INSE 6230
Total Quality Project Management

Lecture 5

Project Cost Management

Outline

- Project cost management – introduction
- Estimating costs
- Budget
- Earned Value Management (EVM)
- EVM projections

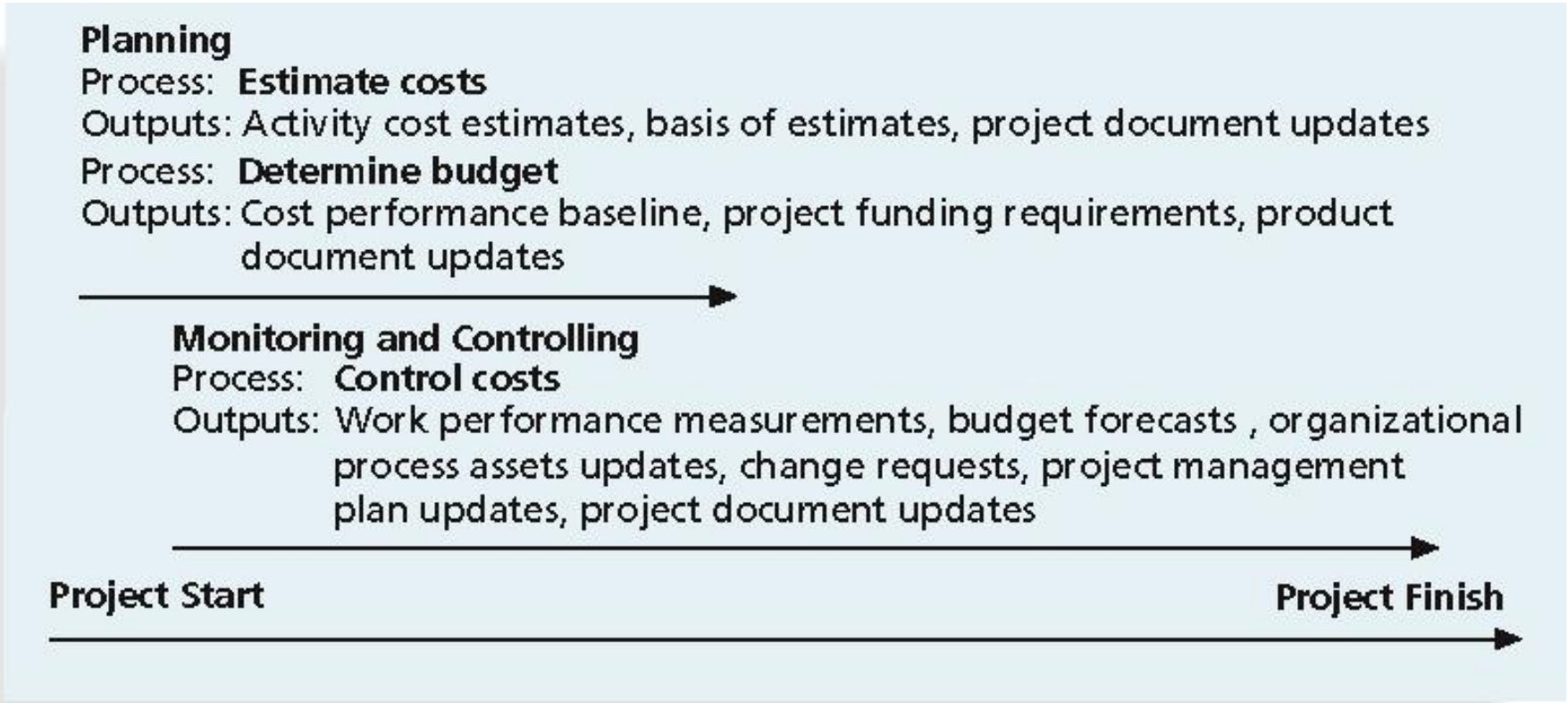
The Importance of Project Cost Management

- IT projects have a poor track record for meeting budget goals
- **Cost overrun** is the additional percentage or dollar amount by which actual costs exceed estimates
- The average cost overrun ranges from 33% to 180%, depending on the study and year
- But overruns can be a result of unrealistic estimates!

Cost and Project Cost Management

- **Cost** is a resource sacrificed or foregone to achieve a specific objective or something given up in exchange
  - Usually measured in monetary units (*e.g.* $, €, £, ¥)
- **Project cost management** includes the processes required to ensure that the project is completed within an approved budget. It involves 3 processes:
  - **Estimating costs**: developing an approximation or estimate of the costs of the resources needed to complete a project
  - **Determining the budget**: allocating the overall cost estimate to individual work items to establish a baseline for measuring performance
  - **Controlling costs**: controlling changes to the project budget

Project Cost Management



Estimating Costs

- Based on the **resource** requirements
  - People, skills, hours, equipment, *etc.*
- **Types of cost estimates:**

Type	Purpose	Accuracy
Rough Order of Magnitude (ROM)	Project selection decisions	-50% to +100%
Budgetary	Creation of the budget	-10% to +25%
Definitive	Details for purchases	-5% to +10%

Cost Estimation Tools and Techniques

- **Top-down estimates** (*analogous estimates*)
  - Use the actual cost of a previous, similar project as the basis for estimating the cost of the current project
    - If projects similar it could be very accurate
- **Bottom-up estimates** (*activity based costing*)
  - Involve estimating individual work items or activities and summing them to get a project total
  - Based on WBS
    - Accurate but time intensive
- **Parametric modeling**
  - Uses project characteristics (parameters) in a mathematical model to estimate project costs
    - Accurate, reliable, flexible

Top-down estimates

Cost index

- Dimensionless number reflecting **the change in price over time** (e.g. Labor cost index, Material cost index, or composite indexes such as Commodity Price Index CPI, Manufacturer's Price Index)
- $$\frac{\text{Cost at time A}}{\text{Cost at time B}} = \frac{\text{Index value at time A}}{\text{Index value at time B}}$$

Power-sizing model

- Used to estimate costs of industrial plants and equipment
- Reflects the differences in costs due to **the change in size or capacity**
- Uses the power-sizing exponent x, to represent economies of scale in size or capacities
- $$\frac{\text{Cost of size A}}{\text{Cost of size B}} = \left(\frac{\text{size A}}{\text{size B}}\right)^{x}$$

x<1 economies of scale
x=1 no economies of scale
x>1 diseconomies of scale

Top-down estimates

- Examples of power sizing exponent *(x)* values

Equipment/Facility	Size Range	Power-Sizing Exponent
Blower, centrifugal	10,000–100,000 ft^3/min	0.59
Compressor	200–2100 hp	0.32
Crystallizer, vacuum batch	500–7000 ft^2	0.37
Dryer, drum, single atmospheric	10–100 ft^2	0.40
Fan, centrifugal	20,000–70,000 ft^2/min	1.17
Filter, vacuum rotary drum	10–1500 ft^2	0.48
Lagoon, aerated	0.05–20 million gal/day	1.13
Motor	5–20 hp	0.69
Reactor, 300 psi	100–1000 gal	0.56
Tank, atmospheric, horizontal	100–40,000 gal	0.57

Top-down Estimate – *Example of Cost Index*

Estimate annual labor and material costs for a new production facility based on the following data:

- *Labor costs:* Labor cost index value was 124 ten years ago and is 188 today. Annual labor costs for a similar facility were $575,500 ten years ago
- *Material costs:* Material cost index value was at 544 three years ago and is 715 today. Annual material costs for a similar facility were $2,455,000 three years ago

