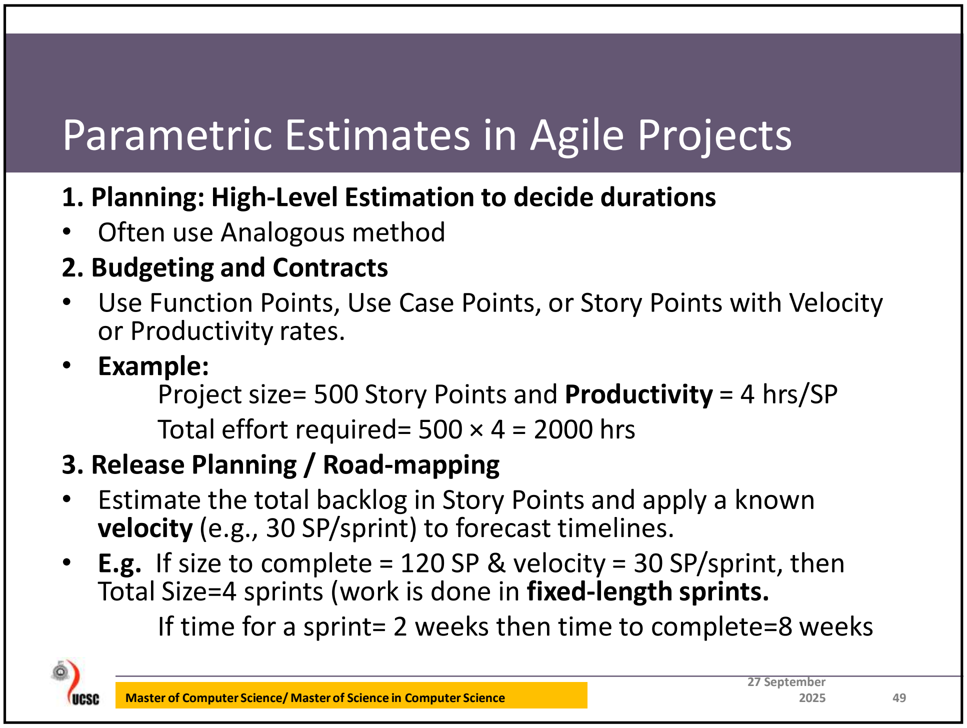
Tdev(O)= **2.5 (Effort)** $^{\mathbf{0.38}}$ months

46



Exercise 3:

- ABC company has to do a project on developing a Business Intelligence System. Even though they have an expert to do the coding, they don't have prior experience in developing BIS. So, to develop this system, they expect to hire an expert to support them in doing the work. The proposed software product will have about 400,000 lines of new source code, and the two software engineers assigned for the development must be paid at least Rs. 90,000/- per month per each.
- Use the COCOMO model and calculate the effort required to develop the software product, the **nominal development time** and the **cost required for the development** of the system. Write the formulas that you use to do the calculations.



Parametric Estimates in Agile Projects

1. Planning: High-Level Estimation to decide durations

- Often use Analogous method

2. Budgeting and Contracts

- Use Function Points, Use Case Points, or Story Points with Velocity or Productivity rates.
- **Example:**

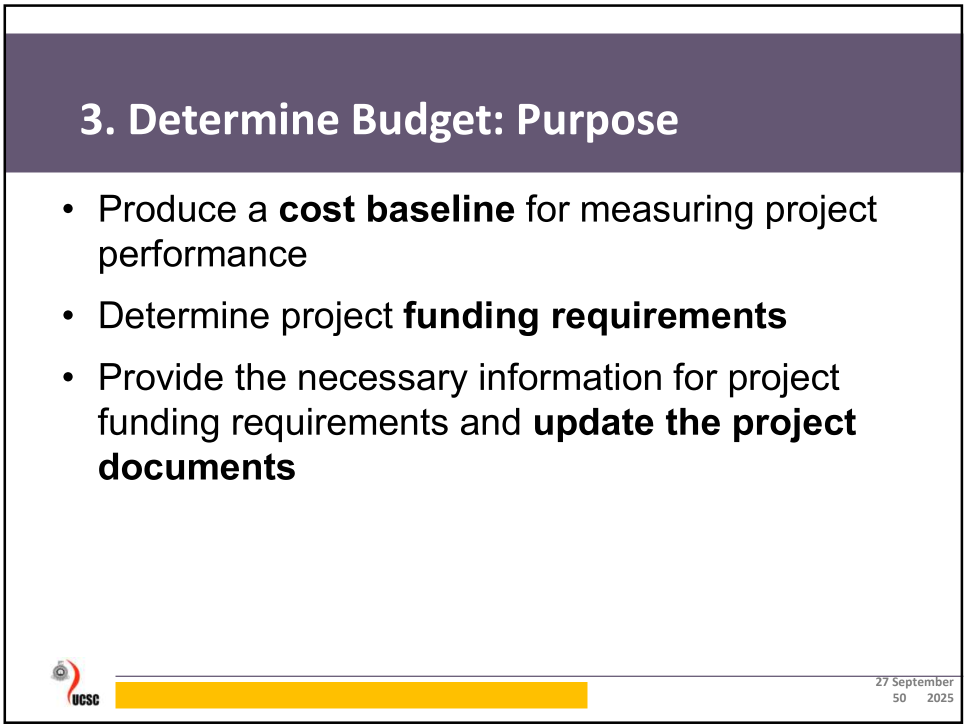
  Project size= 500 Story Points and **Productivity** = 4 hrs/SP

