Earned Value Management: A Practical Approach

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Washington, DC - USA

Agenda

- Introduction/Intent
- Historical Background/Basis
- Key EVM Data Elements/Metrics
- Where Does Earned Value Come From?
- Developing a Sound Baseline
- A Mini-Case Study
- Revisions and Change Control
- Questions and Answers (time-dependent)

Speaker Introduction

- Currently
  - Director of Project Controls, Strategic Management Solutions, LLC (SMSI)
  - Past President of Orange County Post of Society of American Military Engineers (SAME)
- Formerly
  - President of AACE International
  - EVM Practice Manager over past several years (MSLLC, PT&C, SM&A)
  - Vice President of Project Controls for Parsons Government Group
  - Sr. Cost Engineer/Scheduler at various major EPC contractors

Workshop Intent

- Understand definition of earned value (EV), earned value management (EVM), and earned value management systems (EVMS)
- Understand how above terms have historically been applied in support of projects/programs
- Understand differences in application of these terms between government and commercial projects/programs
- Understand recommended practices relating to the use of EVM in support of different types of projects/programs

Historical
Background and Basis

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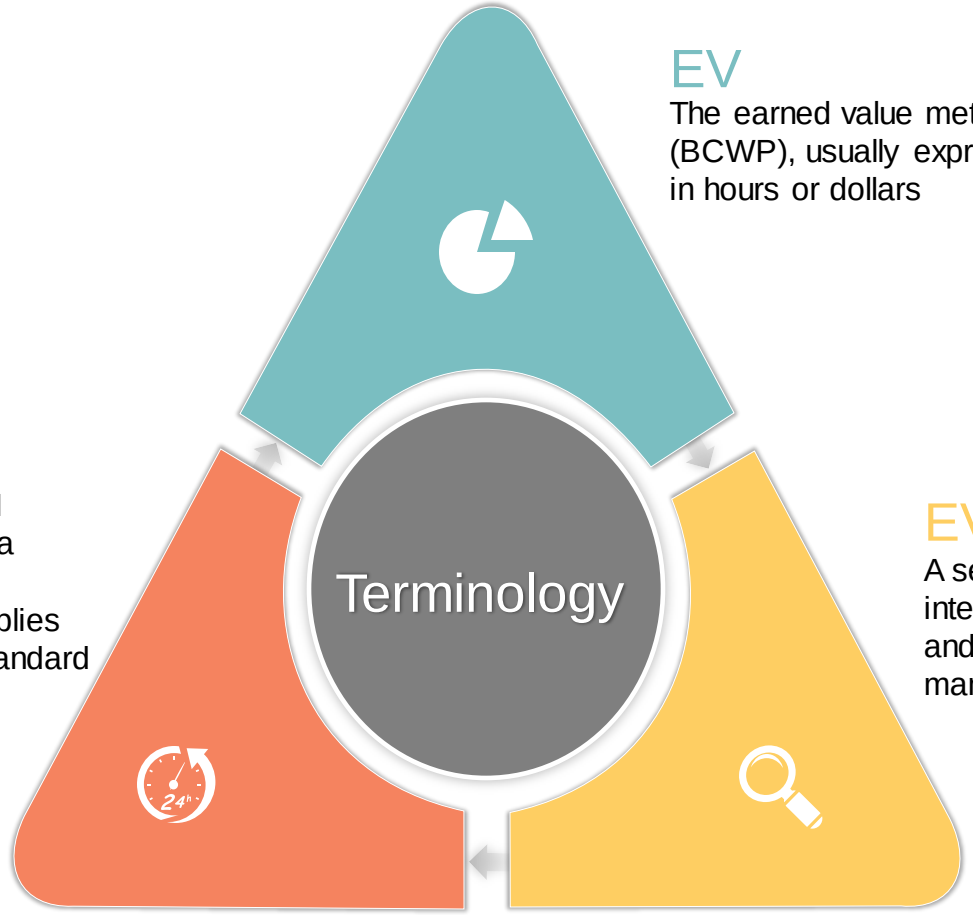
A Three-tiered Approach



