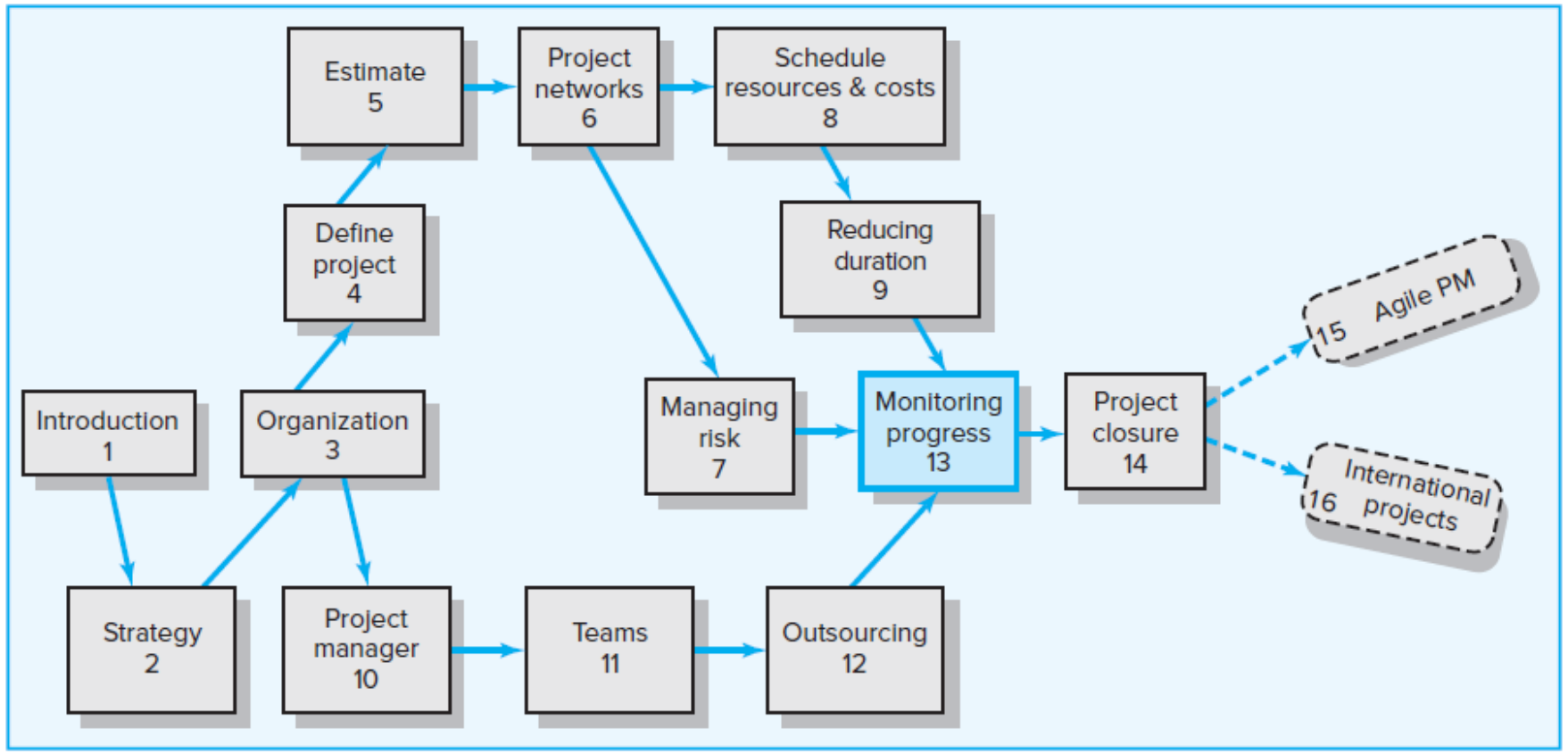
OntarioTech
Engineering
& Applied Science

Project Management for Engineers - ENGR 5410G
Fall 2024

Unit 7:
Monitoring Progress (ch 13)

Where We Are Now



Learning Objectives

13-01 Identify the four steps for controlling a project.

13-02 Utilize a tracking Gantt to monitor time performance.

13-03 Understand and appreciate the significance of earned value management.

13-04 Calculate and interpret cost and schedule variance.

13-05 Calculate and interpret performance and percent indexes.

13-06 Forecast final project cost.

13-07 Identify and manage scope creep.

Chapter Outline

13.1 Structure of a Project Monitoring Information System

A project monitoring system involves

- Determining what data to collect
- Determining how, when, and who will collect the data
- Analysis of the data
- Reporting current progress

What Data Are Collected?

The data need to answer questions such as

- What is the current status of the project in terms of schedule and cost?
- How much will it cost to complete the project?
- When will the project be completed?
- Are there potential problems that need to be addressed now?
- What, who, and where are the causes for cost or schedule overruns?
- If there is a cost overrun midway in the project, can we forecast the overrun at completion?

Collecting Data and Analysis

- Will the data be collected by the project team, contractor, independent cost engineers, project manager?
- Will the data be derived electronically from some form of surrogate data?
- Should the reporting period be one hour, one day, one week, or what?
- Is there a central repository for the data collected and is someone responsible for its dissemination?

Reports and Reporting

- Who gets the progress reports?
- How will the reports be transmitted?
- When will the reports be distributed?

A common topic format for progress reports

- Progress since last report
- Current status of project: 1) schedule, 2) cost, 3) scope
- Cumulative trends
- Problems and issues since last report:
  1) Actions and resolutions of earlier problems
  2) New variances and problems identified
- Corrective action planned

13.2 The Project Control Process

Control

Is the process of comparing actual performance against plan to identify deviations, evaluate possible alternative courses of actions, and take appropriate corrective action.

Project control steps for measuring and evaluating project performance

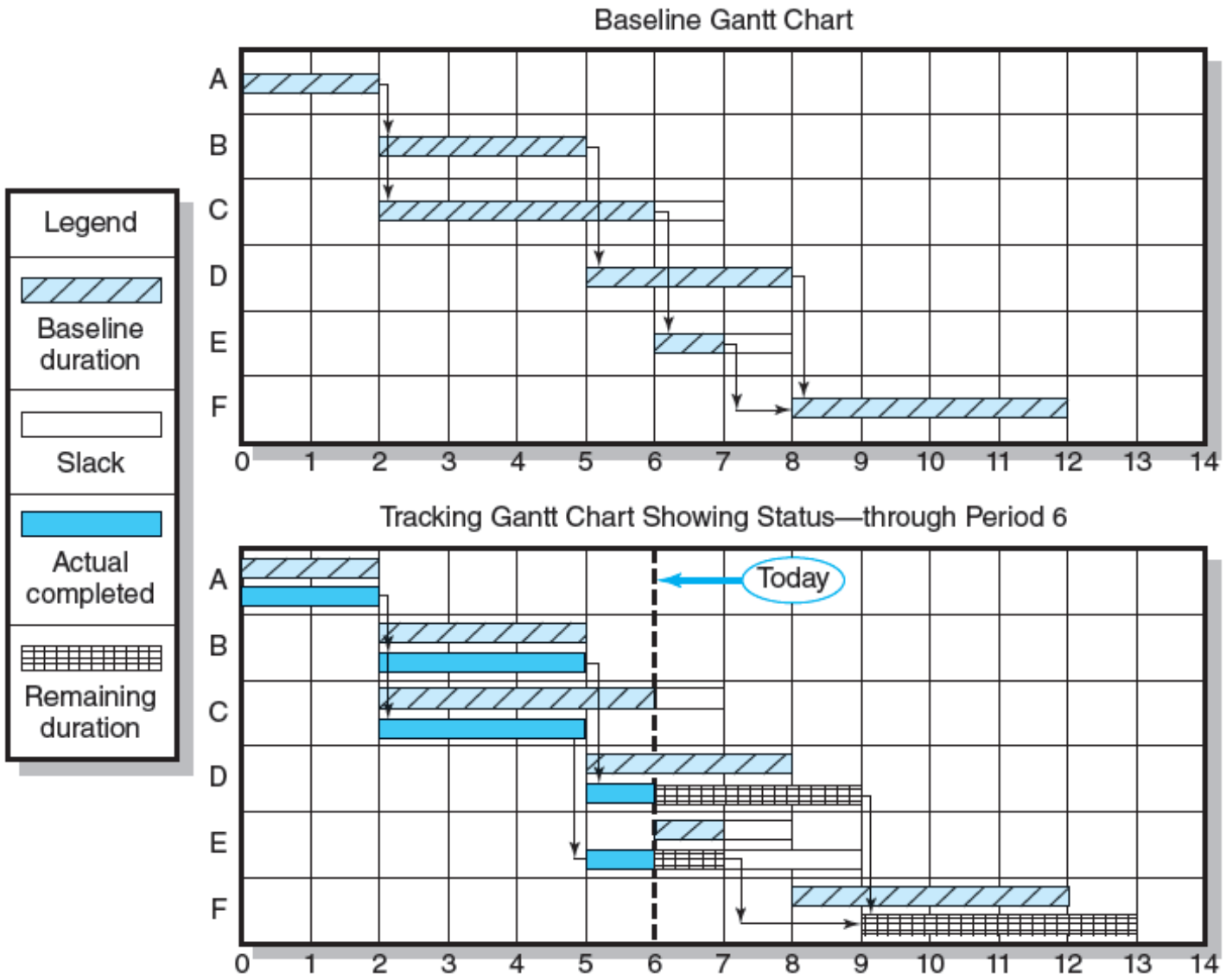
1. Setting a baseline plan
2. Measuring progress and performance
3. Comparing plan against actual
4. Taking action