- Solution:
- **Labor costs:** $\frac{\text{Annual cost today}}{\text{Annual cost 10 yrs ago}} = \frac{\text{Index value today}}{\text{Index value 10 yrs ago}}$

  Annual cost today = (188/124)*$575,500 = $872,532

- **Material costs:** $\frac{\text{Annual cost today}}{\text{Annual cost 3 yrs ago}} = \frac{\text{Index value today}}{\text{Index value 3 yrs ago}}$

  Annual cost today = (715/544)*$2,455,000 = $3,226,700

Bottom-up Estimate - *Example based on WBS*

	# Units/Hrs.	Cost/Unit/Hr.	Subtotals	WBS Level 1 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		
6. Reserves (20% of total estimate)			$253,540	**$253,540**	**17%**
Total project cost estimate				**$1,521,240**	

* See software development estimate

See pages 265-270 for the details

Determining the Budget

- Cost budgeting involves allocating the project cost estimate to individual work items **over time**
- Required inputs to the cost budgeting process
  - WBS
  - Activity cost estimates
  - Project schedule
- Important goal is to produce a **cost baseline**
  - A time-phased budget that project managers use to measure and monitor cost performance

Example - Project Cost Baseline

WBS Items	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1. Project Management													
1.1 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
1.2 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
1.3 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													
5.1 Trainee cost									50,000				50,000
5.2 Travel cost									8,400				8,400
5.3 Project team members							24,000	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

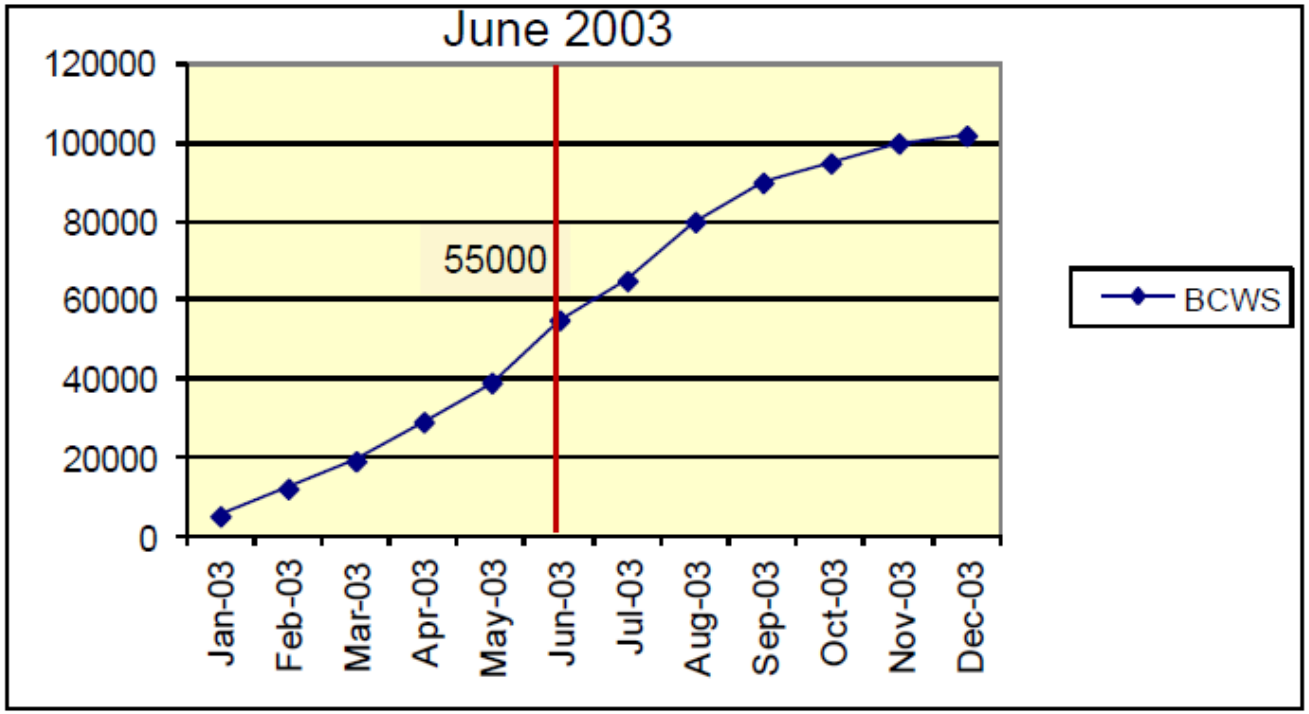
Controlling Costs

- Project cost control includes:
  - Monitor cost performance
    - Comparing “budgeted” and “actual”
  - Ensure that the appropriate project changes are included in a revised cost baseline
  - Inform project stakeholders of authorized changes to the project that will affect costs
- **Earned Value Management (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

Earned Value Management Terms

Planned value (PV)

- BCWS - Budgeted cost of work scheduled = *the budget*
- The portion of the approved total cost estimate planned to be spent on an activity during a given period

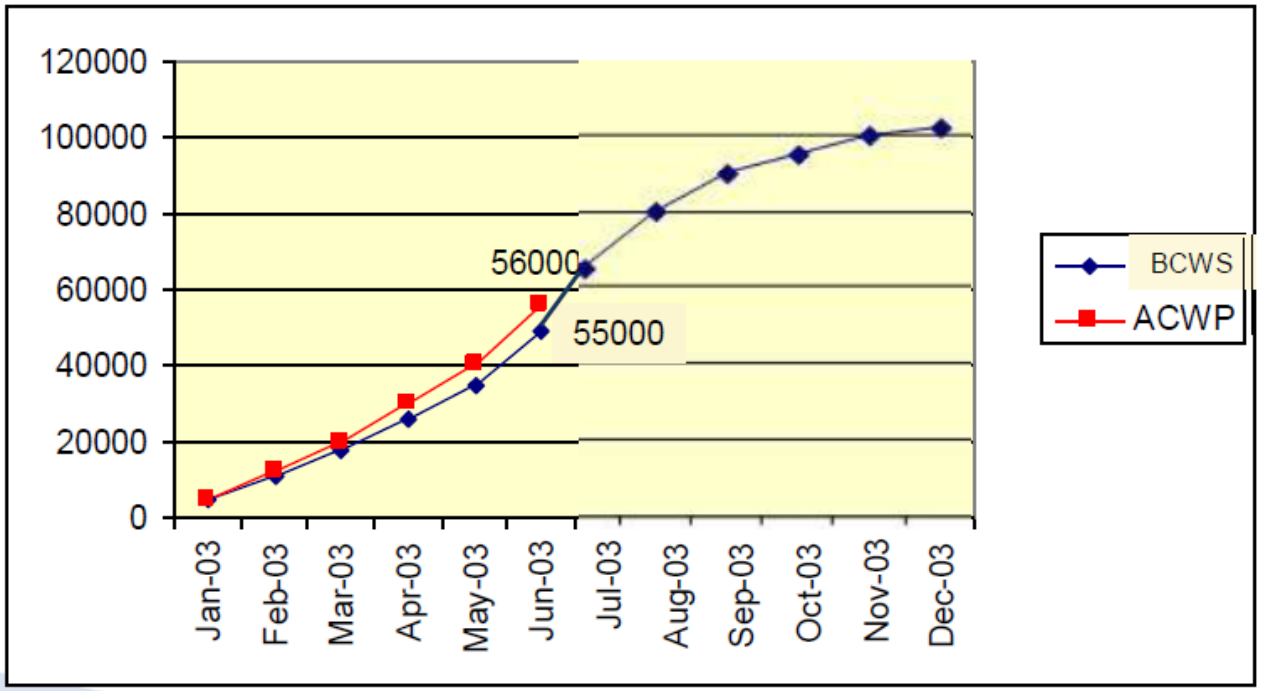


PV

Earned Value Management Terms

Actual cost (AC)