EV

The earned value metric (BCWP), usually expressed in hours or dollars

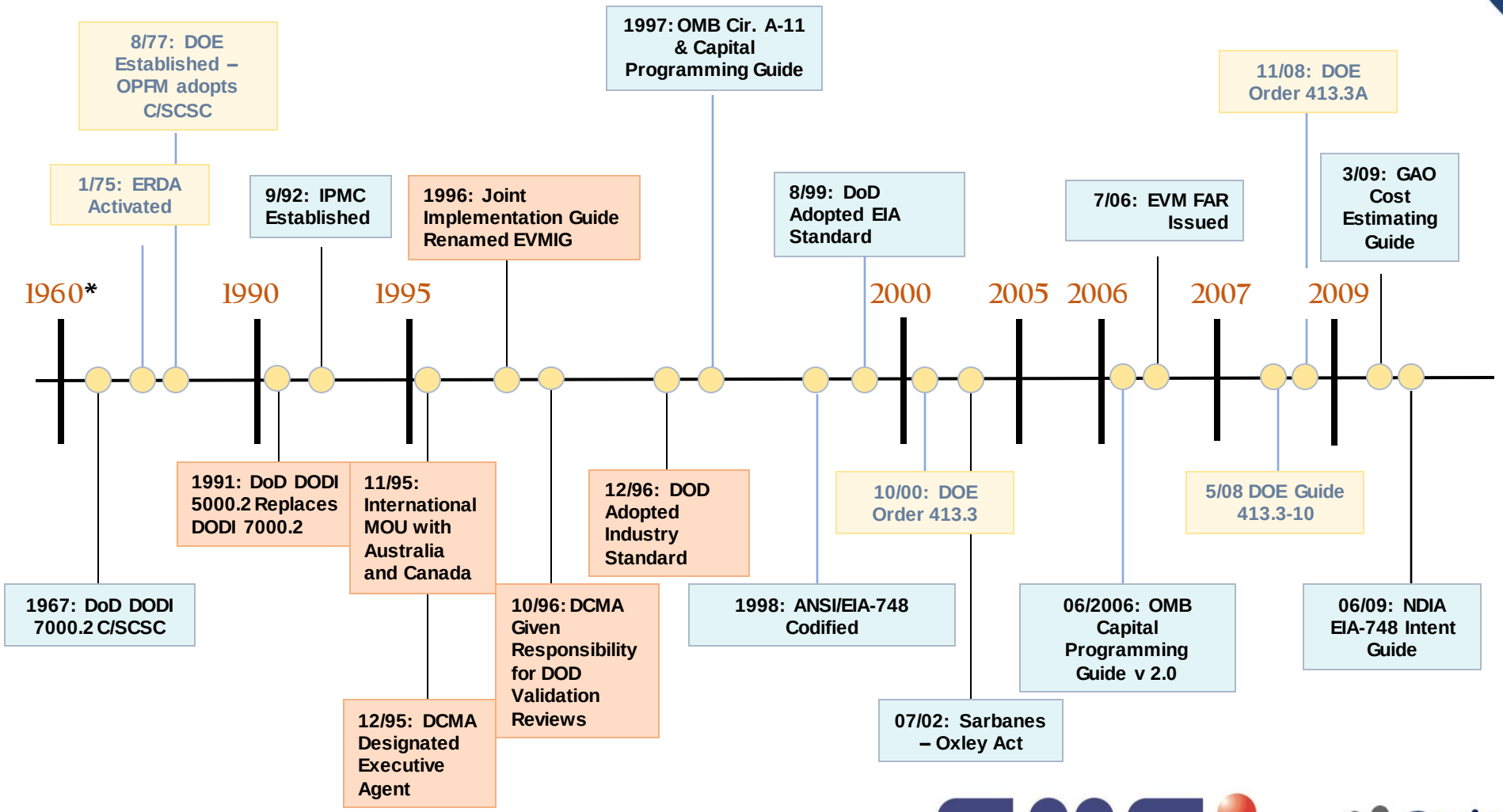
EVMS

A comprehensive EVM system, usually within a federal contracting environment, that complies with the EIA 748(D) Standard

EVM

A set of processes that integrates scope, schedule, and cost to more effectively manage a project/program

The Evolution of EVM/EVMS



* Pre 1960: Various Management Systems

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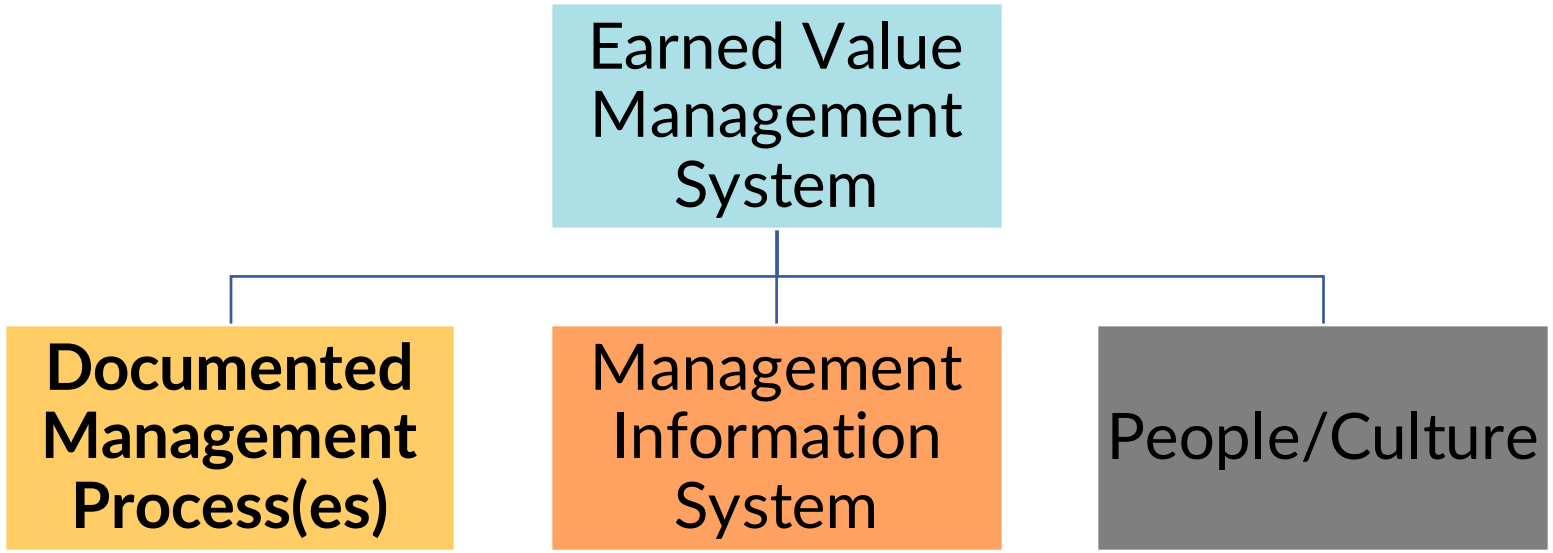
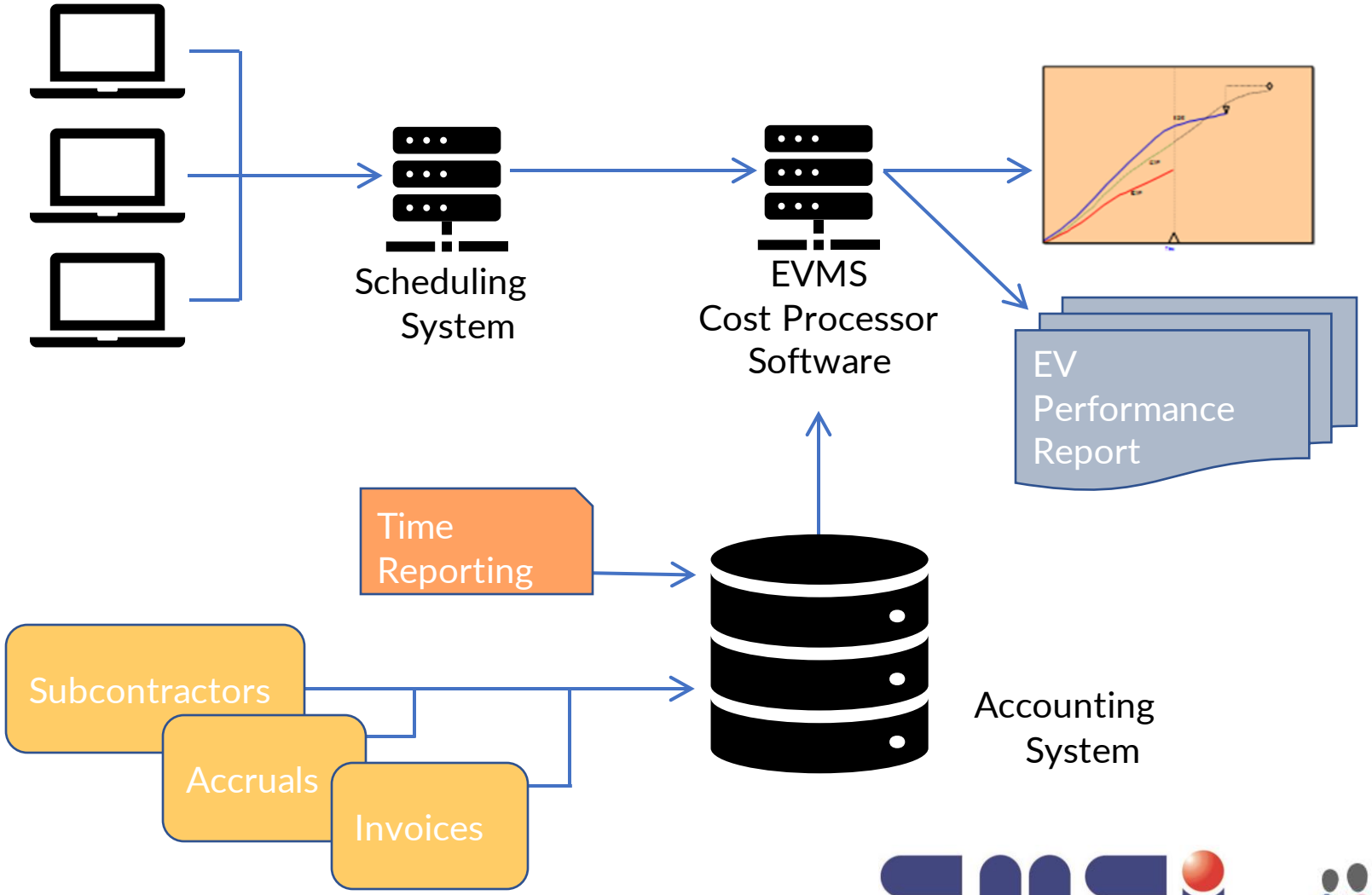
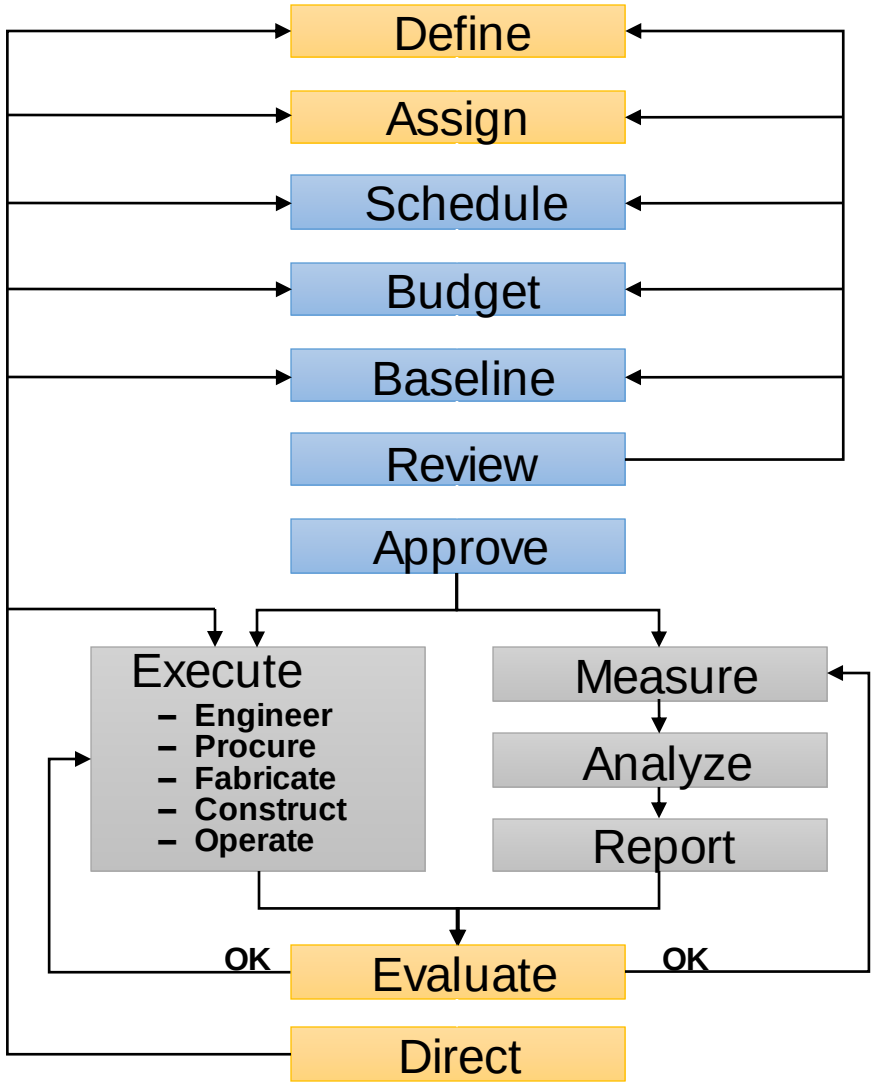
Components of an EVMS