13.3 Monitoring Time Performance

Typical tools used for communicating project schedule status

- Gantt chart (bar chart) is the most favored, used, and understandable. It is commonly referred to as a tracking Gantt chart.
- Control chart is used to plot the difference between the scheduled and actual times on the critical path at a given point on the project.
- Milestone schedules are often used to keep more distal stakeholders informed on the progress of a project.
  - Milestones are significant project events that mark major accomplishments.

Baseline and Tracking Gantt Charts



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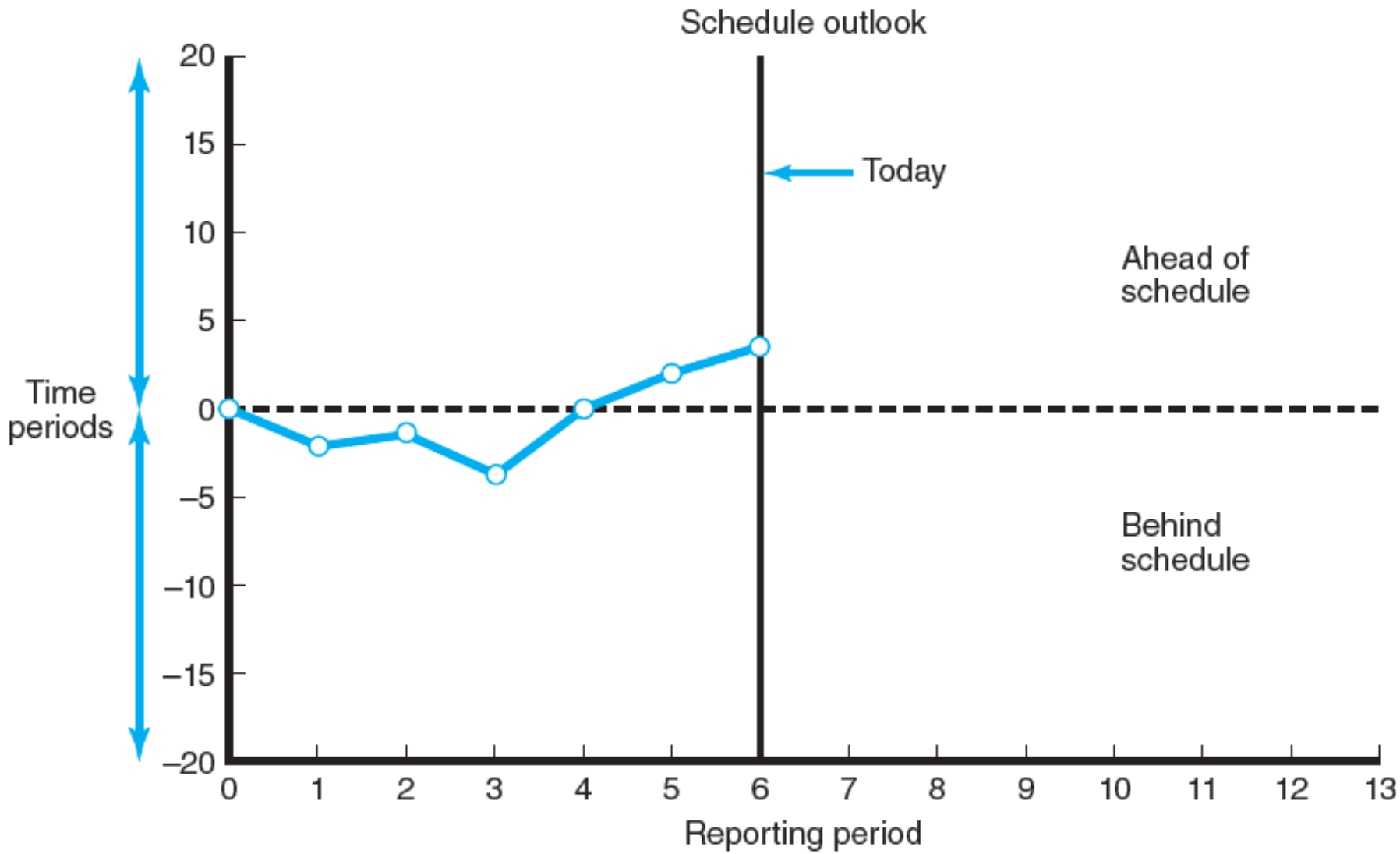
Project Schedule Control Chart



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13.4 Earned Value Management (EVM)

Earned Value Management

- Is a methodology that combines scope, schedule, and resource measurement to assess project performance and progress.
- Was pioneered by the U.S. Department of Defense (DoD) in the 1960s.
- Uses several acronyms and equations for analysis.
- Uses data developed from the work breakdown structure, project network, and schedule.
- Starts with the time-phased costs that provide the project budget baseline, which is called the planned budgeted value of the work scheduled (PV). Then comparisons can be made with actual and planned schedule and costs.