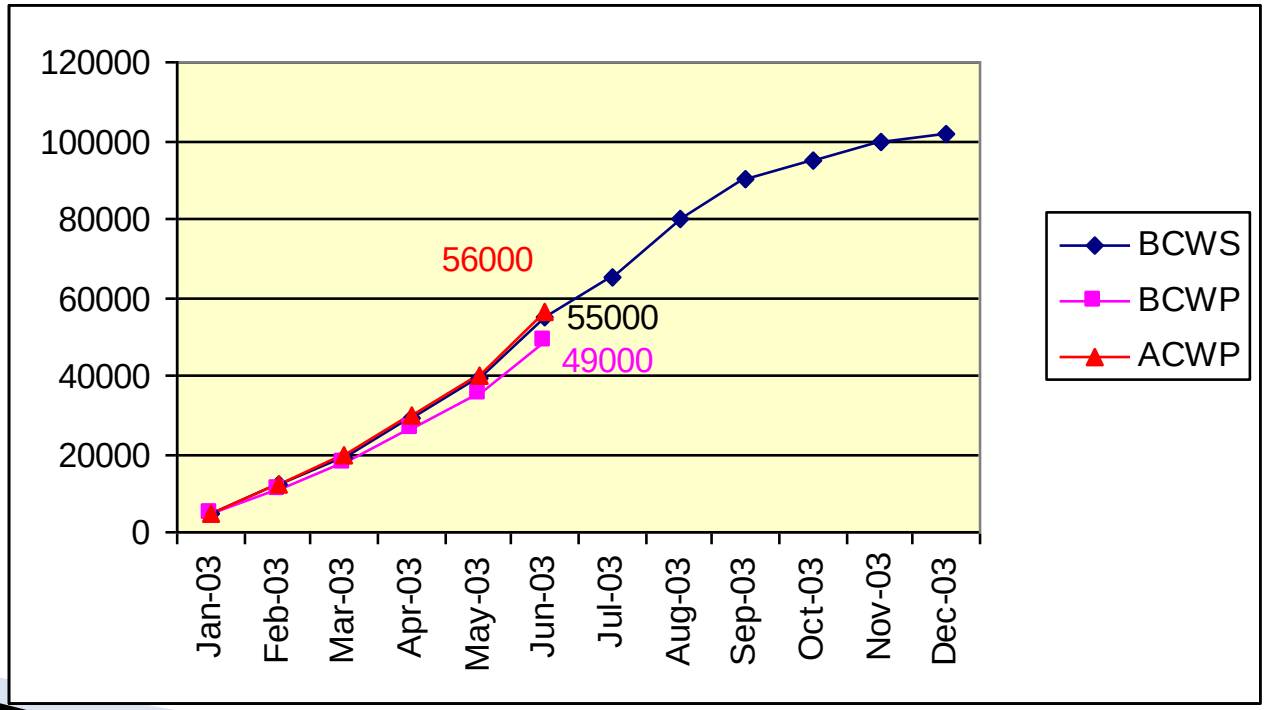
- ACWP = actual cost of work performed
- The total of all costs incurred in accomplishing work on an activity or on the project during a given period



Earned Value Management Terms

Earned value (EV)

- BCWP = budgeted cost of work performed
- An estimate of the value of the physical work actually completed
- EV is based on the original planned costs for the project or an activity and the rate at which the team is completing work on the project or on an activity to date

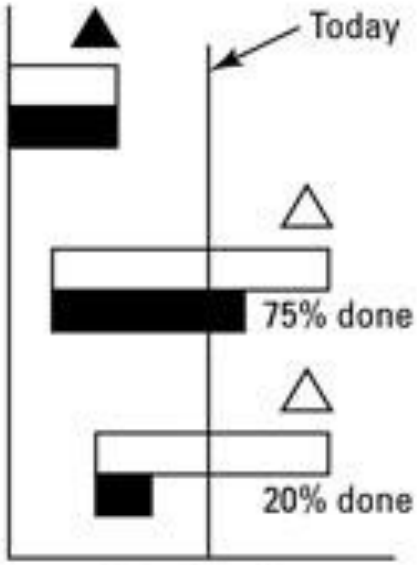


Earned Value Management Terms

- **How to determine EV?**
  - We need to know how much work on each task has been completed to date
- **Percent-complete method**
  - **EV = PV for the whole task * % complete of the task**
    - Pro-rating PV based on task percent completion
    - The most accurate method if % is correctly estimated
    - Supervisor opinion – subjective, possible errors, manipulation
  - **EV = PV for the whole project * % project complete to date**
    - This is used for the whole project
- **Milestone method**
  - **EV=0** as long as the task is not fully completed
  - **EV=PV for the whole task,** when the task is 100% completed
    - The most conservative and the least accurate method
    - Always over budget while performing the activity
- **50/50 method**
  - **EV=0** before the start
  - **EV=50%*PV for the whole task** after the start
  - **EV=100%*PV for the whole task,** when the task is 100% completed
    - More accurate than Milestone method
    - Can mask overspending

Earned Value Management Terms

Activity Work Breakdown Structure Code	PV full task Budgeted Cost at Completion	Earned Value % Complete	50/50	Milestone
1.2.1	$10,000	$10,000	$10,000	$10,000
1.2.2	$20,000	$15,000	$10,000	$0
1.2.3	$30,000	$6,000	$15,000	$0
		$31,000	$35,000	$10,000



- The EV of Task 1.2 is the sum of the EVs for each of the three subtasks that comprise Task 1.2., i.e. 1.2.1, 1.2.2 and 1.2.3:
  - Percent-complete method: **EV = $31,000**
  - Milestone method: **EV = $10,000**
  - 50/50 method: **EV = $35,000**

EVM – *Example 1*

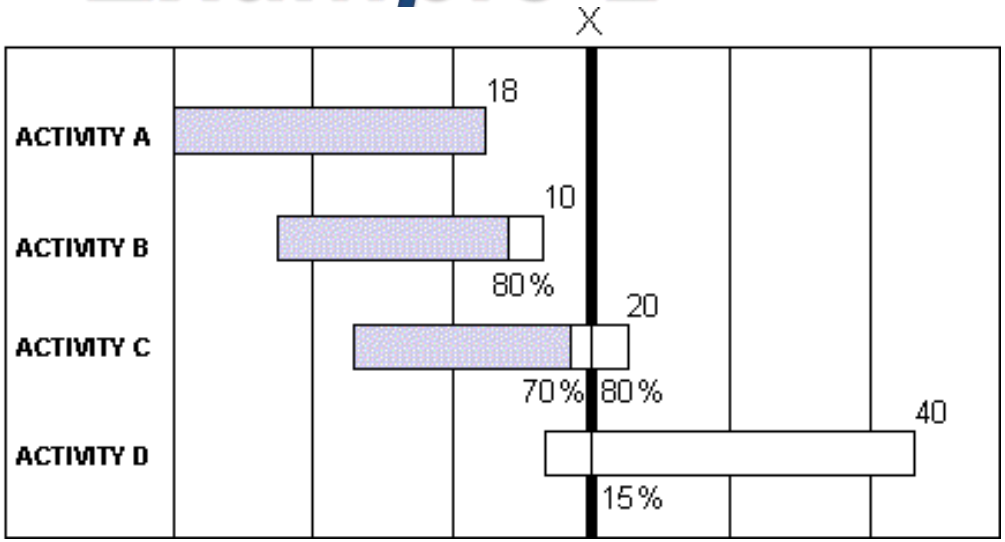
- According to the plan, a web server installation project should take 1 week and $10,000 to be completed. After the first week, the cost was already $15,000 and the project was only 75% complete.
  - What is PV, AC and EV after the first week?