Notional EVMS Management Information System



The EVM Process



- Break down project work scope into finite pieces

- Plan all work scope
- Integrate project work scope, schedule and cost objectives

- Objectively assess accomplishments
- Use actual costs incurred
- Analyze variances

- Control changes to baseline
- **Use information**

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The EIA*-748(D) EVMS “Standard”

- 32 “Guidelines”** organized in five functional areas
  - Organization (7)
  - Planning, Scheduling, & Budgeting (8)
  - Accounting Considerations (6)
  - Analysis & Management Reports (6)
  - Revisions and Data Maintenance (5)

- * Recently changed from ANSI/EIA
- ** Changed from “Criteria” to make standard less proscriptive in nature

[Government] Contracting 101: Who owns the risk?

- Current DoD Policy requires an EVMS that complies with the EIA-748 Standard to be used on cost reimbursable contracts $20 million or more in value
  - Validated (by DCMA) as compliant if $100 million or more

Why?

[Government] Contracting 101: Who owns the risk?

- Contract Type ≈ Risk Ownership
  - High Risk Contracts (from USG's perspective)
    - Cost [Reimbursable]
      - Scope usually not well defined
      - "Best Efforts" contract
      - Cost and performance risk resides with Owner
  - Low Risk Contracts (from USG's perspective)
    - Firm Fixed Price (FFP)
      - Contractor obligated to complete scope of work for lump sum price stated in contract
      - Performance and cost risk "transferred" to contractor

[Government] Contracting 101: Who owns the risk?