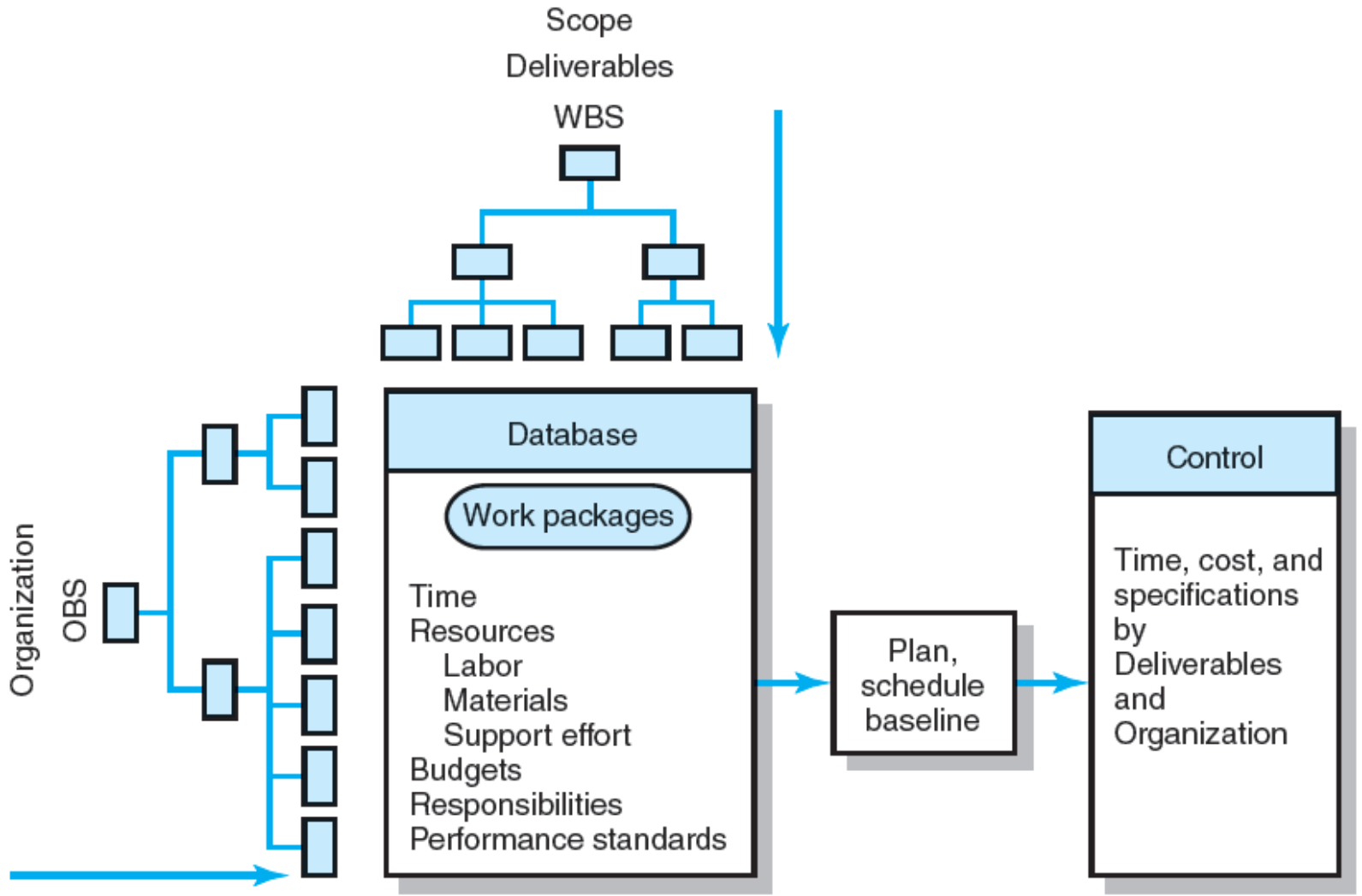
Glossary of Terms

EV	Earned value for a task is the budgeted value of the work accomplished. Work accomplished is often measured in terms of percentages (e.g., 25% complete) in which case, EV is simply percent complete times its original budget. [The older acronym for this value was BCWP—budgeted cost of the work performed.]
PV	The planned time-phased baseline of the value of the work scheduled. An approved cost estimate of the resources scheduled in a time-phased cumulative baseline [BCWS—budgeted cost of the work scheduled].
AC	Actual cost of the work completed. The sum of the costs incurred in accomplishing work [ACWP—actual cost of the work performed].
CV	Cost variance is the difference between the earned value and the actual costs for the work completed to date where CV = EV – AC.
SV	Schedule variance is the difference between the earned value and the baseline to date where SV = EV – PV.
BAC	Budgeted cost at completion. The total budgeted cost of the baseline or project cost accounts.
EAC	Estimated cost at completion
ETC	Estimated cost to complete remaining work
VAC	Cost variance at completion. VAC indicates expected actual over- or underrun cost at completion.

Developing an Integrated Cost/Schedule System

1. Define the work using a WBS.
   - Scope
   - Work package
   - Deliverables
   - Organization units
   - Resources
   - Budgets for each work package
2. Develop work and resource schedule.
   - Schedule resources to activities
   - Time-phase work packages into a network
3. Develop a time-phased budget using work packages included in an activity called the planned budgeted cost of the work scheduled (PV).
4. At the work package level, collect the actual costs for the work performed called the actual cost of the work completed (AC). Multiple percent complete with the original budget amount to be earned value (EV).
5. Compute the schedule variance (SV = EV – PV) and cost variance (CV = EV – AC).

Project Management Information System Overview



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Development of Project Baseline

Purposes of a Baseline (PV)

- To measure and report progress
- To estimate cash flow

Rules in Assigning Costs to the Baseline

- Costs are placed (time-phased) in the baseline exactly as managers expected them to be “earned.”
- Percent complete is the workhorse most commonly used. Someone familiar with each task estimates what percent of the task has been completed or how much of the task remains.

What Costs Are Included in Baselines?

- Baseline is the sum of the cost accounts and each cost account is the sum of the work packages in the cost account.
- Three direct costs are typically included in baselines—labor, equipment, and materials.

Methods of Variance Analysis

Comparing earned value with

- The expected schedule value
- The actual costs

Assessing current status of a project requires three data elements

- Planned cost of the work scheduled (PV)
- Budgeted cost of the work completed (EV)
- Actual cost of the work completed (AC)

Computing schedule variance (SV) and cost variance (CV)

- A positive variance indicates a desirable condition, while a negative variance suggests problems or changes that have taken place.

Variances

Cost variance (CV) = EV – AC

- Tells us if the work accomplished costs more or less than was planned at any point over the life of the project.