    - Planned value: budgeted cost until this point
      PV = 10,000

    - Actual cost: actual cost spent until this point
      AC = 15,000

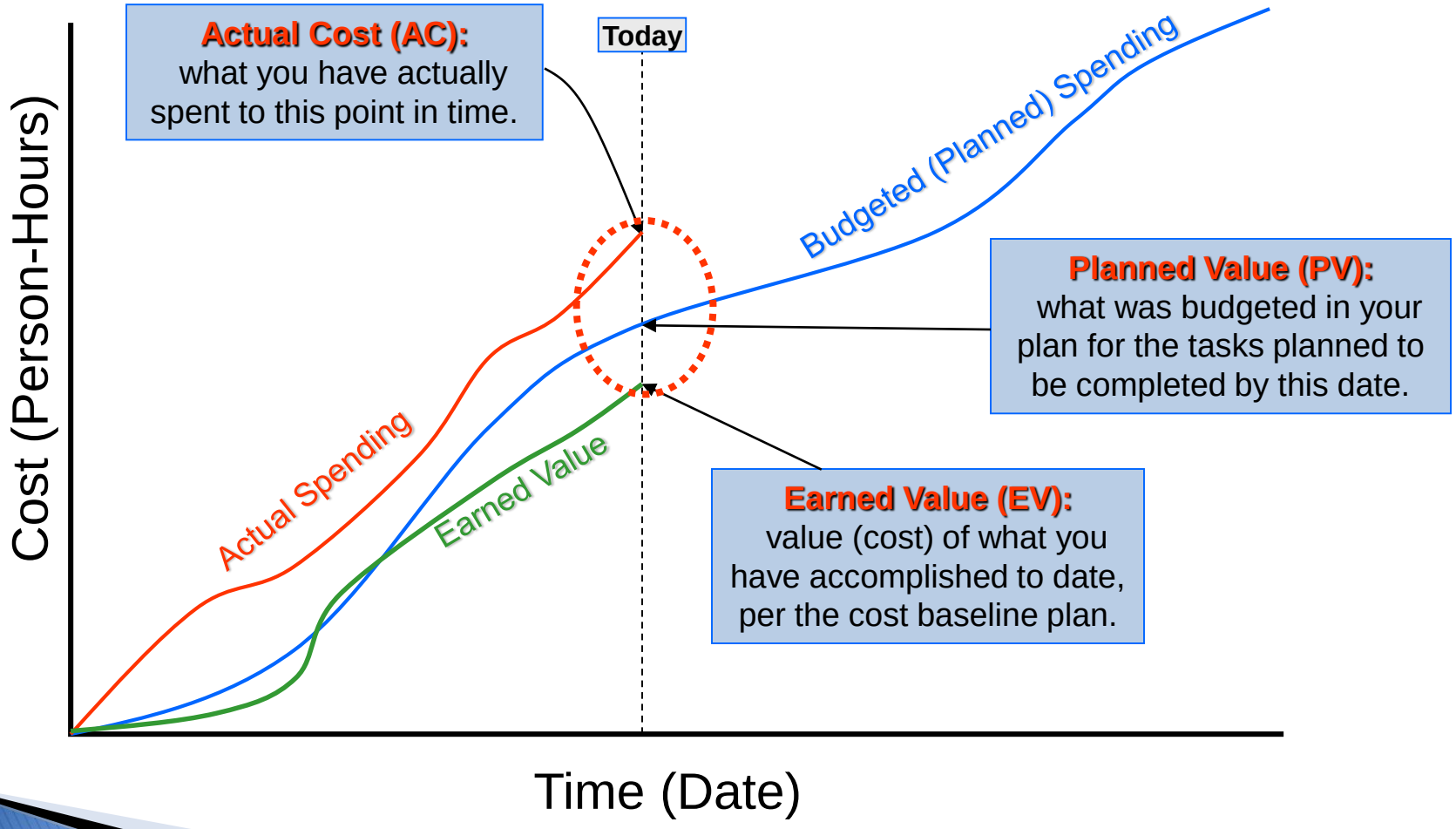
    - Earned value: actual cost of the work performed
      EV = PV for the project * % project complete to date
      EV = 10,000*75%
      EV = 7,500