- Many Engineering, Procurement, and Construction (EPC) contractors use EVM to manage their own risk
  - Bechtel
  - Fluor
  - Jacobs
  - Kiewit
  - Parsons
- EPC ≈ high % of self-performed work = higher risk
  - Contract types are usually FFP
  - Systems utilized typically not “fully” compliant with EIA 748

Key EVM Data Elements and Metrics

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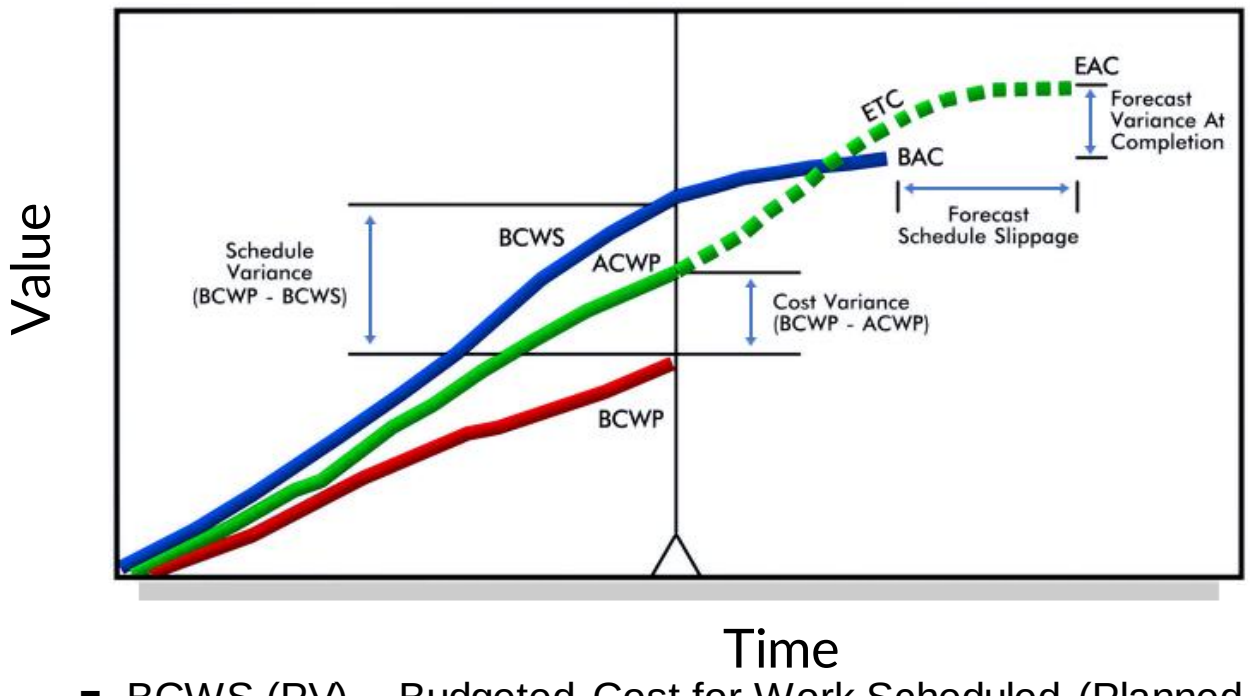
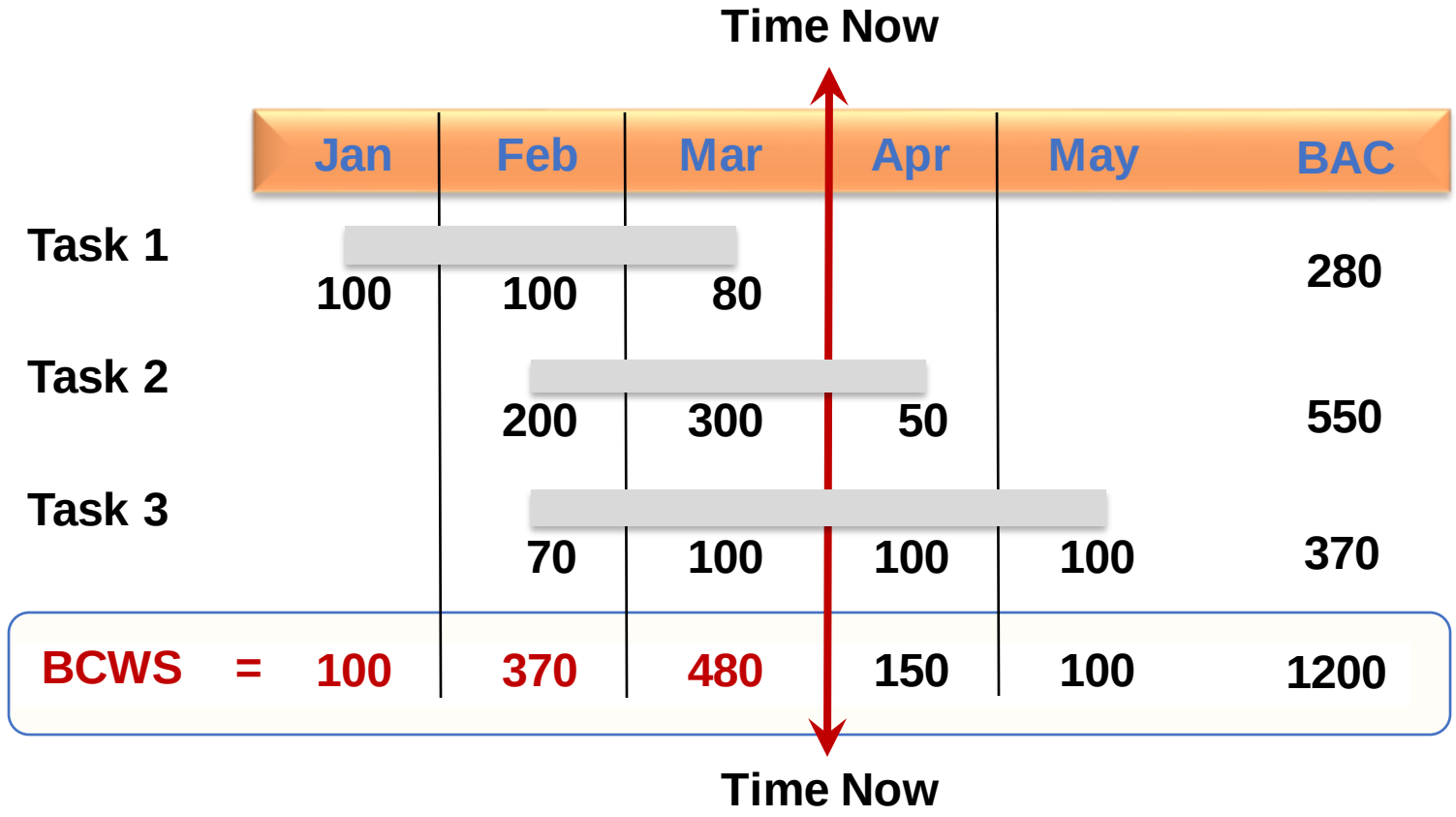