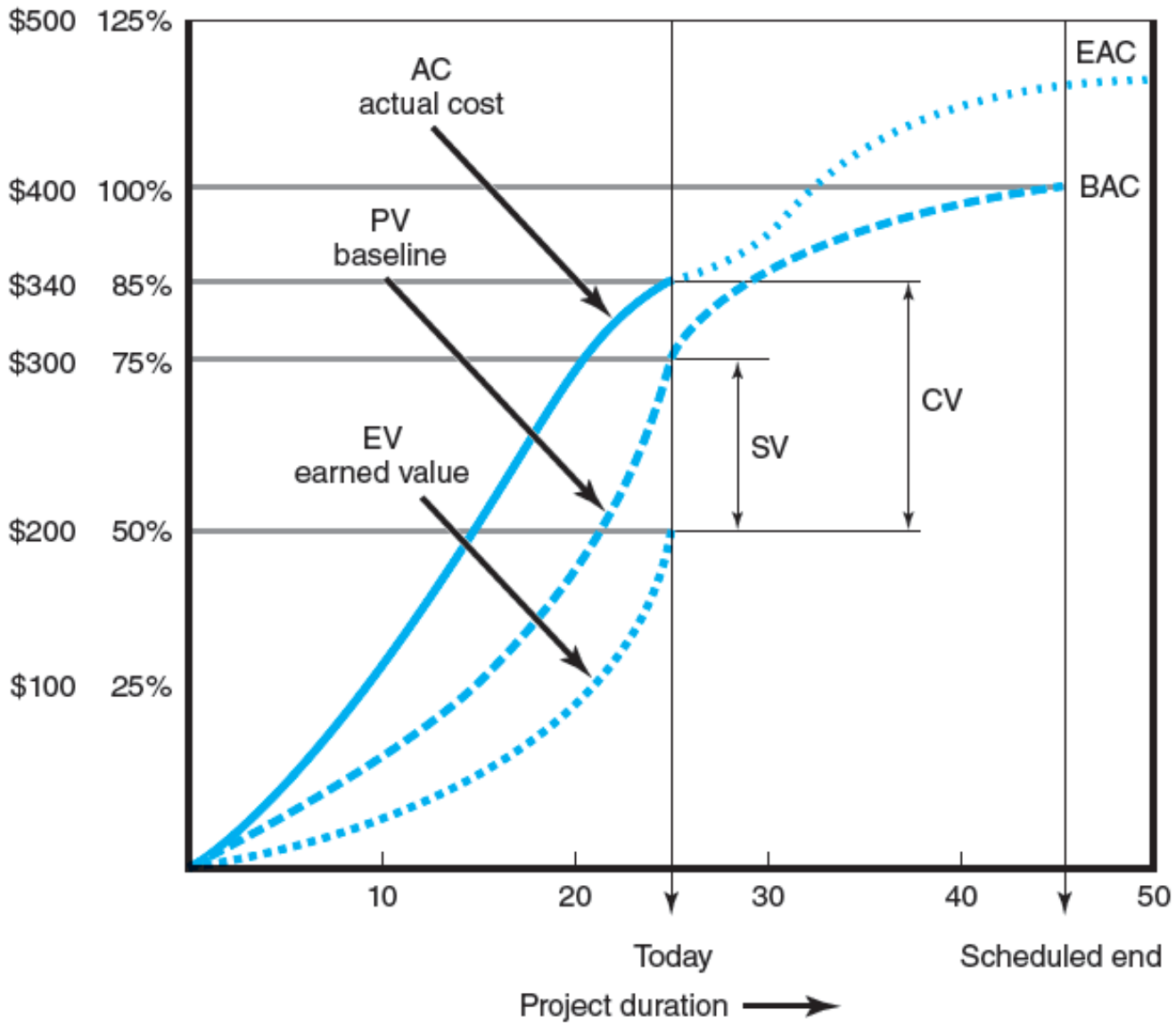
Schedule variance (SV) = EV – PV

- Presents an overall assessment of all work packages in the project scheduled to date.
- Contains no critical path information.
- Measures progress in dollars rather than time units.

Variance at completion (VAC) = BAC – EAC

- Suggests whether the costs at completion of the project will differ from what was planned.

Cost/Schedule Graph



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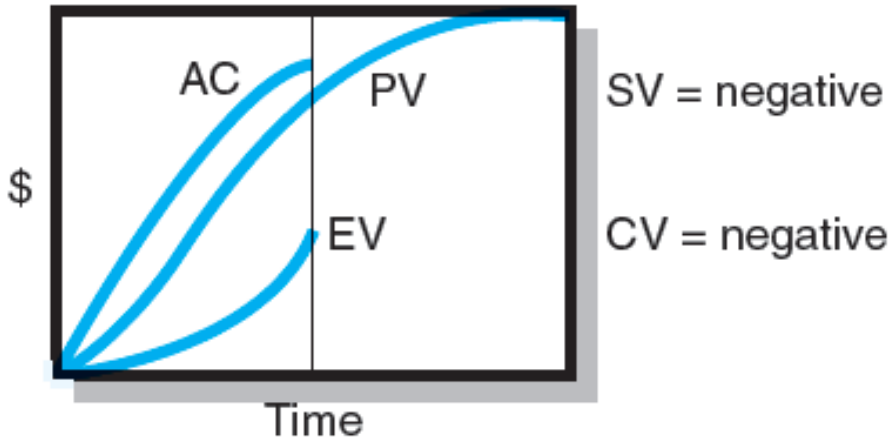
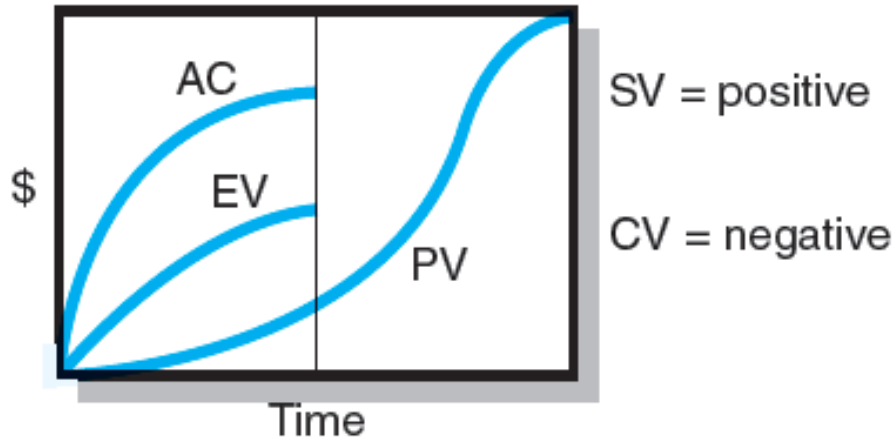
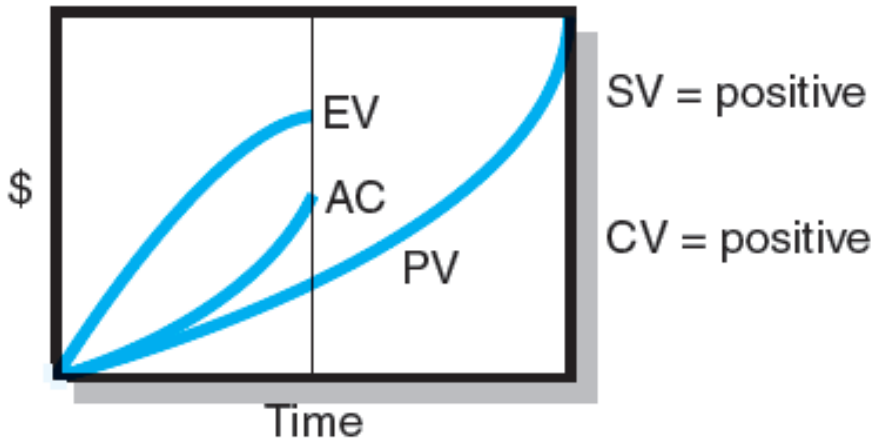
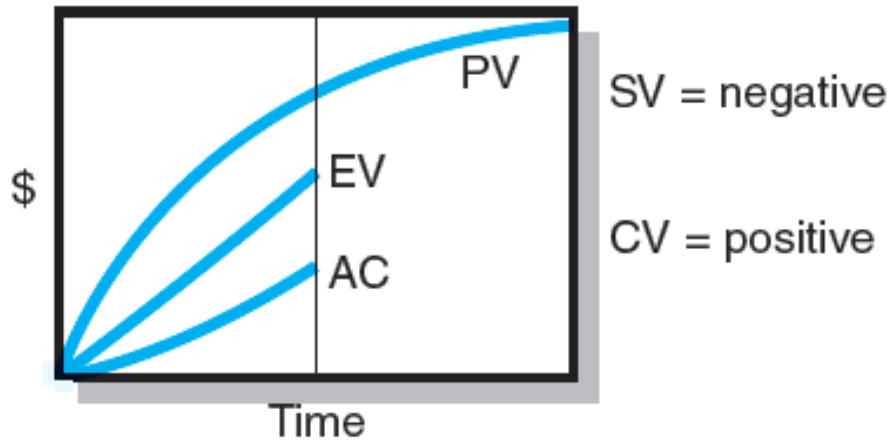
Earned Value Review Exercise