  Total effort required= 500 × 4 = 2000 hrs

3. Release Planning / Road-mapping

- Estimate the total backlog in Story Points and apply a known **velocity** (e.g., 30 SP/sprint) to forecast timelines.
- **E.g.** If size to complete = 120 SP & velocity = 30 SP/sprint, then Total Size=4 sprints (work is done in **fixed-length sprints.**

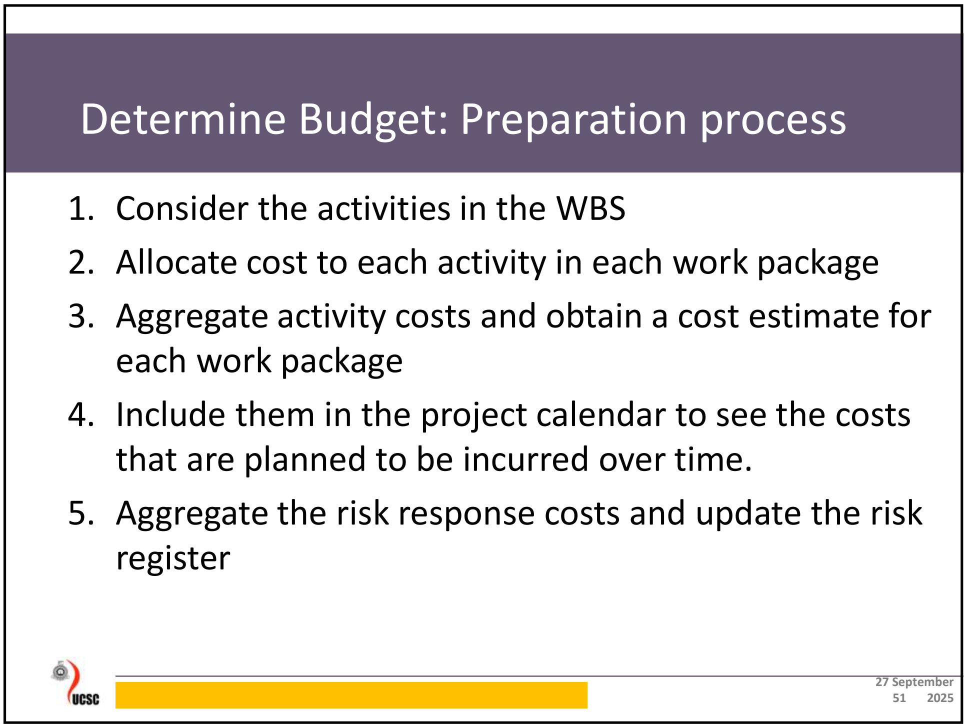
  If time for a sprint= 2 weeks then time to complete=8 weeks



3. Determine Budget: Purpose

- Produce a **cost baseline** for measuring project performance
- Determine project **funding requirements**
- Provide the necessary information for project funding requirements and **update the project documents**

50



Determine Budget: Preparation process

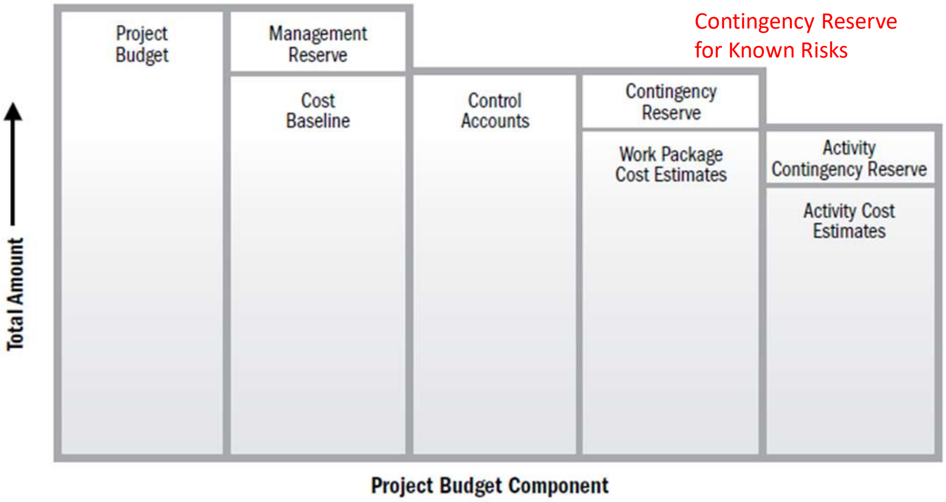
1. Consider the activities in the WBS
2. Allocate cost to each activity in each work package
3. Aggregate activity costs and obtain a cost estimate for each work package
4. Include them in the project calendar to see the costs that are planned to be incurred over time.
5. Aggregate the risk response costs and update the risk register