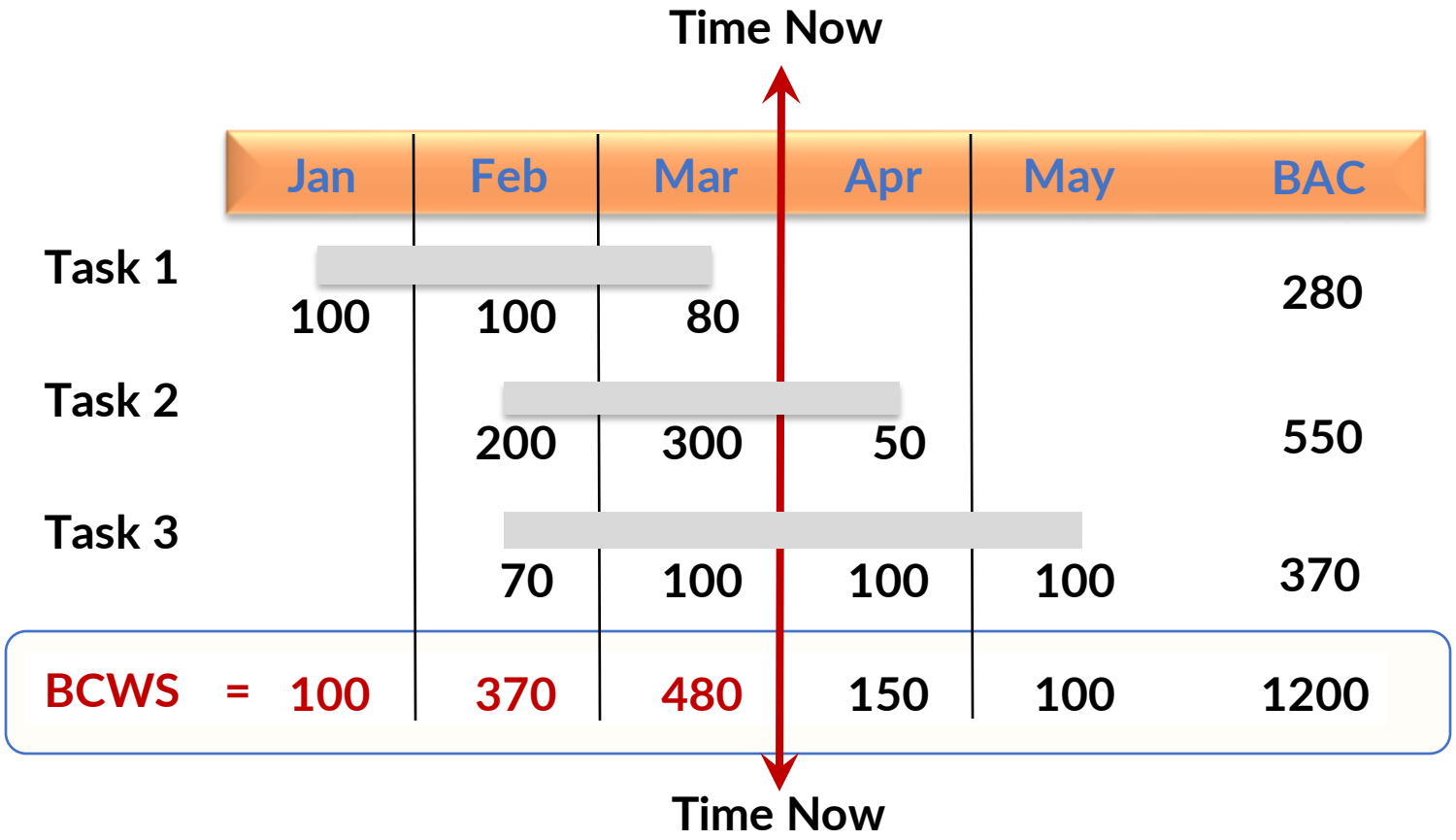
- BCWS (PV) – Budgeted Cost for Work Scheduled (Planned Value)
- BCWP (EV) – Budgeted Cost for Work Performed (Earned Value)
- ACWP (AC) – Actual Cost of Work Performed (Actual Cost)
- BAC – Budget at Completion
- EAC – Estimate at Completion
- ETC – Estimate to Completion
- CV and SV – Cost and Schedule Variances
- CPI and SPI – Cost and Schedule Indices
- VAC – Variance at Complete