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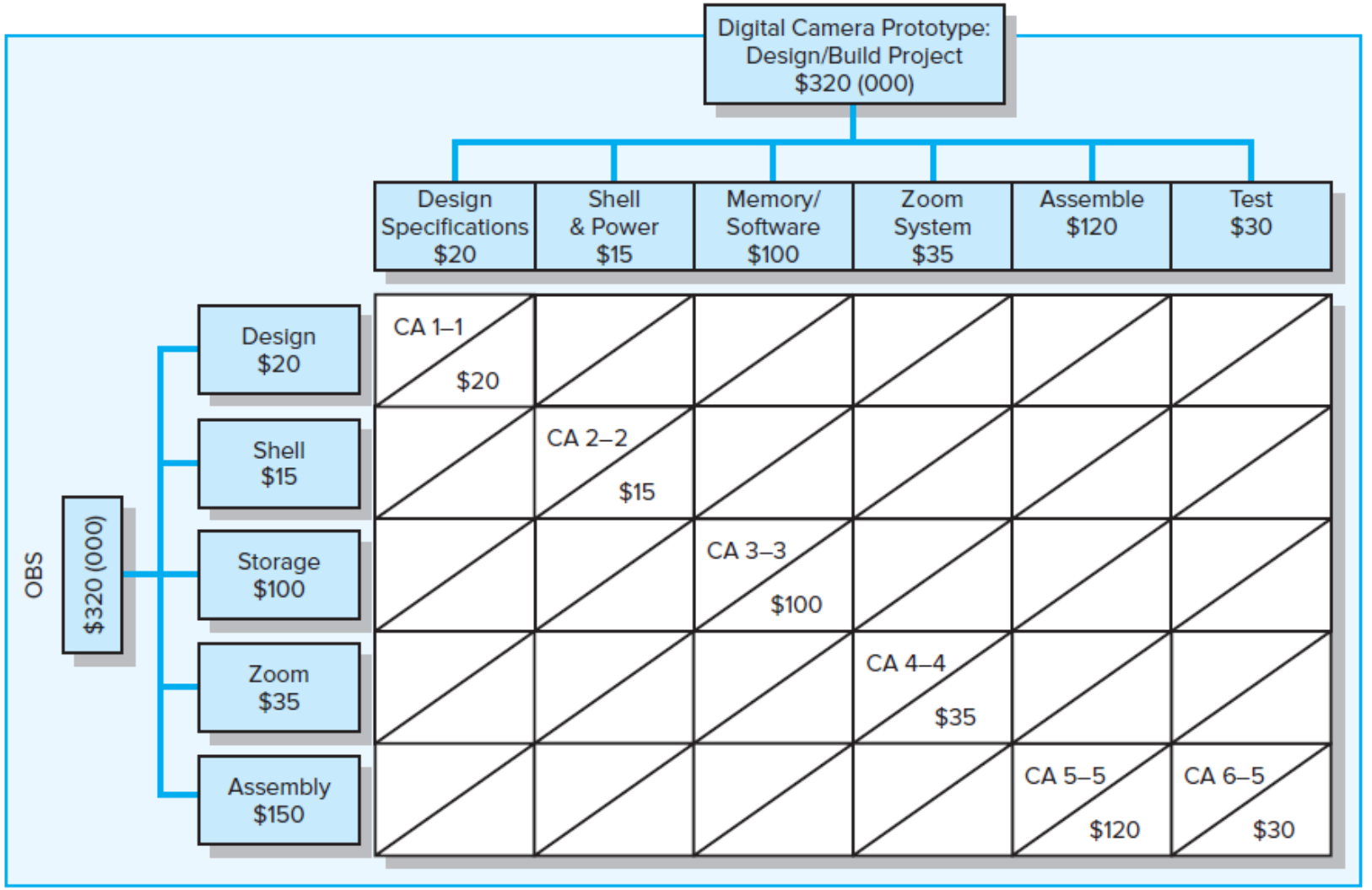
13.5 Developing a Status Report: A Hypothetical Example

Assumptions

- Each cost account has only one work package, and each cost account will be represented as an activity on the network.
- The project network early start times will serve as the basis for assigning the baseline values.
- From the moment work on an activity task begins, some actual costs will be incurred each period until the activity is completed.

Work Breakdown Structure with Cost Accounts



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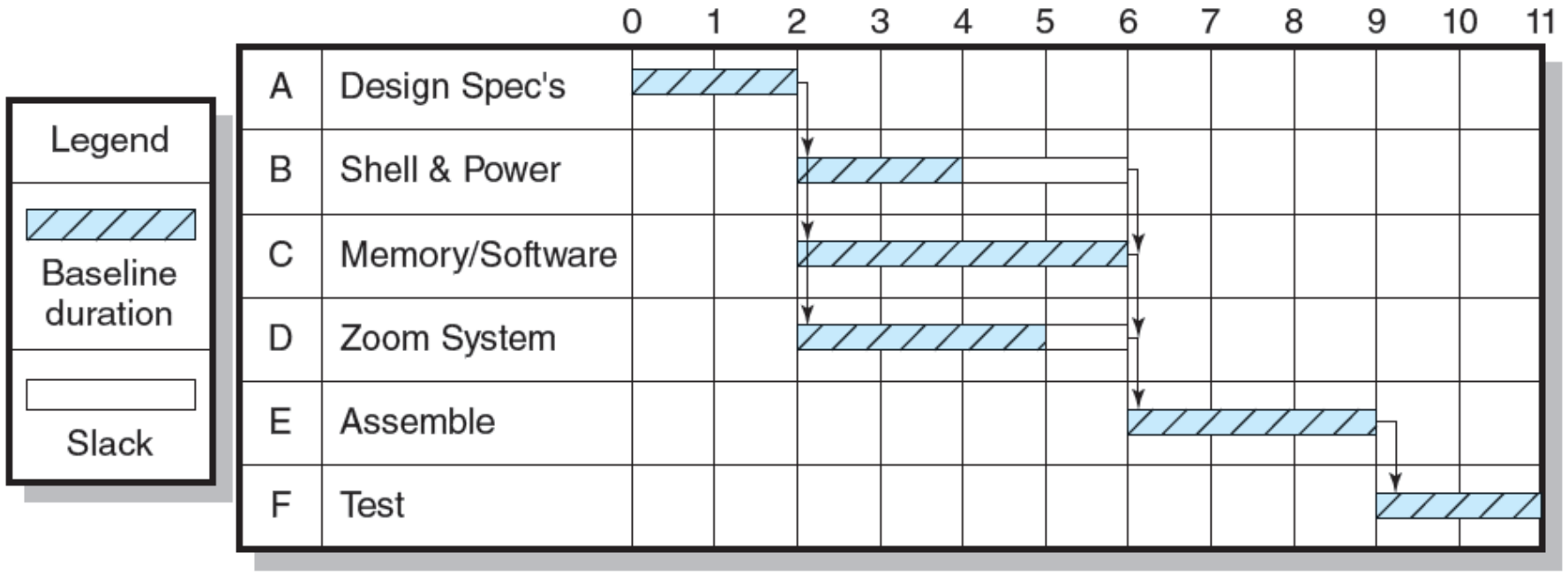
Digital Camera Prototype Project Baseline Gantt Chart



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Digital Camera Prototype Project Baseline Budget ($000)

Schedule information						Baseline budget needs										
ACT/ WP	DUR	ES	LF	SL	Total PV	Time period 0	1	2	3	4	5	6	7	8	9	10	11
A	2	0	2	0	20	10	10										
B	2	2	6	2	15			5	10								
C	4	2	6	0	100			20	30	30	20						
D	3	2	6	1	35			15	10	10							
E	3	6	9	0	120							30	40	50			
F	2	9	11	0	30										10	20	
Total PV by period						10	10	40	50	40	20	30	40	50	10	20	
Cumulative PV by period						10	20	60	110	150	170	200	240	290	300	320	

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Digital Camera Prototype Status Reports: Periods 1–3

Cost Variance	CV = EV − AC
Schedule Variance	SV = EV − PV

Status Report: Ending Period 1

Task	%Complete	EV	AC	PV	CV	SV
A	50%	10	10	10	0	0
Cumulative Totals		**10**	**10**	**10**	**0**	**0**

Status Report: Ending Period 2

Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
Cumulative Totals		**20**	**30**	**20**	**−10**	**0**

Status Report: Ending Period 3

Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
B	33%	5	10	5	−5	0
C	20%	20	30	20	−10	0
D	60%	21	20	15	+1	+6
Cumulative Totals		**66**	**90**	**60**	**−24**	**+6**

Digital Camera Prototype Status Reports: Periods 4–5

Status Report: Ending Period 4

Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	50%	50	70	50	−20	0
D	80%	28	30	25	−2	+3
Comulative Totals		**113**	**150**	**110**	**−37**	**+3**

Status Report: Ending Period 5

Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	60%	60	100	80	−40	−20
D	80%	28	50	35	−22	−7
Cumulative Totals		**123**	**200**	**150**	**−77**	**−27**

TABLE 13.2 (Continued)