51

Project Budget Components

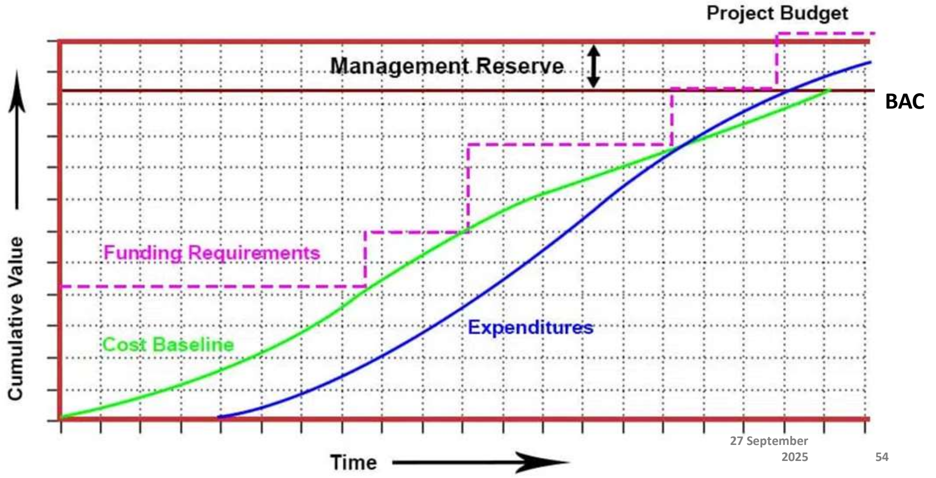
For Unknown Risks

Contingency Reserve for Known Risks

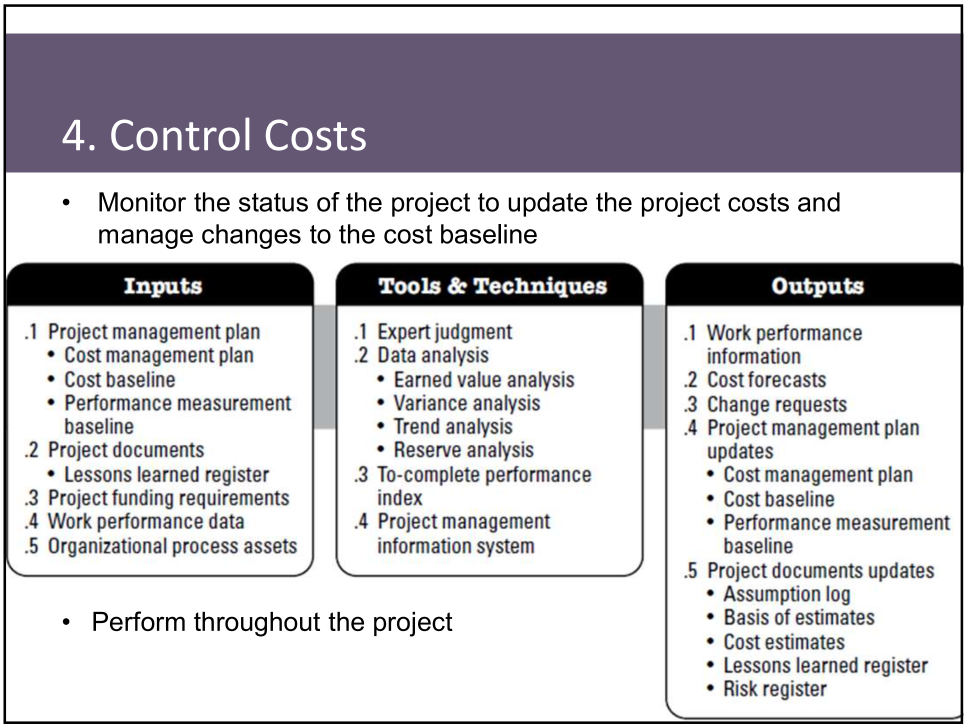


53

Cost Baseline, Expenditures, and Funding Requirements



54



4. Control Costs

- Monitor the status of the project to update the project costs and manage changes to the cost baseline

Inputs

.1 Project management plan
- Cost management plan
- Cost baseline
- Performance measurement baseline

.2 Project documents
- Lessons learned register

.3 Project funding requirements
.4 Work performance data
.5 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data analysis
- Earned value analysis
- Variance analysis
- Trend analysis
- Reserve analysis

.3 To-complete performance index
.4 Project management information system

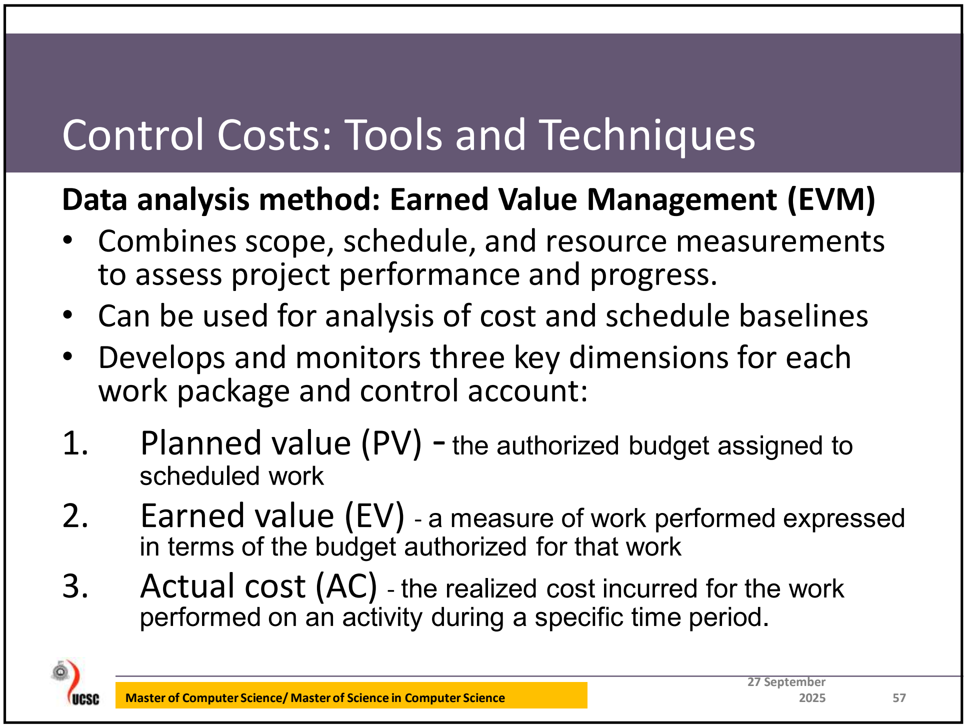
Outputs

.1 Work performance information
.2 Cost forecasts
.3 Change requests
.4 Project management plan updates
- Cost management plan
- Cost baseline
- Performance measurement baseline