BCWS (PV): The Time-Phased Budget Plan



Cum BCWS = 950

ACWP (AC): What's Been Spent



ACWP = 800
BCWS = 950

Spending Variance + 150

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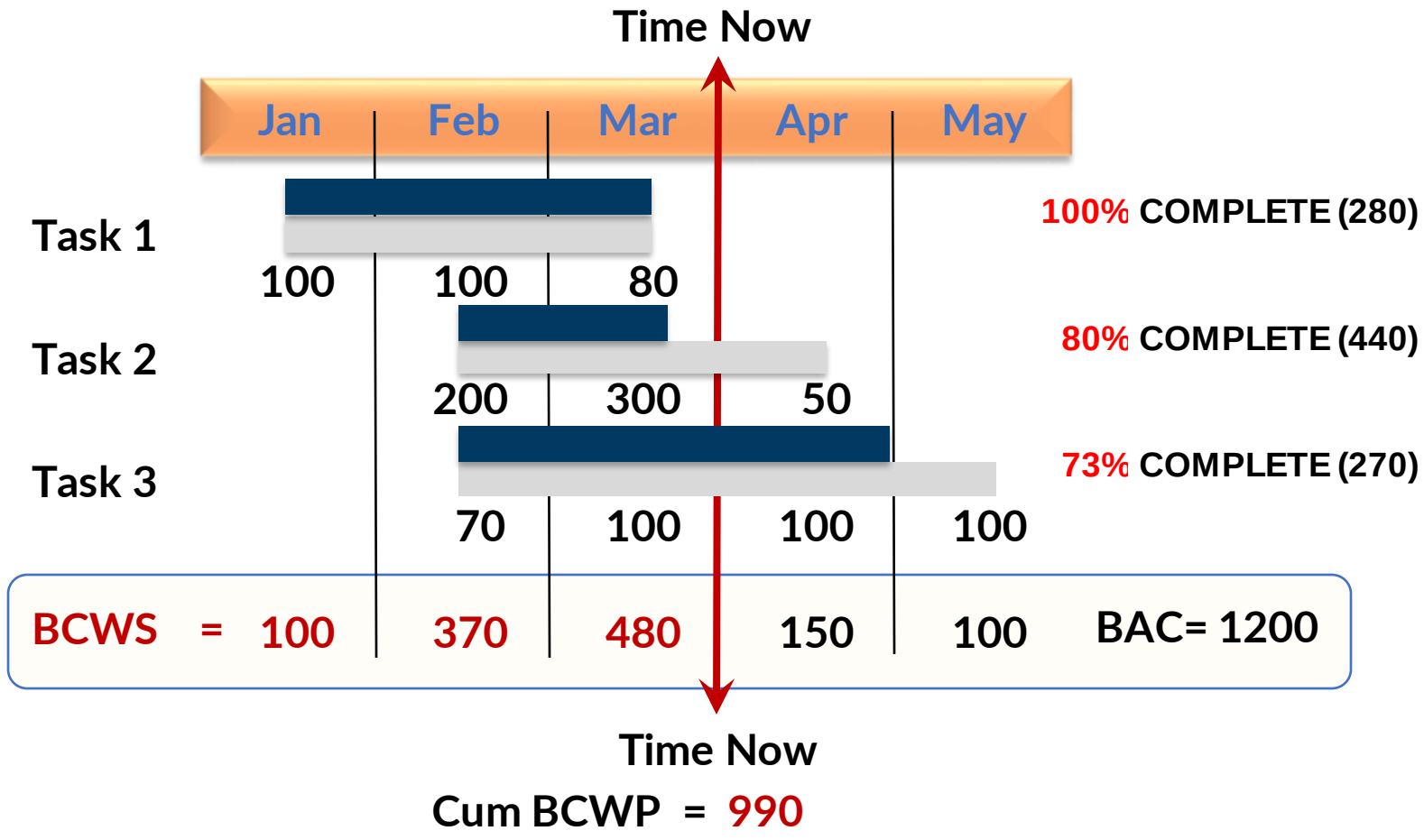
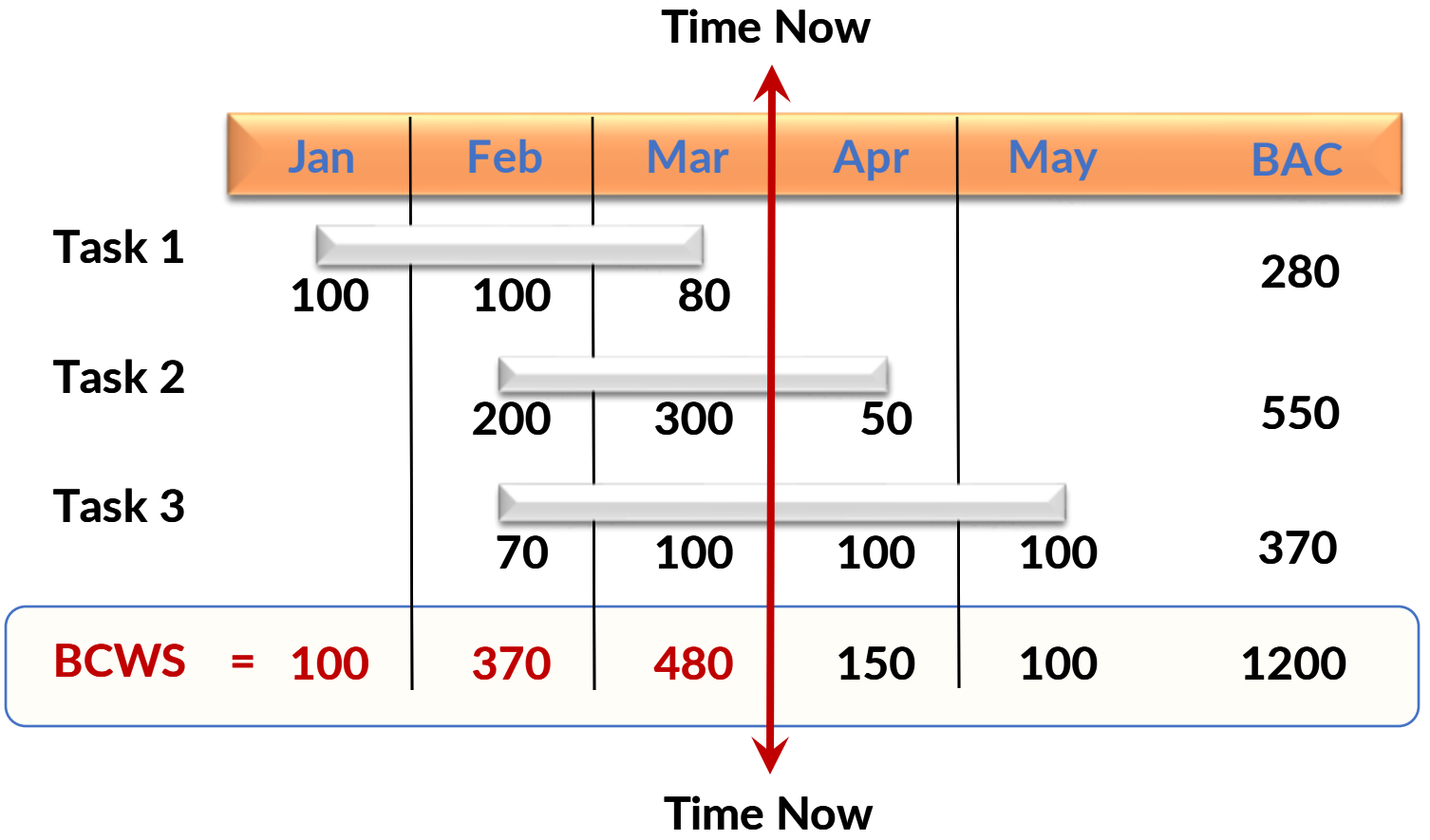
BCWP (EV): Budget for the Work Completed



Calculating Schedule and Cost Variances



SV = BCWP - BCWS
= 990 – 950 = + 40

CV = BCWP- ACWP
= 990 – 800 = + 190

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Key Data Comparisons

950	BCWS	Schedule Variance (SV)
990	BCWP	
800	ACWP	Cost Variance (CV)
210	BCWR	(BAC – BCWP)
1200	BAC	Variance At Completion (VAC)
?	EAC	

Earned Value:
Where Does it Come From?