Digital Camera Prototype Status Reports: Periods 6–7

Status Report: Ending Period 6

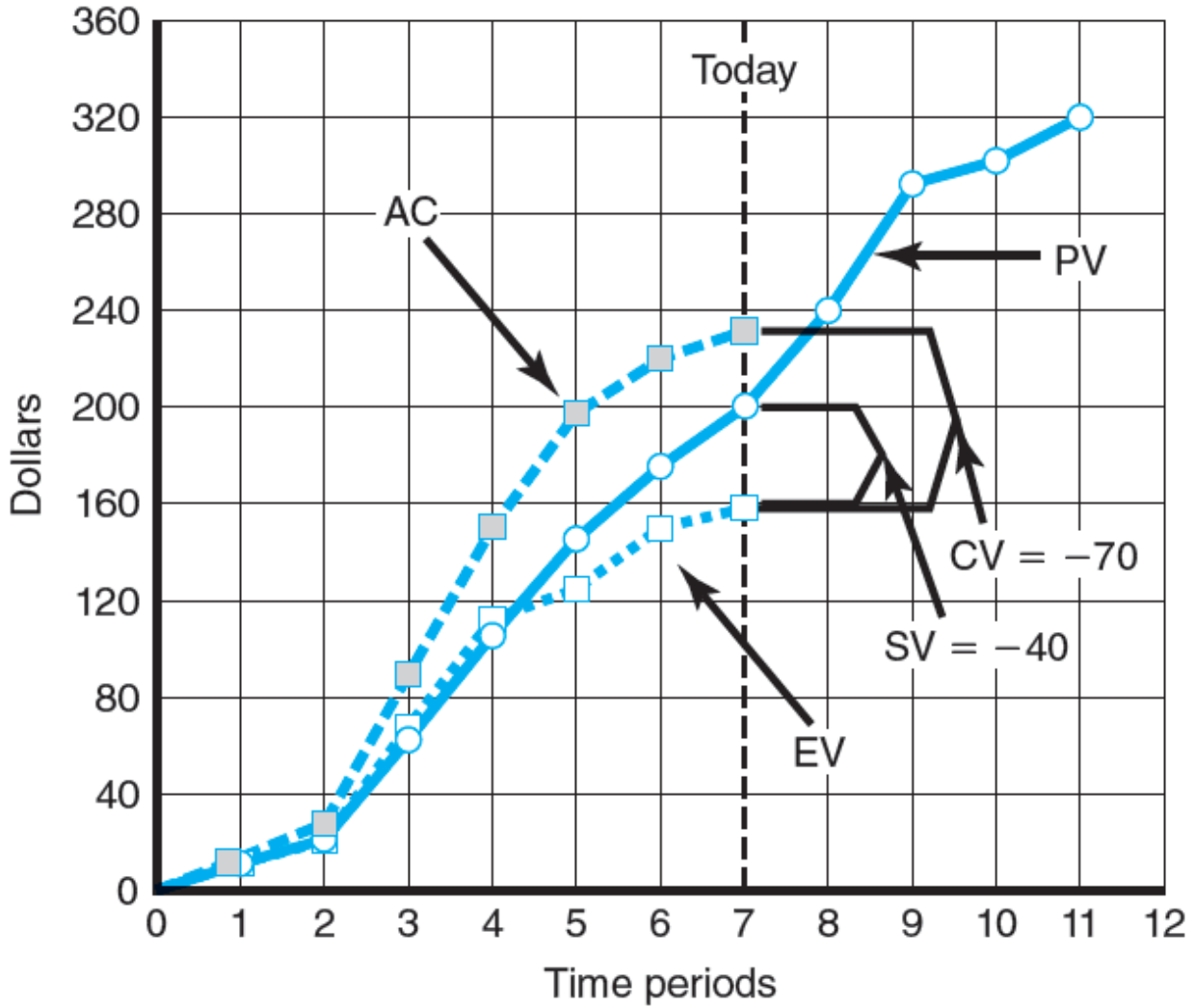
Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	80%	80	110	100	−30	−20
D	Finished	35	60	35	−25	0
Cumulative Totals		**150**	**220**	**170**	**−70**	**−20**

Status Report: Ending Period 7

Task	%Complete	EV	AC	PV	CV	SV
A	Finished	20	30	20	−10	0
B	Finished	15	20	15	−5	0
C	90%	90	120	100	−30	−10
D	Finished	35	60	35	−25	0
E	0%	0	0	30	0	−30
F	0%	0	0	0	0	0
Cumulative Totals		**160**	**230**	**200**	**−70**	**−40**

TABLE 13.2 (Continued)

Digital Camera Prototype Summary Graph ($000)



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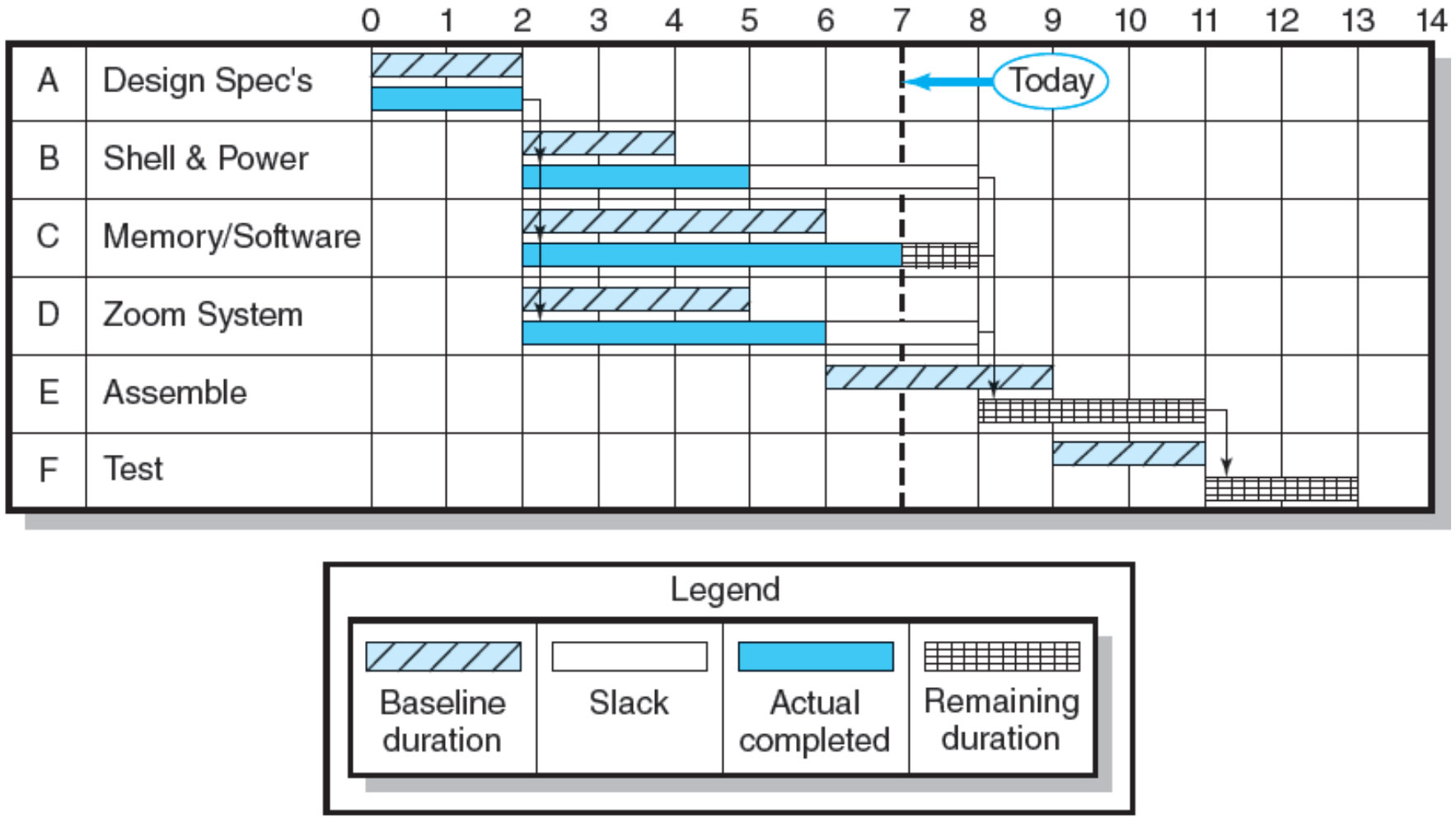
Digital Camera Project-Tracking Gantt Chart Showing Status—through Period 7