.5 Project documents updates
- Assumption log
- Basis of estimates
- Cost estimates
- Lessons learned register
- Risk register

- Perform throughout the project

55



Control Costs: Tools and Techniques

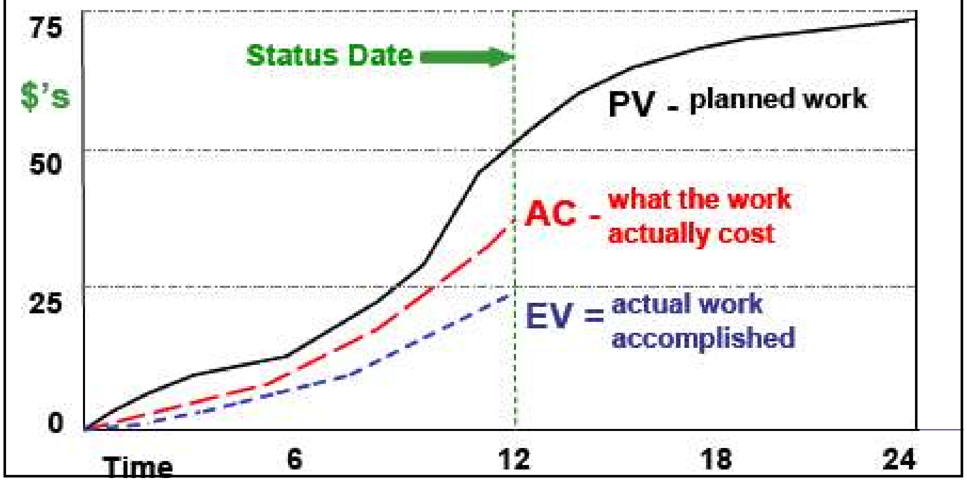
Data analysis method: Earned Value Management (EVM)

- Combines scope, schedule, and resource measurements to assess project performance and progress.
- Can be used for analysis of cost and schedule baselines
- Develops and monitors three key dimensions for each work package and control account:

1. Planned value (PV) - the authorized budget assigned to scheduled work
2. Earned value (EV) - a measure of work performed expressed in terms of the budget authorized for that work
3. Actual cost (AC) - the realized cost incurred for the work performed on an activity during a specific time period.

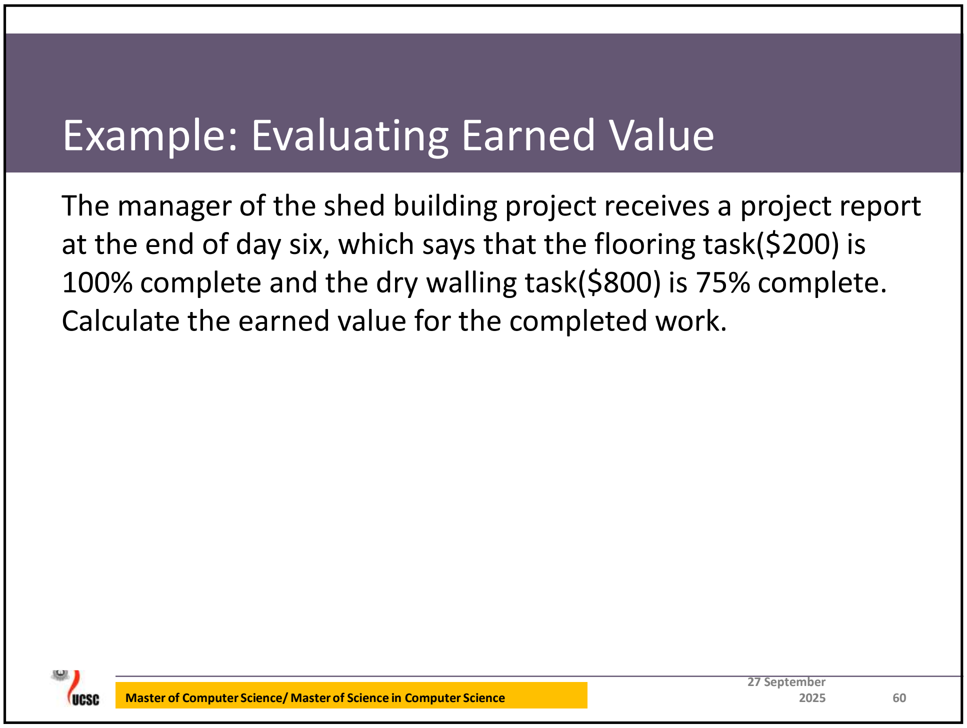
57

Earned Value Management (EVM)