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The Earned Value Metric

- COMPLETED TASKS
  - Budget target
- IN-PROCESS TASKS
  - Estimate of budget for completed portion
  - Important to use logical technique

or…

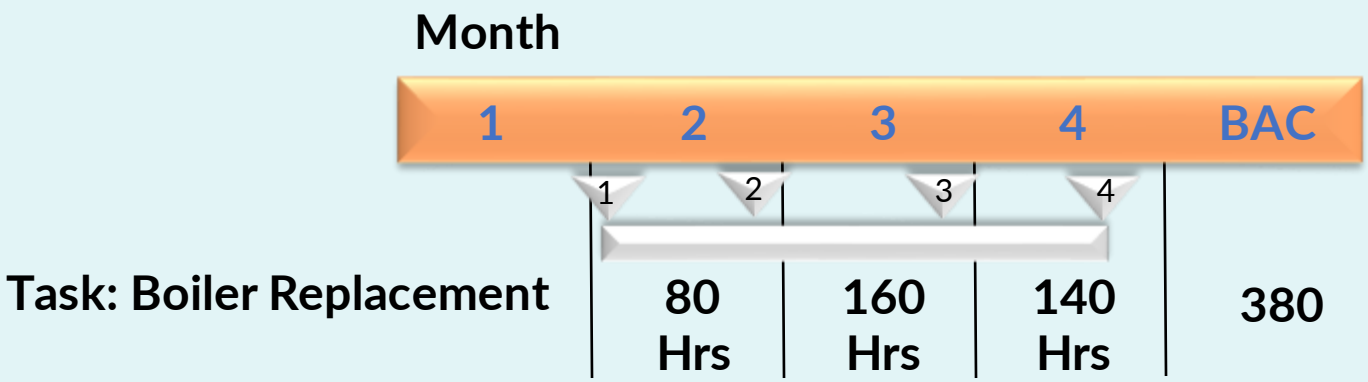
The budget associated with work accomplished!

Progress Measurement Techniques (Documented Rules of Performance)

- Discrete Effort
  - Valued Milestones
    - 0/100
    - 50/50
    - Weighted Milestone
  - Management Assessment
    - Units Completed
    - Equivalent Units
    - Percent Complete
  - Standard Hours
- Apportioned Effort
- **Level of Effort**

Milestone Technique

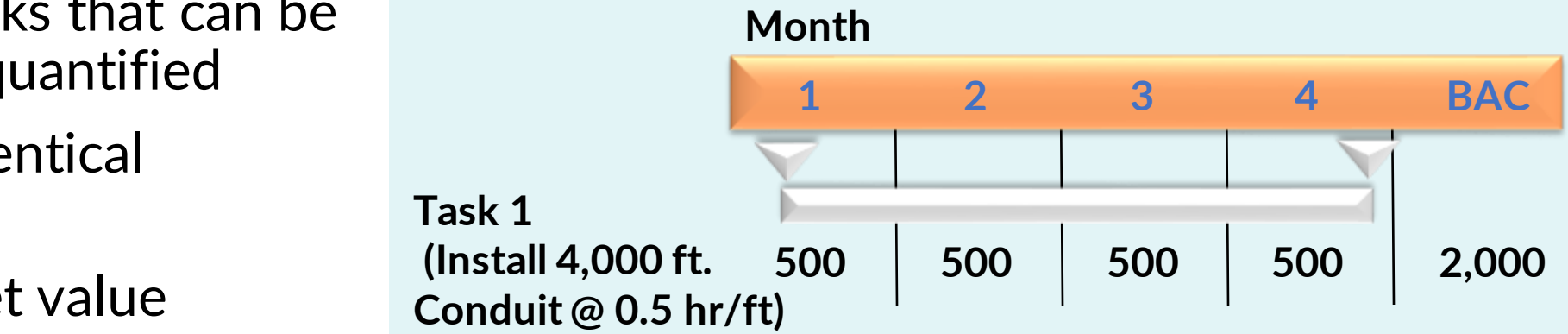
- Used for longer tasks
- Ideally should have milestone each month
- Milestones should be weighted based on budgeted resources
- Basis for “Steps” function in P6



M/S#	Description	Weight	%
1	Notice to Proceed	0	0
2	Boilers 1 & 2 Removed	80 Hrs	21
3	Complete Asbestos Abatement	160 Hrs	42
4	Install and Test Replacements	140 Hrs	37

Units Completed

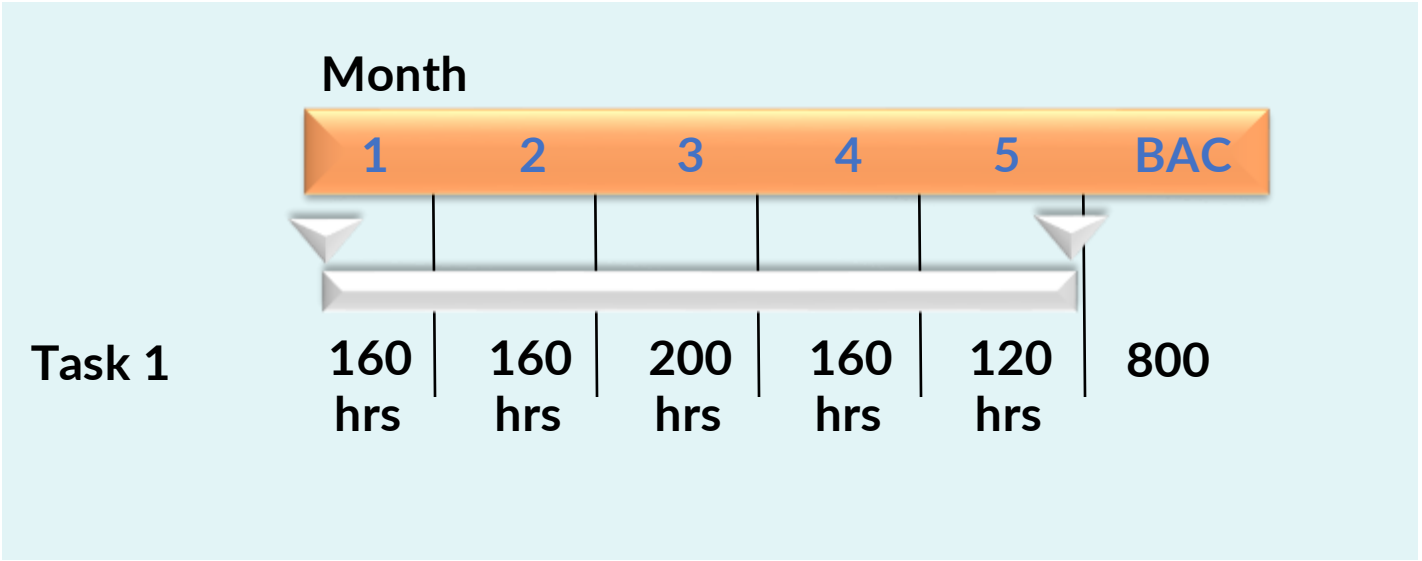
- Used for tasks that can be effectively quantified
- Units are identical or similar
- Same budget value for each unit
- BCWS = Planned Qty x Unit value
- BCWP = Actual Qty completed x Unit value