EVM – *Example 2*

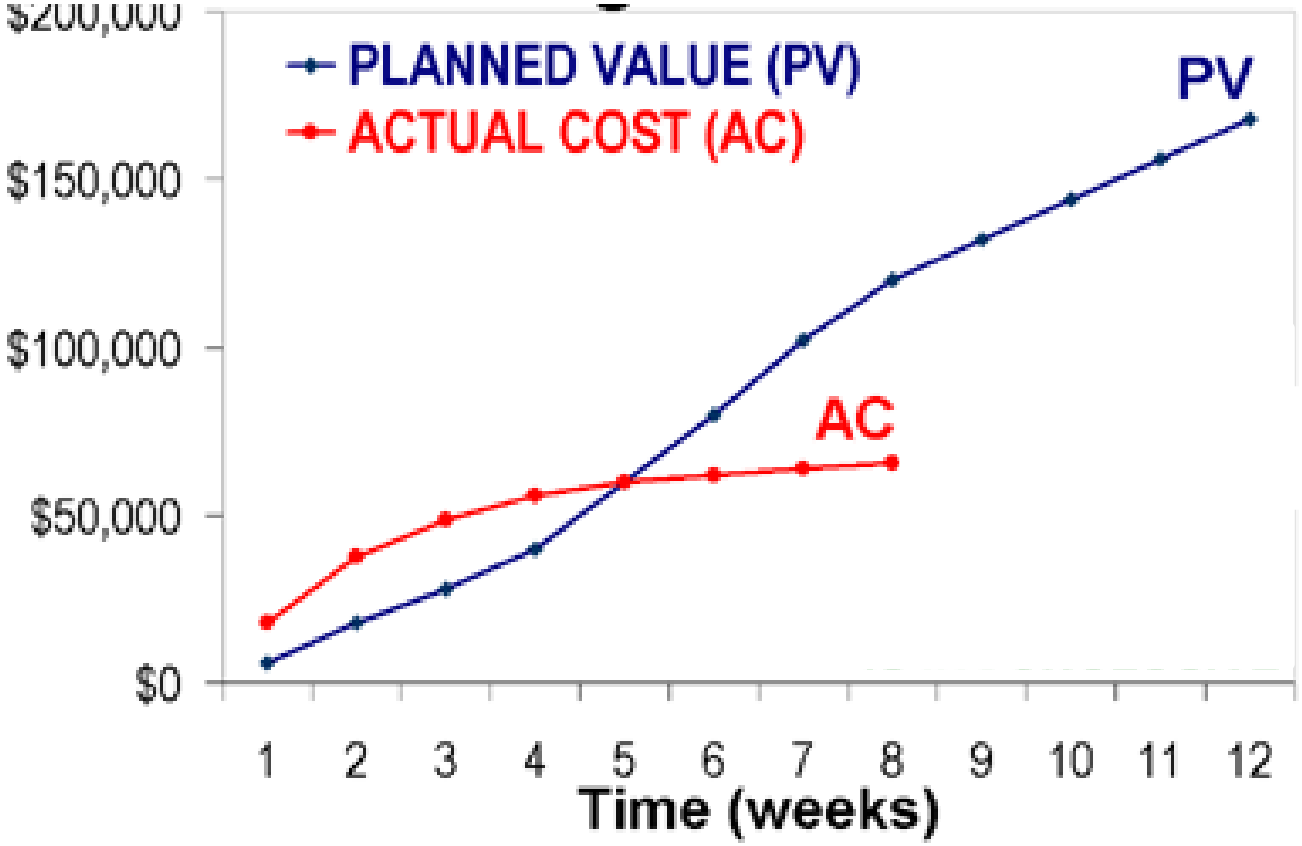


- What is PV, AC and EV on day X?
- **Planned Value** (budgeted cost until this point)
  PV = 18 + 10 + (20*0.8) + (40*0.15) = 18 + 10 + 16 + 6 = $50
- **Earned Value** (actual cost of the work performed)
  EV = 18 + (10*0.8) + (20*0.7) + 0 = 18 + 8 + 14 + 0 = $40
- **Actual Cost** (actual cost spent until this point)
  AC = $45 (Data from the accounting system, not evident from the above chart)

Earned Value Management Terms



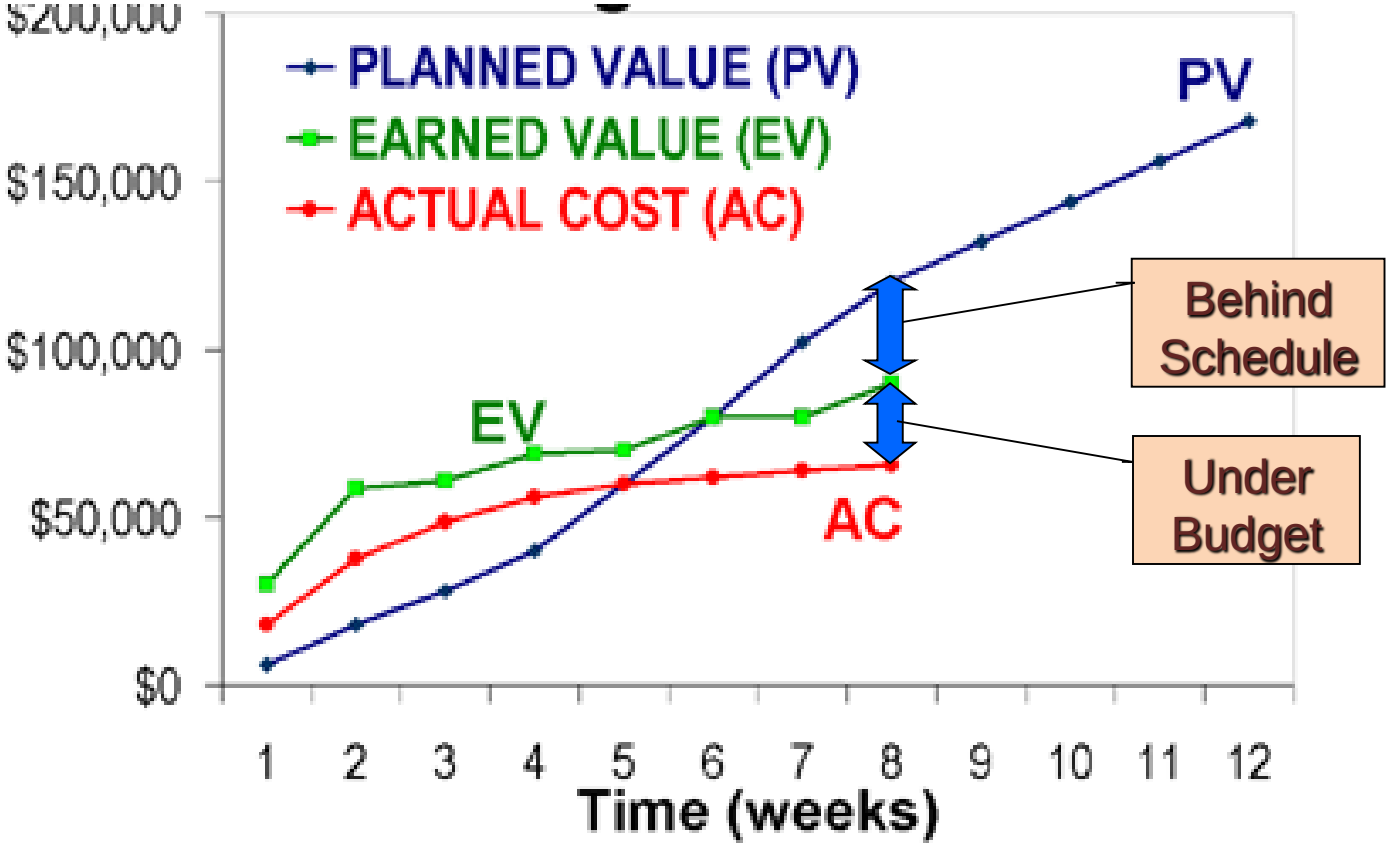
Earned Value Management Terms



At week 8 it looks like we spent much less than we were supposed to, but we do not see how much work has been done!

PROJECT TRACKING WITHOUT EARNED VALUE IS INCONCLUSIVE

Earned Value Management Terms



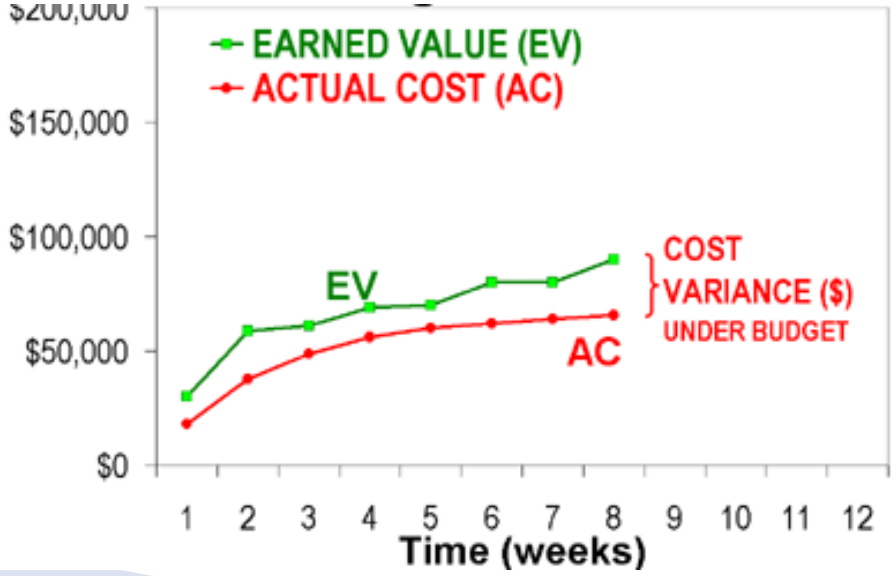
*At week 8, the value of the work performed is only $90,000 but it was supposed to be $120,000 → We are **behind schedule***

*At week 8, the value of the work performed is $90,000, but the cost incurred is only $60,000 → We are **under budget***