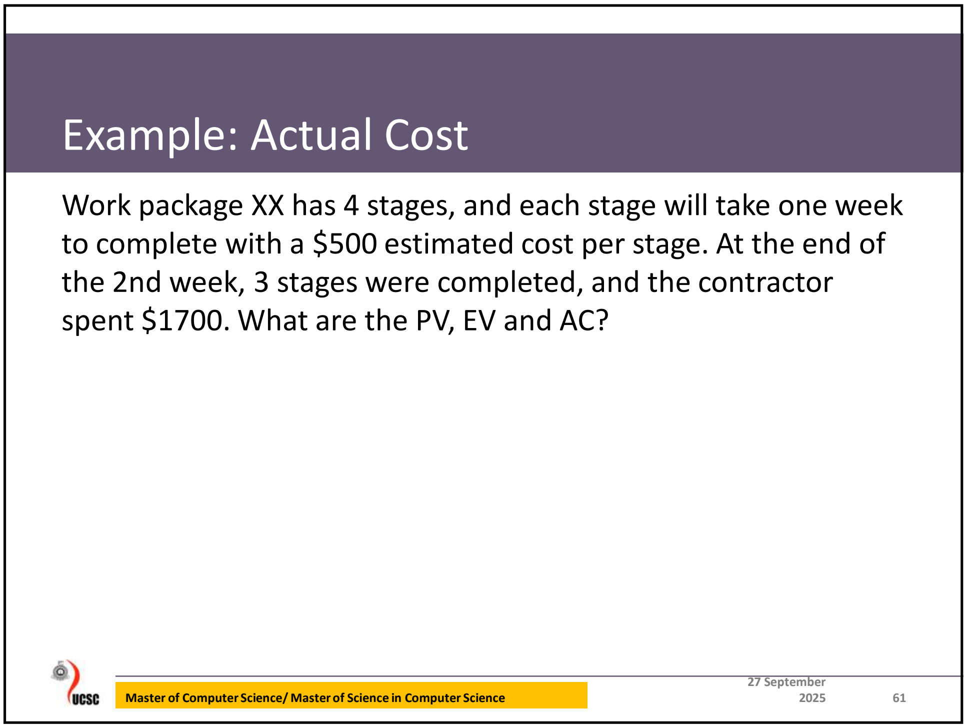
Example: Evaluating Planned Value

A project to build a shed was proposed. It involved three tasks: flooring, drywalling, and roofing. The flooring was budgeted for $200 and will take two days to complete. The task of drywalling was budgeted for $800 and will take four days to complete. Roofing was budgeted for $600 and will take three days to complete. The total Budget for building the shed came to $1,600. What is the PV for the first six days?



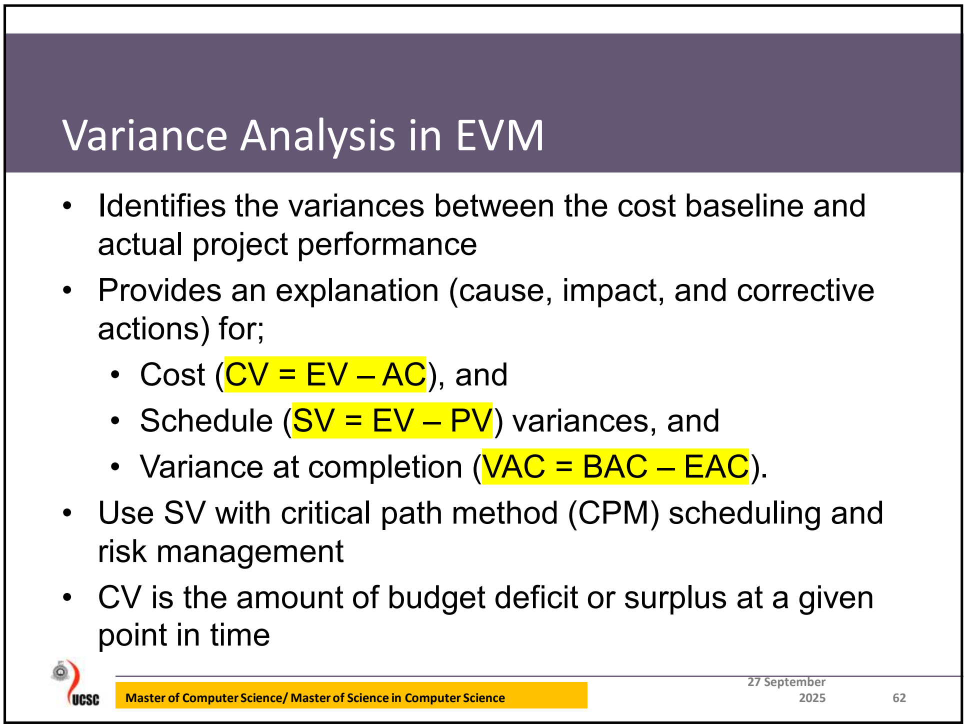
Example: Evaluating Earned Value

The manager of the shed building project receives a project report at the end of day six, which says that the flooring task($200) is 100% complete and the dry walling task($800) is 75% complete. Calculate the earned value for the completed work.



Example: Actual Cost

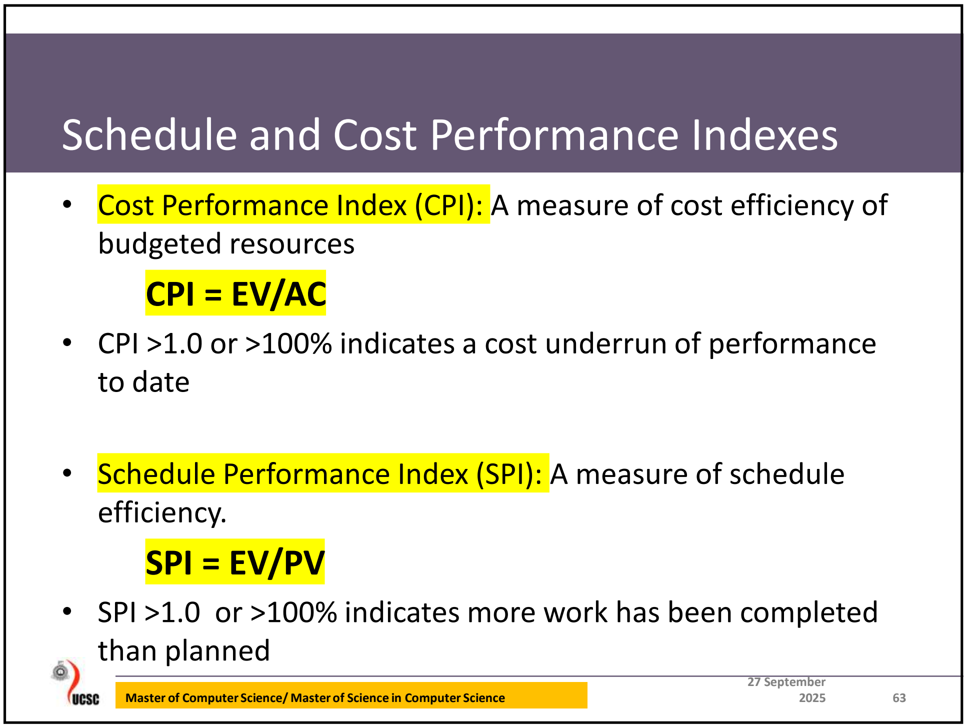
Work package XX has 4 stages, and each stage will take one week to complete with a $500 estimated cost per stage. At the end of the 2nd week, 3 stages were completed, and the contractor spent $1700. What are the PV, EV and AC?