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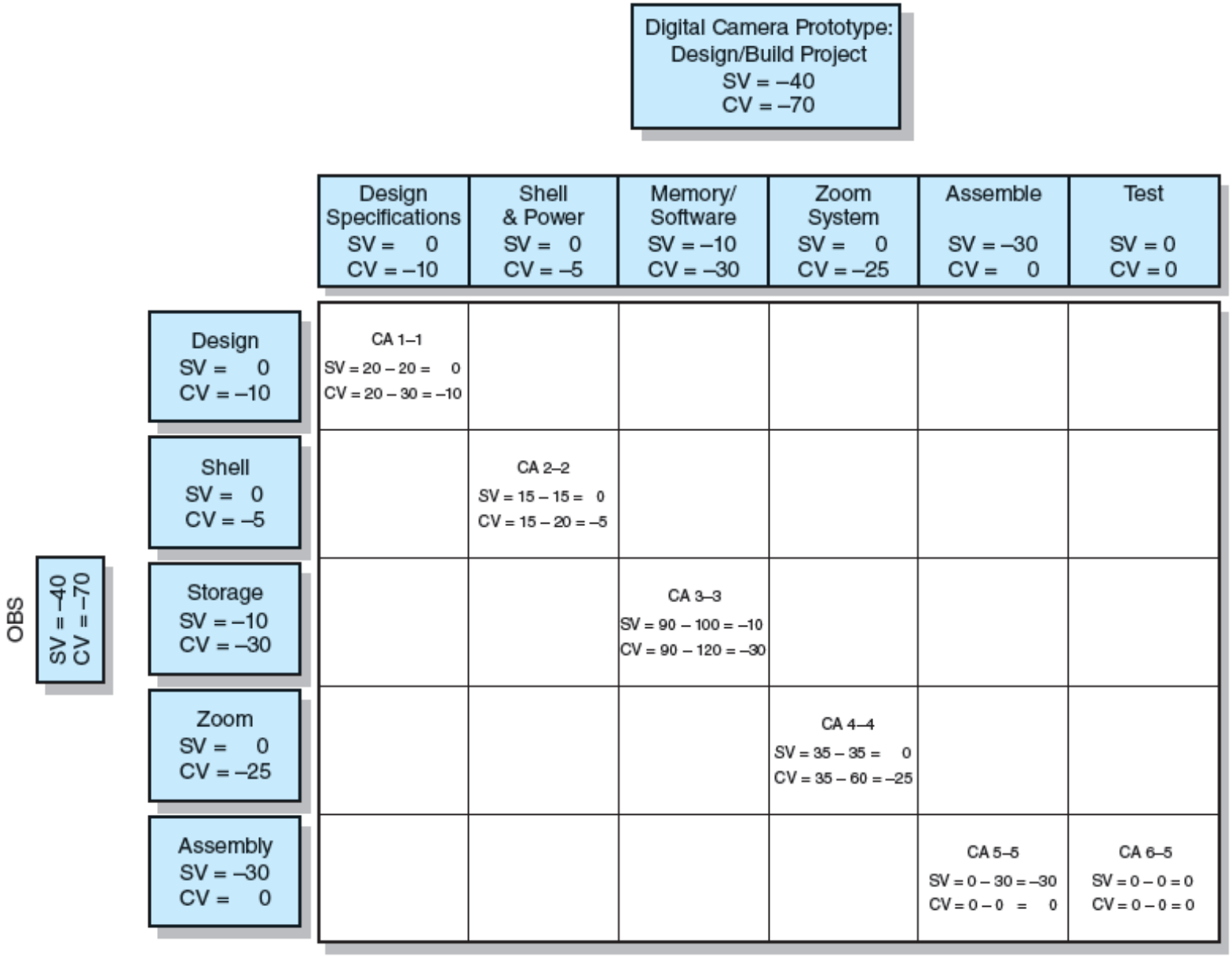
Project Rollup End Period 7 ($000)



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13.6 Indexes to Monitor Progress

Performance Indexes

- Cost performance index (CPI) = EV/AC
  - Measures cost efficiency of the work accomplished to date
- Scheduling performance index (SPI) = EV/PV
  - Measures scheduling efficiency to date

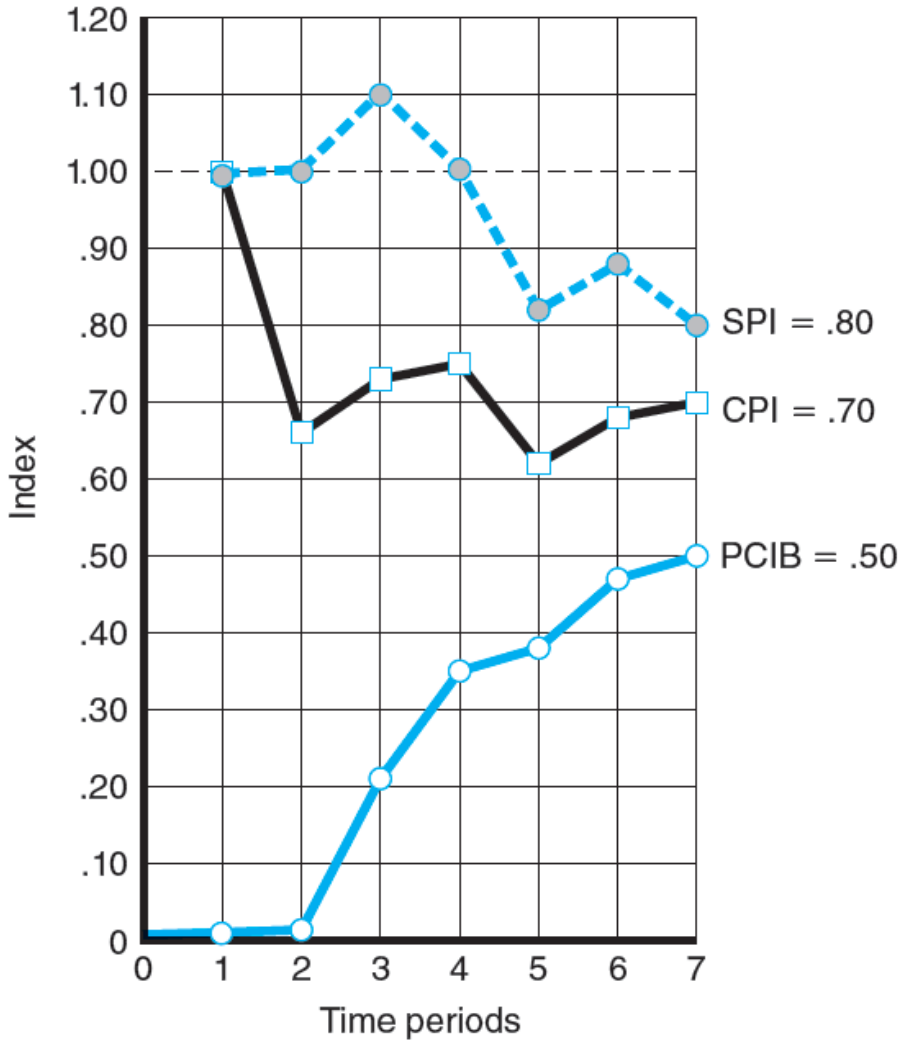
Project Percent Complete Indexes

- Percent complete index budgeted costs (PCIB) = EV/BAC
- Percent complete index actual costs (PCIC) = AC/EAC
- Management reserve index (MRI) = CV/MR
  - Is popular in the construction industry
  - Reflects the amount of management reserves that has been absorbed by cost overruns.

Interpretation of Indexes

Index	Cost (CPI)	Schedule (SPI)
>1.00	Under cost	Ahead of schedule
=1.00	On cost	On schedule
<1.00	Over cost	Behind schedule

Indexes Periods 1–7



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Additional Earned Value Rules

Rules applied to short-duration activities and/or small-cost activities

- **0/100 rule**
  - Assumes 100% of the budget is earned when the work package is completed.
- **50/50 rule**
  - Allows 50% of the value of the work package budget to be earned when it is started and 50% to be earned when the package is completed.