Earned Value Management Terms

- **Variance** - any **schedule or cost deviation** from a specific plan.
  - Used within an organization to verify the budget and schedule for a project and as a key component of plan reviews and performance measurement
- **Cost variance (CV)** **CV = EV – AC**
  - A comparison of the budgeted *cost of work performed* with actual cost.
  - CV=0: according to the plan
  - Negative CV: performing the work was more expensive than planned
  - Positive CV: performing the work was less expensive than planned
    - CV much greater than 0 could be a bad sign as well

At week 8, the value of the work performed is $90,000 (EV), but the cost incurred is only $60,000 (AC):
CV = EV – AC = $ 30,000
→ Positive CV

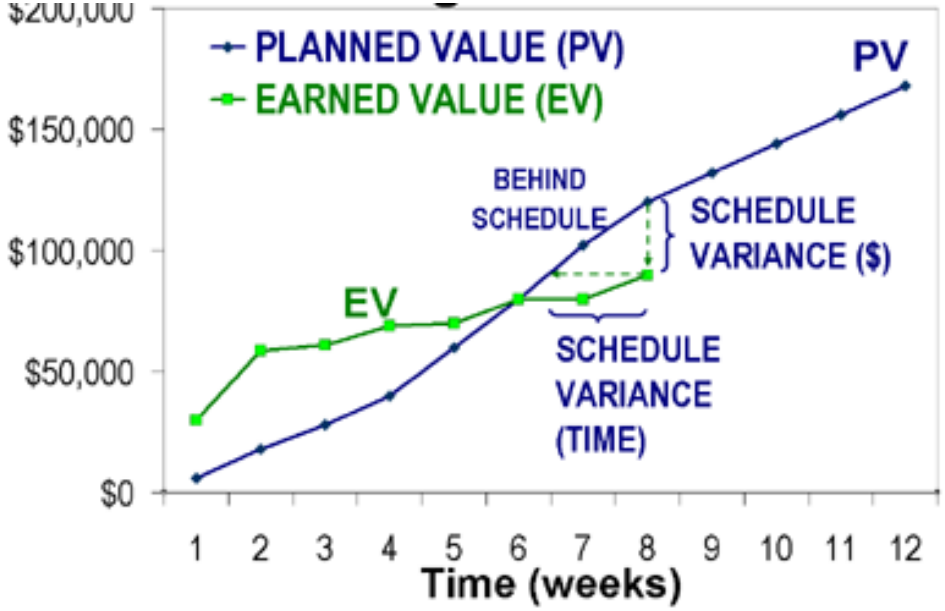


Earned Value Management Terms

- **Schedule variance (SV)** **SV = EV – PV**
  - A comparison of *amount of work performed* during a given period of time to the amount of work scheduled to be performed.
  - SV=0: according to the plan
    - SV equals zero at project completion
  - Negative SV: it took longer than planned to perform the work
  - Positive SV: it took shorter than planned to perform the work
    - SV much greater than 0 could be a bad sign as well

At week 8, the value of the work performed is only $90,000 (EV) but it was supposed to be $120,000 (PV):
SV = EV – PV = - $30,000
→ ***Negative SV*** *($)*

The work which is valued at $90,000 should have been completed at 6 ½ weeks, but it was completed at week 8
→ ***Negative SV*** *(weeks)*



Earned Value Management Terms

- **Cost performance index (CPI)** **CPI = EV / AC**
  - To estimate ***the projected cost*** of performing the project
  - CPI = 1 the costs are exactly as budgeted
  - CPI < 1 the project is over budget
  - CPI > 1 the project is under budget

- **Schedule performance index (SPI)** **SPI = EV / PV**
  - To estimate ***the projected time*** to complete the project
  - SPI = 1 the project is on schedule
  - SPI < 1 the project is behind the schedule
  - SPI > 1 the project is ahead of schedule

EVM – *Example 1 continued*

- PV = 10,000
  AC = 15,000
  EV = 7,500

➢ CV, SV, CPI, SPI?

Cost variance: CV = EV – AC
CV = 7,500 – 15,000
CV = -7,500

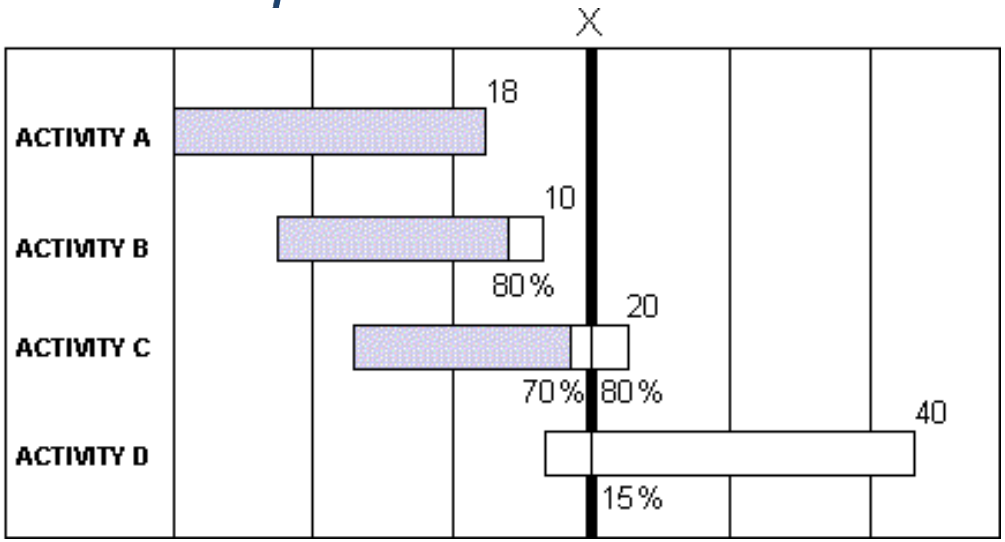
Cost performance index: CPI = EV/AC
CPI = 7,500/15,000
CPI = 50%

Schedule variance: SV = EV – PV
SV = 7,500 – 10,000
SV = -2,500

Schedule performance index: SPI = EV/PV
SPI= 7,500/10,000
SPI = 75%

The project is over budget and behind schedule.