Variance Analysis in EVM

- Identifies the variances between the cost baseline and actual project performance
- Provides an explanation (cause, impact, and corrective actions) for;
  - Cost (CV = EV – AC), and
  - Schedule (SV = EV – PV) variances, and
  - Variance at completion (VAC = BAC – EAC).
- Use SV with critical path method (CPM) scheduling and risk management
- CV is the amount of budget deficit or surplus at a given point in time

62



Schedule and Cost Performance Indexes

- **Cost Performance Index (CPI):** A measure of cost efficiency of budgeted resources

  CPI = EV/AC
- CPI >1.0 or >100% indicates a cost underrun of performance to date

- **Schedule Performance Index (SPI):** A measure of schedule efficiency.

  SPI = EV/PV
- SPI >1.0 or >100% indicates more work has been completed than planned

63

Example

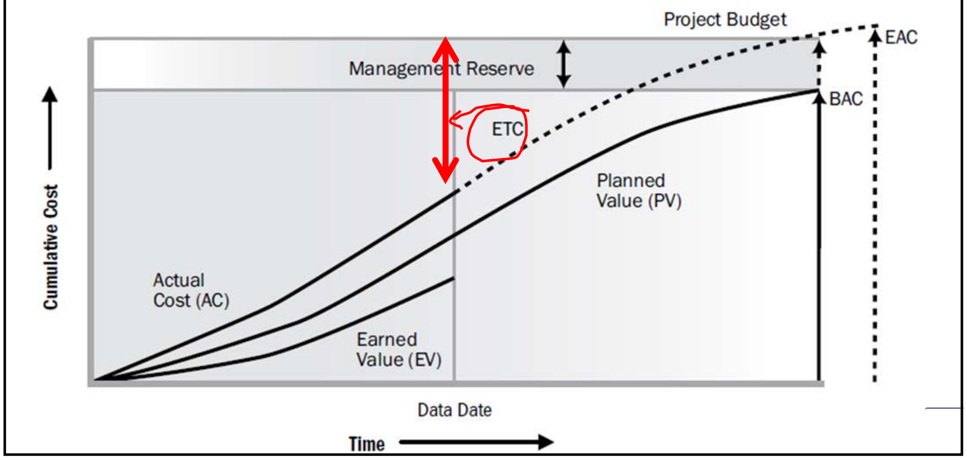
A project included the activity of purchasing and installing a new web server. According to the plan, it would take one week and cost a total of $10,000 for the labour hours, hardware, and software. However, the project was halfway completed by the end of Week 1, and it actually took two weeks and cost $20,000 to purchase and install the new web server. $15,000 of these actual costs were incurred during Week 1, and $5,000 was incurred during Week 2.

1. Find CV, SV, EV, CPI and SPI by the end of week 1.
2. Explain the status of this project.

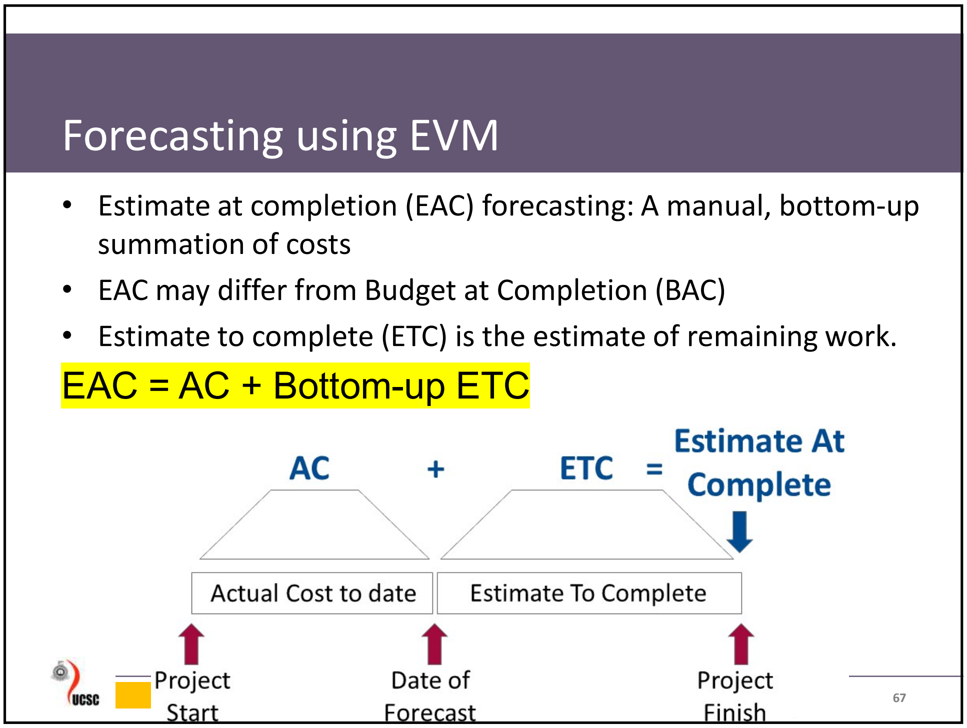
64

Trend Analysis: Charts

- S-curves to display EV data for a project that is performing over budget and behind the schedule



66



Forecasting using EVM

- Estimate at completion (EAC) forecasting: A manual, bottom-up summation of costs
- EAC may differ from Budget at Completion (BAC)
- Estimate to complete (ETC) is the estimate of remaining work.