Rule used gates before the total budgeted value of an activity can be claimed

- **Percent complete with weighted monitoring gates**
  - Uses subjective estimated percent complete in combination with hard, tangible monitoring points.

13.7 Forecasting Final Project Cost

Two methods used to revise estimates of future project costs

- Revised estimated cost at completion (EAC_{re})
  - Allows experts in the field to change original baseline durations and costs because new information tells them the original estimates are not accurate.
- Forecasted total cost at completion (EAC_f)
  - Uses the actual costs to date plus an efficiency index (CPI=EV/AC) applied to the remaining project work.

Forecasting Models: EAC_{re} and EAC_f

- Revised estimated cost at completion (EAC_{re}) = AC + ETC_{re}

where AC = cumulative actual cost of work completed to date

ETC_{re} = revised estimated cost to complete remaining work

- Forecasted total cost at completion (EAC_f) = ETC + AC

$$= \frac{\text{Work remaining}}{\text{CPI}} + \text{AC}$$

$$= \frac{\text{BAC} - \text{EV}}{\text{EV/AC}} + \text{AC}$$

where ETC = estimated cost to complete remaining work

AC = cumulative actual cost of work completed to date

CPI = cumulative cost index to date

BAC = total budget of the baseline

EV = cumulative budgeted cost of work completed to date

Another Forecasting Index

To Complete Performance Index (TCPI) = $\frac{\text{BAC} - \text{EV}}{\text{BAC} - \text{AC}}$

- Used as a supplement to the estimate at completion (EAC_f) computation.
- Measures the amount of value each remaining dollar in the budget must earn to stay within the budget.
- A ratio less than 1.00 indicates an ability to complete the project without using all of the remaining budget.

Monthly Status Report

Project: Red Octopus (#72) **Project manager:** Xavier Hart

Project priority now: 4

Status as of: April 1

Earned value figures:

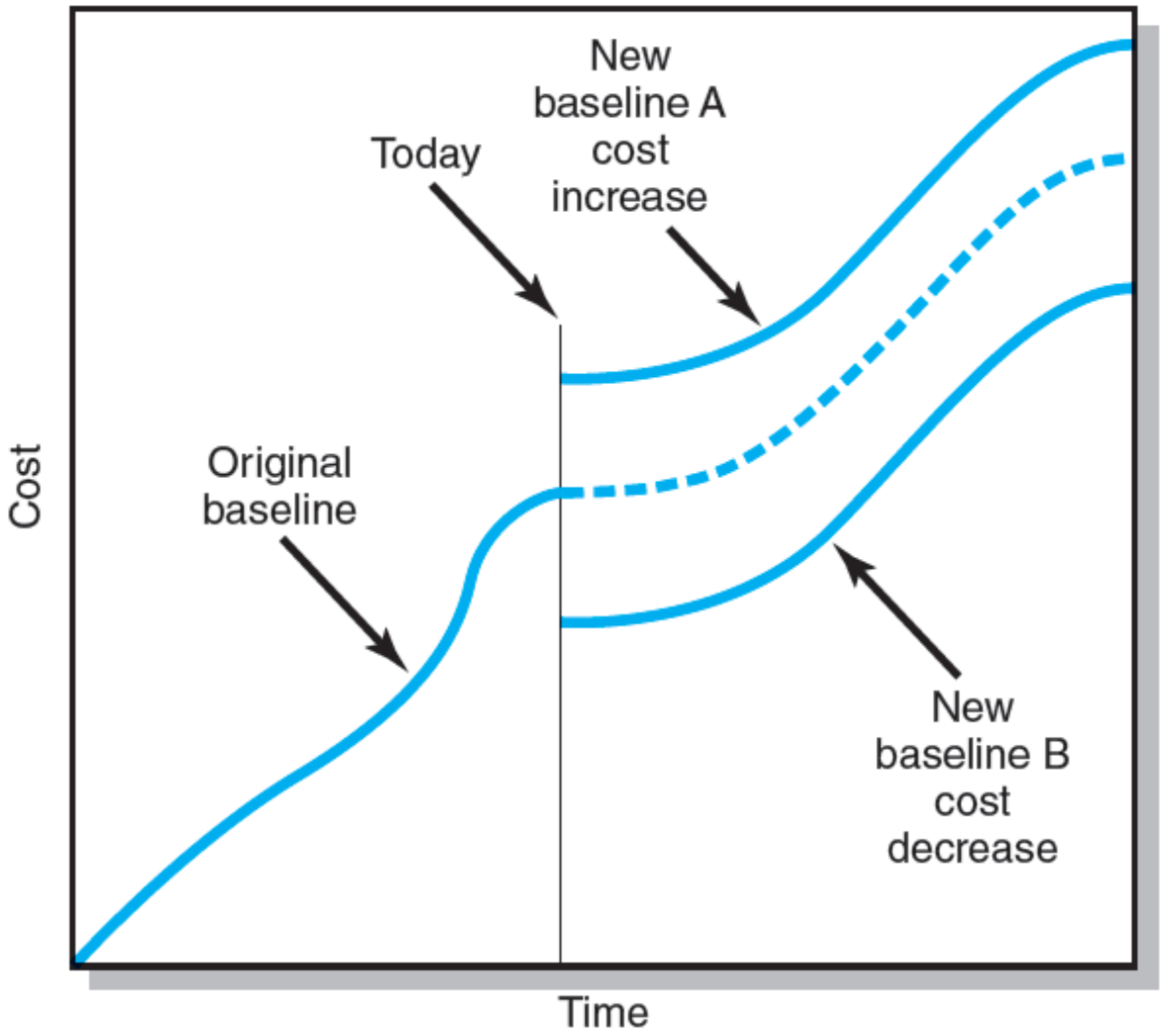
PV	EV	AC	SV	CV	BAC
588,240	566,064	596,800	−22,176	−30,736	1,051,200
EAC	**VAC**	**EAC_f**	**CPI**	**PCIB**	**PCIC**
1,090,640	−39,440	1,107,469	.95	.538	.547

Project description: A computer-controlled conveyor belt that will move and position items on the belt with accuracy of less than one millimeter.
Status summary: The project is approximately 25 days behind schedule and $30,736 over budget.
Explanations: The schedule variance has moved from noncritical activities to those on the critical path. Integration first phase, scheduled to start 3/26, is now expected to start 4/19, which means it is approximately 25 days behind schedule. This delay is traced to the loss of the second design team, which made it impossible to start utilities documentation on 2/27 as planned. The cost variance to date is largely due to a design change that cost $21,000.
Major changes since last report: The major change was loss of one design team to the project.
Total cost of approved design changes: $21,000. Most of this amount is attributed to the improved design of the serial I/O drivers.
Projected cost at completion: EAC_f is estimated to be $1,107,469. This represents an overrun of $56,269, given a CPI of .95.
Forecasted completion date: October 23.
Risk watch: Five team members were stricken with flu.

13.8 Other Control Issues

- Technical performance measurement is as important as measuring schedule and cost performance.
- Scope creep causes problems because the “minor refinements” eventually build to be major scope changes.
- Baseline changes should be allowed only if it is clear that the project will fail without the change, the project will be improved significantly with the change, or the customer wants it and will pay for it.
- Data acquisition is time consuming and costly.

Scope Changes to a Baseline



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Key Terms

Control chart

Cost performance index (CPI)

Cost variance (CV)

Earned value (EV)

Earned value management (EVM)

Forecasted total cost at completion (EAC_f)

Management reserve index (MRI)

Percent complete index actual costs (PCIC)

Percent complete index budgeted costs (PCIB)

Revised estimated cost at completion (EAC_{re})

Schedule variance (SV)

Scheduling performance index (SPI)

Scope creep

To complete performance index (TCPI)

Tracking Gantt

Variance at completion (VAC)

Any Questions!