EVM – *Example 2 continued*

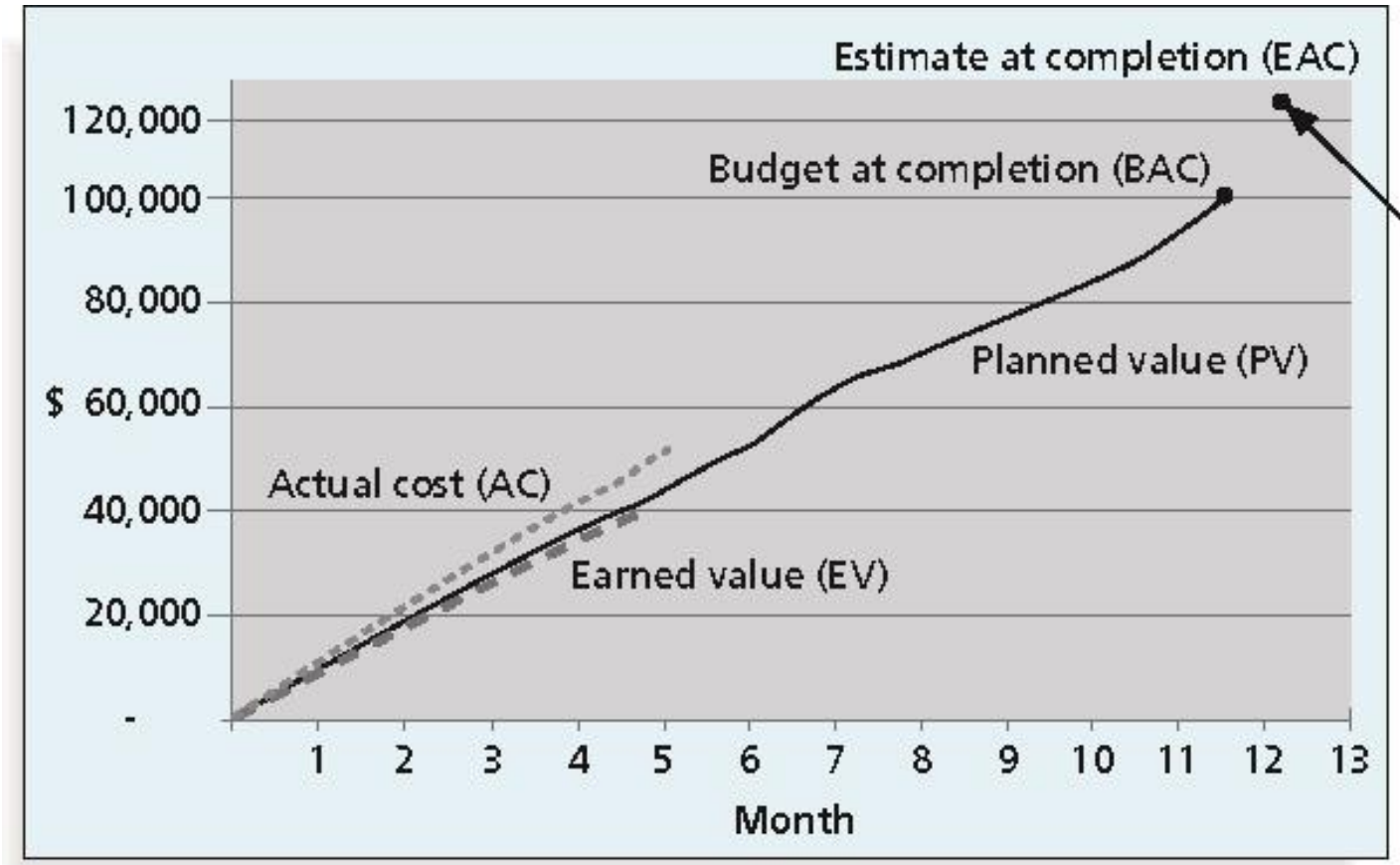


- On day X:
  - Planned Value: PV = $50
  - Earned Value: EV = $40
  - Actual Cost: AC = $45

Therefore:

- Schedule Variance: SV = EV – PV = 40 - 50 = -10 *(behind schedule)*
- Schedule Performance Index: SPI = EV / PV = 0.8, or 80% of plan
- Cost Variance: CV = EV - AC = 40 - 45 = -5 *(over budget)*
- Cost Performance Index CPI = EV / AC = 40 / 45 = 0.89, or you are getting an 89¢ return on every $ (person-hour) spent on this project

EVM Projections



EVM Projections

- **Budget at completion (BAC)**
  - The original total budget for the project
- **Estimate at completion (EAC)**
  - An estimate of what it will cost to complete the project based on performance to date
    - ***Medium estimate*: EAC = BAC / CPI**
      - Most common/popular calculation
      - It is expected that the project continues under the same conditions as until now
      - We encountered a variance which will likely continue
      - We expect all future task overrun at the same rate as now
    - ***Low estimate:* EAC= AC + (BAC - EV)**
      - It is expected that the project continues under the conditions as originally planned
      - There was a one-time atypical variance
      - We have fixed the problems behind the current cost overrun
    - ***High estimate:* EAC = AC + (BAC - EV) / (CPI * SPI)**
      - There was a variance, and it is expected that the project continues even worse than experienced to date
      - We expect further problems

EVM Projections

- **Estimate to Complete (ETC)**
  - An estimate of the cost to complete the remainder of the project
    - **ETC = EAC – AC**
  - Can be also determined by re-estimating the remaining costs for the project
    - **ETC = new estimates**
      - Bottom-up estimate (e.g. ask work package owners, team members, or vendors for revised estimates)
- **Variance at Completion (VAC)**
  - The difference between what the project was expected to cost (baseline) and what it is expected to cost now
    - **VAC = BAC – EAC**
      - Negative VAC: is unfavourable and means that we expect a cost overrun (over budget)
      - Positive VAC: is favourable and is a forecast of a cost underrun (under budget)

EVM Projections – *Example 1*

- A project has an original total budget of $1,000,000. At month 10, the AC is $800,000. Suppose CPI=0.87, and SPI=0.93. Calculate EAC under the 3 following situations: (1) The project continues under the same conditions experienced to date; (2) The project continues under the conditions as originally planned; (3) We expect further problems. For case (1) calculate also ETC and VAC.

- BAC=1,000,000, at month 10: AC = 800,000, CPI=0.87, and SPI=0.93

- 1) EAC = BAC/CPI = 1,000,000/0.87 = <u>1,149,425</u>

  2) EAC = AC + (BAC-EV)

  EV = CPI*AC = 0.87*800,000 = 696,000

  EAC = AC + (BAC – EV) = 800,000 + (1,000,000 – 696,000) = <u>1,104,000</u>

  3) EAC = AC + (BAC-EV) / (CPI * SPI)

  EAC = 800,000 + (1,000,000 - 696,000) / (0.87 * 0.93) = <u>1,175,726</u>

- ETC = EAC – AC = 1,149,425 – 800,000 = <u>349,425</u>

- VAC = BAC – EAC = 1,000,000 – 1,149,425 = <u>- 149,425</u>

EVM Projections – *Example 2*

- You are in the middle of your bathroom remodeling project. The original budget was $1,500 and you have completed approximately 40% of the work. The costs spent until now have been $900. Calculate EAC, ETC and VAC for two scenarios:
- (A) You learn that the contractor found some mold in the sheetrock and needed to replace it.
- (B) You learn that the workers that are being used are actually much more expensive than what you originally estimated.

- BAC = $1,500; at this point: 40% complete, AC = $900

- (A): Replacing mold will cause a one-time variance → use the low estimate formula for EAC:

EAC = AC + BAC – EV = $900 + $1,500 - $600 = $1,800
ETC = EAC – AC = $1,800 - $900 = $900
VAC = BAC – EAC = $1,500 - $1,800 = - $300