EAC = AC + Bottom-up ETC

AC + ETC = Estimate At Complete

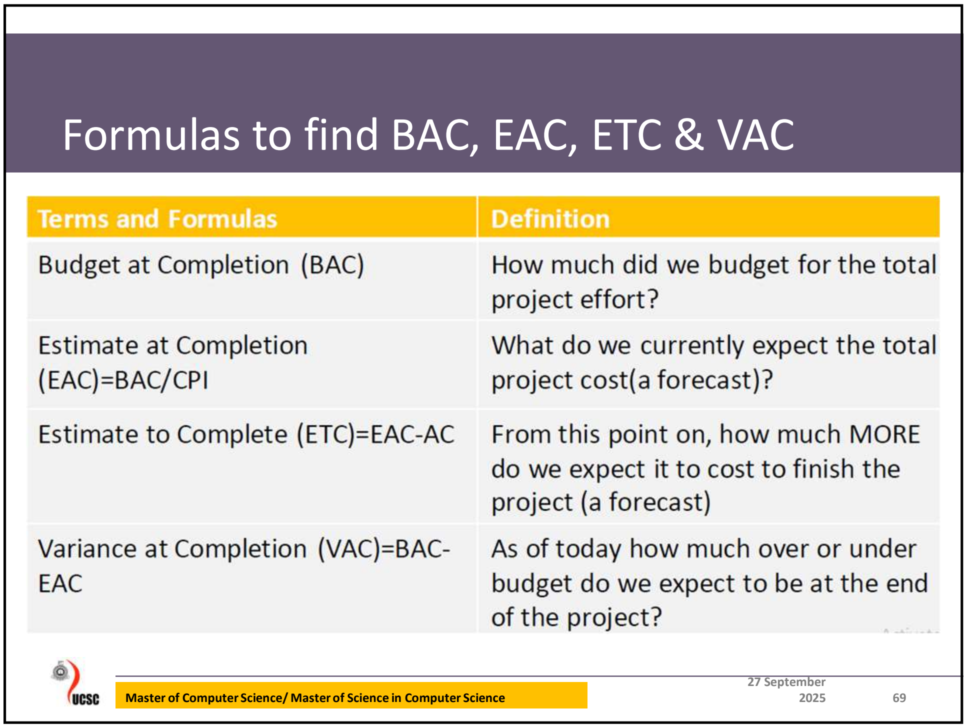
Actual Cost to date | Estimate To Complete

Project Start

Date of Forecast

Project Finish

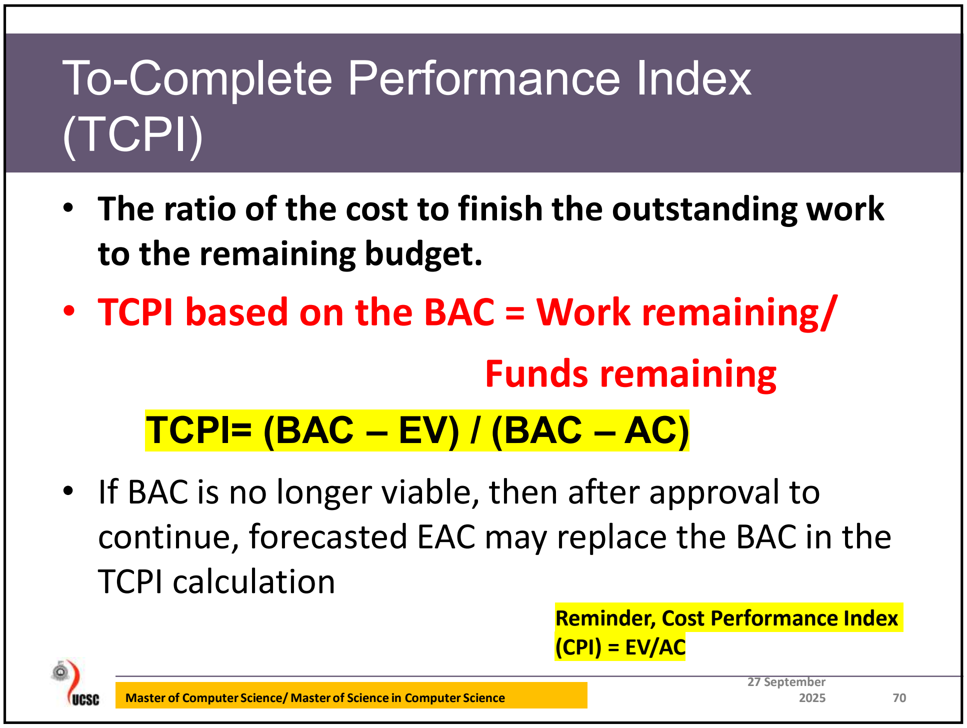
67



Formulas to find BAC, EAC, ETC & VAC

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?

69



To-Complete Performance Index (TCPI)

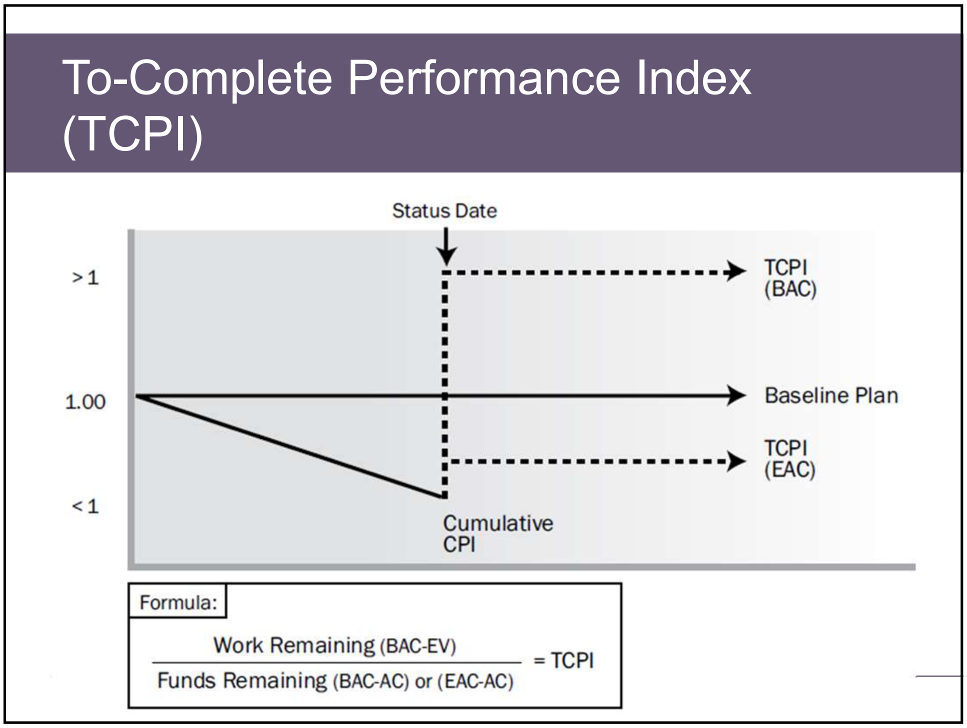
- **The ratio of the cost to finish the outstanding work to the remaining budget.**
- **TCPI based on the BAC = Work remaining/ Funds remaining**

TCPI= (BAC – EV) / (BAC – AC)

- If BAC is no longer viable, then after approval to continue, forecasted EAC may replace the BAC in the TCPI calculation

Reminder, Cost Performance Index (CPI) = EV/AC

70



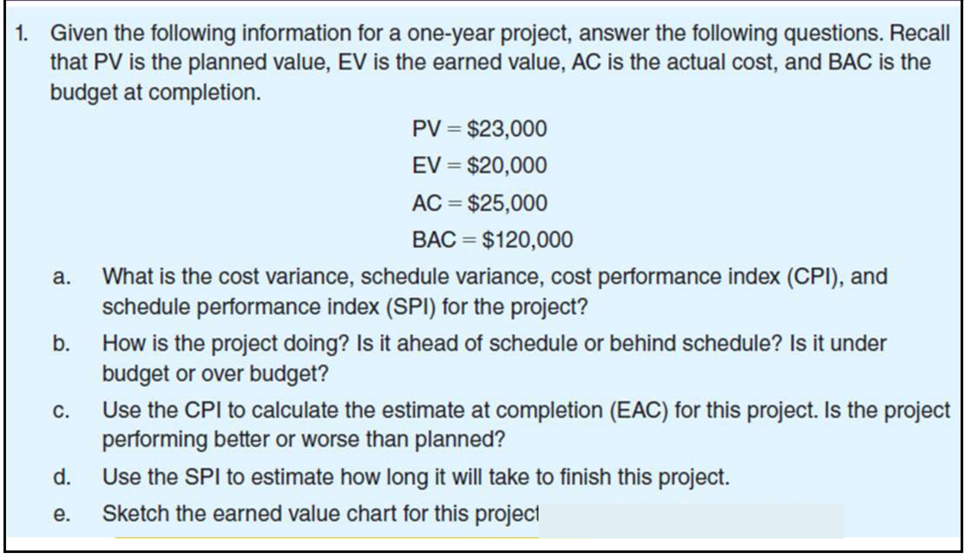
To-Complete Performance Index (TCPI)

Formula:

$$\frac{\text{Work Remaining (BAC-EV)}}{\text{Funds Remaining (BAC-AC) or (EAC-AC)}} = \text{TCPI}$$

71

Exercise 5



1. Given the following information for a one-year project, answer the following questions. Recall that PV is the planned value, EV is the earned value, AC is the actual cost, and BAC is the budget at completion.

$$PV = \$23,000$$
$$EV = \$20,000$$
$$AC = \$25,000$$
$$BAC = \$120,000$$

   a. What is the cost variance, schedule variance, cost performance index (CPI), and schedule performance index (SPI) for the project?

   b. How is the project doing? Is it ahead of schedule or behind schedule? Is it under budget or over budget?

   c. Use the CPI to calculate the estimate at completion (EAC) for this project. Is the project performing better or worse than planned?

   d. Use the SPI to estimate how long it will take to finish this project.

   e. Sketch the earned value chart for this project

Reserve Analysis During Project

- **Initiation:** Identify risks
- **Planning:** Distribute contingency reserve based on risks
- **Execution:** Monitor project progress and modify reserves when new risks arise
- **Closure:** Complete reserve analysis to close out and account for all reserves in the project report