EVM Projections – *Example 2 continued*

- BAC = $1,500; at this point: 40% complete, AC = $900

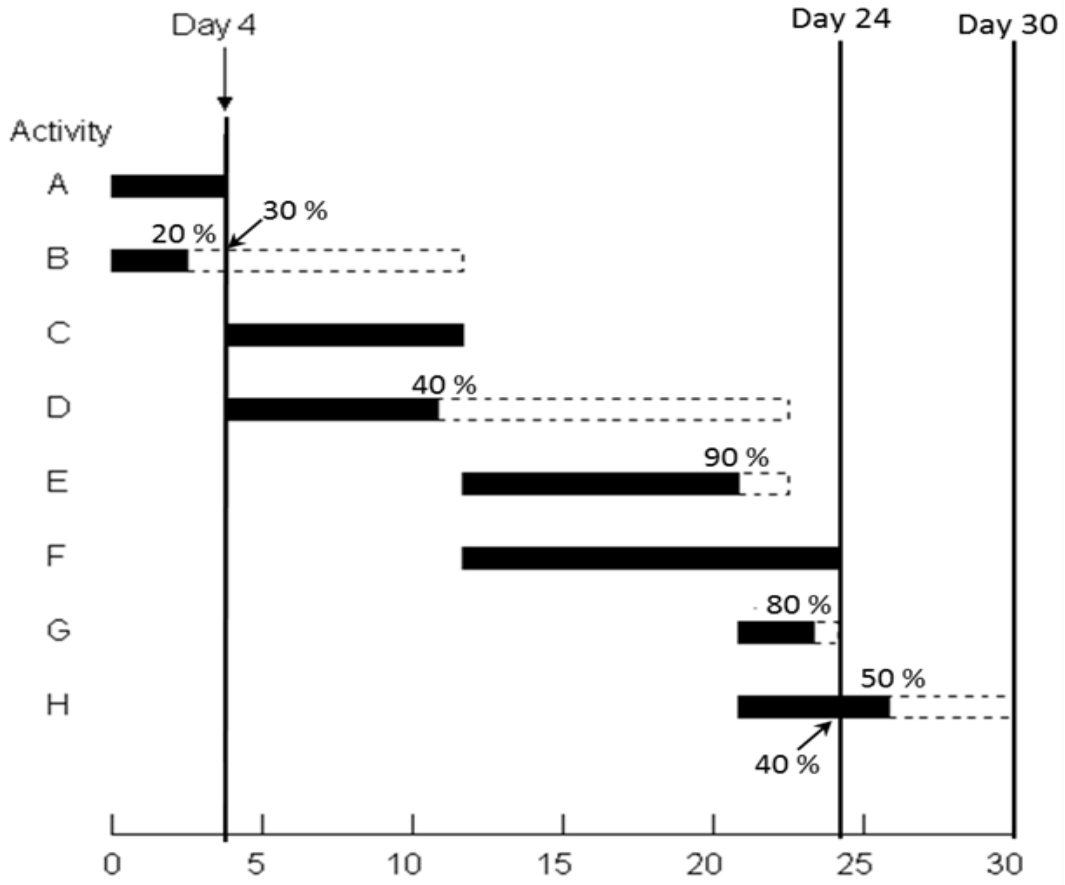
- (B): The workers that are being used are actually much more expensive. The more expensive workforce will continue during the whole project → use the medium estimate formula EAC = BAC / CPI
  For this we need CPI → CPI = EV/AC
  For this we need EV → EV = PV for the project * % project complete to date
  EV = $1,500 * 40% = 600
  CPI = EV/AC = $ 600 / $ 900 = 0.67
  We are over budget

  EAC = BAC / CPI = $1,500 / 0.67 = $2,239
  ETC = EAC – AC = $2,239 - $900 = $1,339
  VAC = BAC – EAC = $1,500 - $2,239 = - $739

EVM - *Example 3*

- The Gantt chart below shows the progress of a project at t=24 days. The total budgeted cost for the activities and their durations are given in the table. The cost at day 24 is already $2000, but at this point it is expected that the project continues under the conditions as originally planned. Evaluate the project progress at day 24:
  - PV, EV?
  - SV, SPI, CV, CPI?
  - BAC, EAC?

	Budgeted cost ($)	Duration (days)
A	100	4
B	200	12
C	150	8
D	1000	18
E	400	10
F	300	12
G	250	6
H	500	9

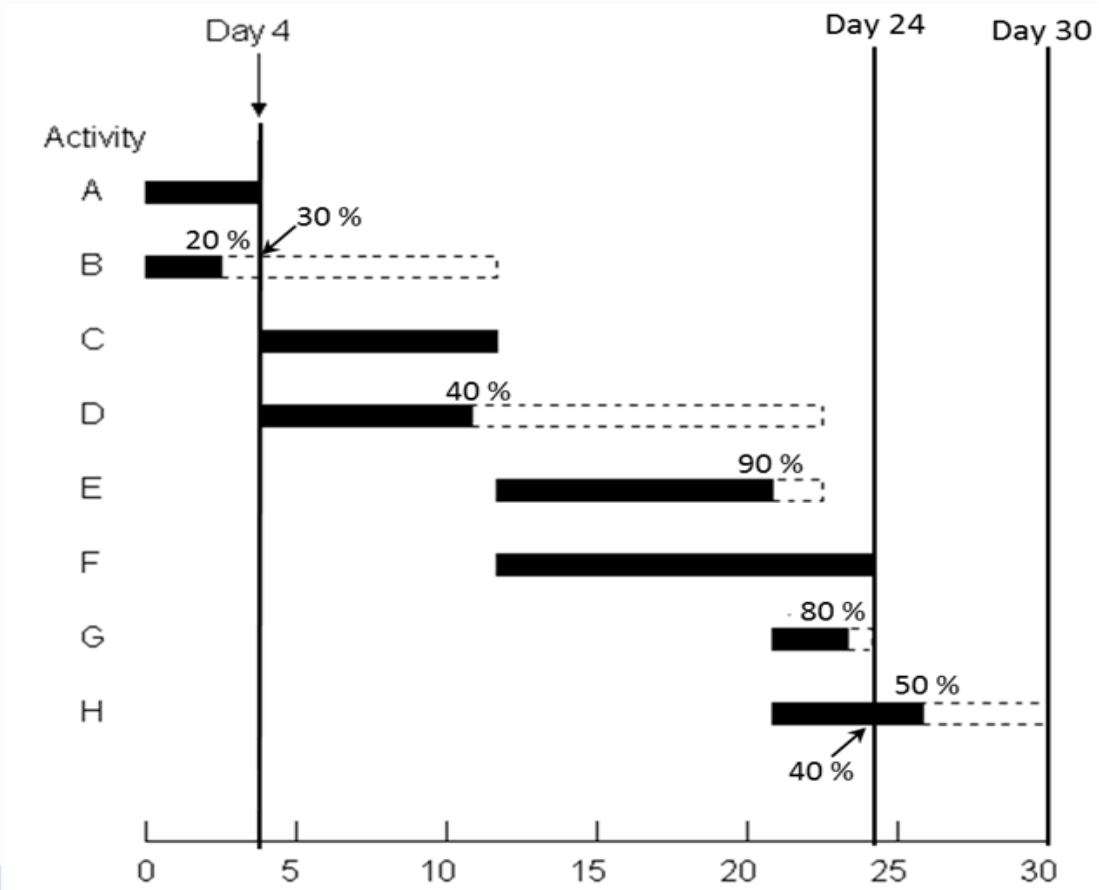


EVM - *Example 3 contd.*

	Budgeted cost ($)	Duration
A	100	4
B	200	12
C	150	8
D	1000	18
E	400	10
F	300	12
G	250	6
H	500	9

- **PV**=100+200+150+1000+400+300+250+(0.4*500)=2600
- **EV**=100+(0.2*200)+150+(0.4*1000)+(0.9*400)+300+(0.8*250)+(0.5*500)=1800
- **SV**=EV-PV=1800-2600=-800
- **SPI**=EV/PV=1800/2600=0.69
- **CV**=EV-AC=1800-2000=-200
- **CPI**=EV/AC=1800/2000=0.9
- **BAC**=100+200+150+1000+400+300+250+500=2900
- **EAC**= AC + (BAC - EV)= 2000+(2900-1800)=3100

- The project is behind schedule and over budget.



Chapter Summary

- Project cost management is a traditionally weak area of IT projects, and project managers must work to improve their ability to deliver projects within approved budgets
- Main processes include:
  - Estimate costs
  - Determine the budget
  - Control costs

Next Lectures

- February 19 – Midterm winter break
- February 26 – Introduction to MS Project
- March 5 – Quiz 1