*Avoid Negative BCWP

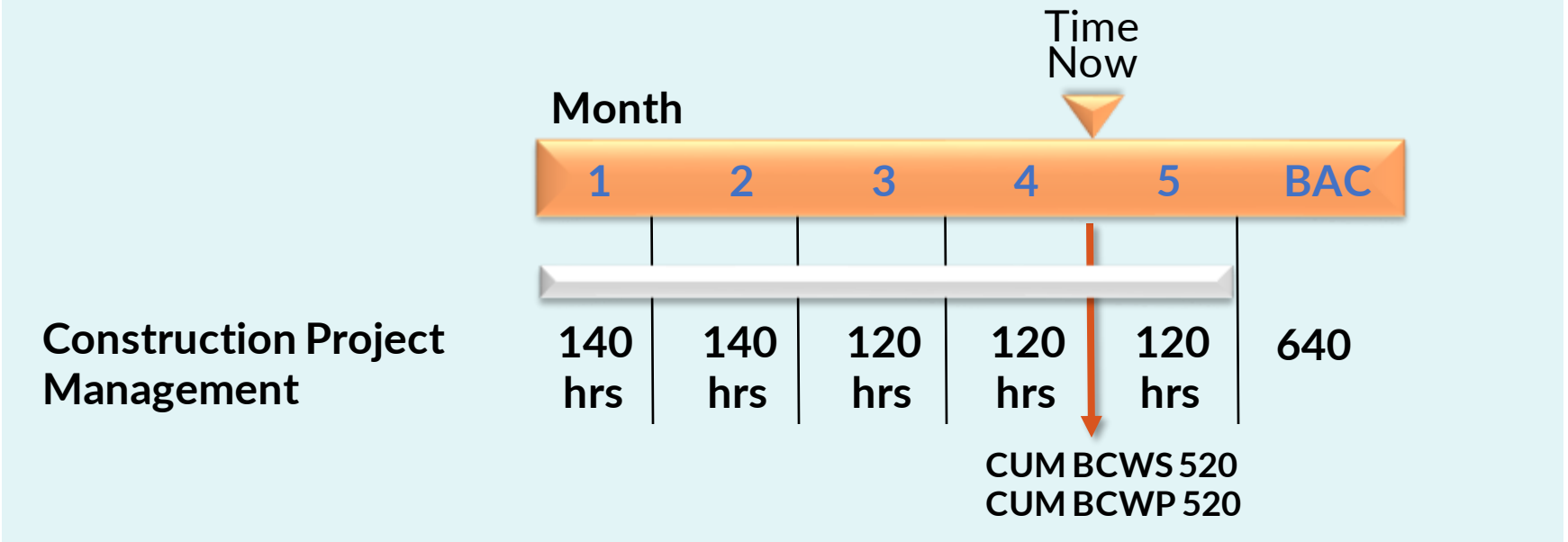
Percent Complete

- Used only when no interim milestones possible
- Based on schedule update or individual's assessment of percent complete of total work to be performed (formerly called "Supervisor Opinion")
- Should be as objective as possible (resource-loading)
- Least desirable method (as it can be distorted)



Level of Effort (LOE)

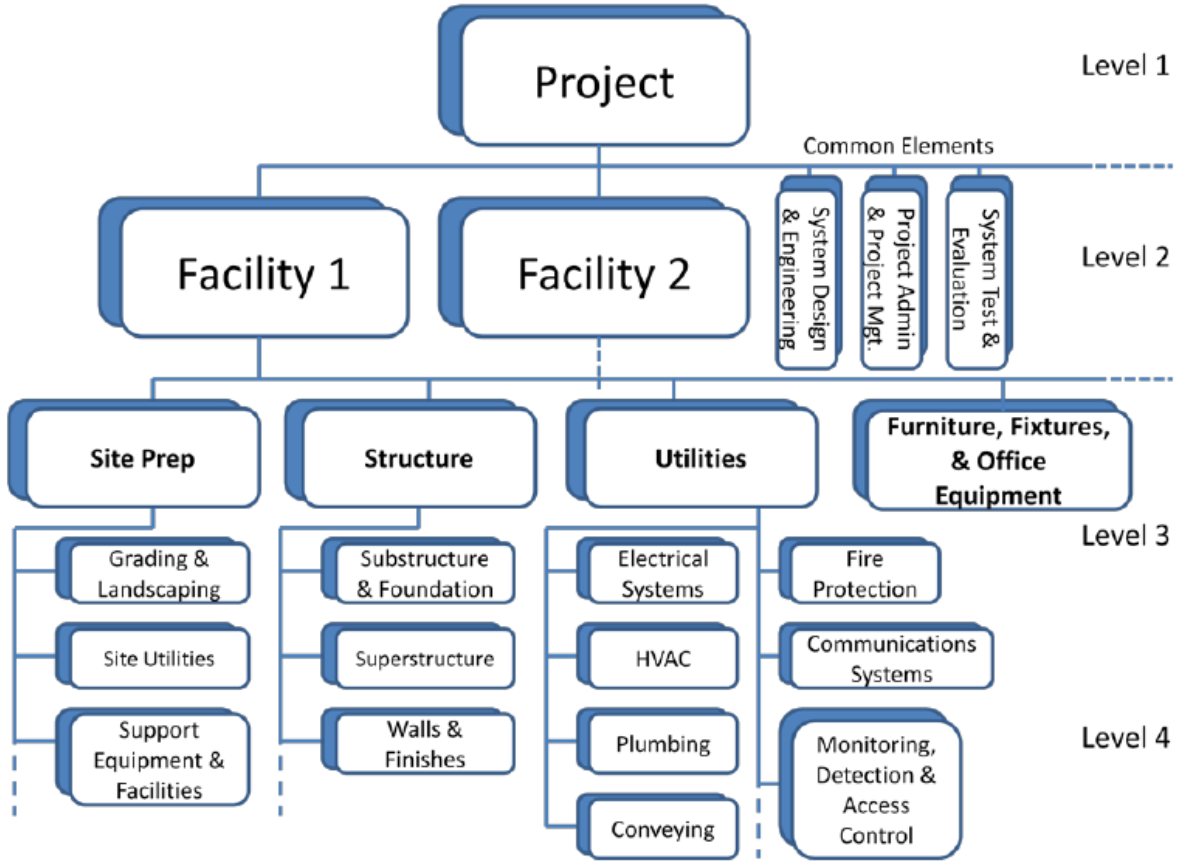
- Support type effort
- No product or accomplishment criterion
- Based on passage of time
- BCWP = BCWS
- No schedule variance (often omitted from schedule as a result)
- Positive cost variance indicates what?



Developing a Sound Baseline

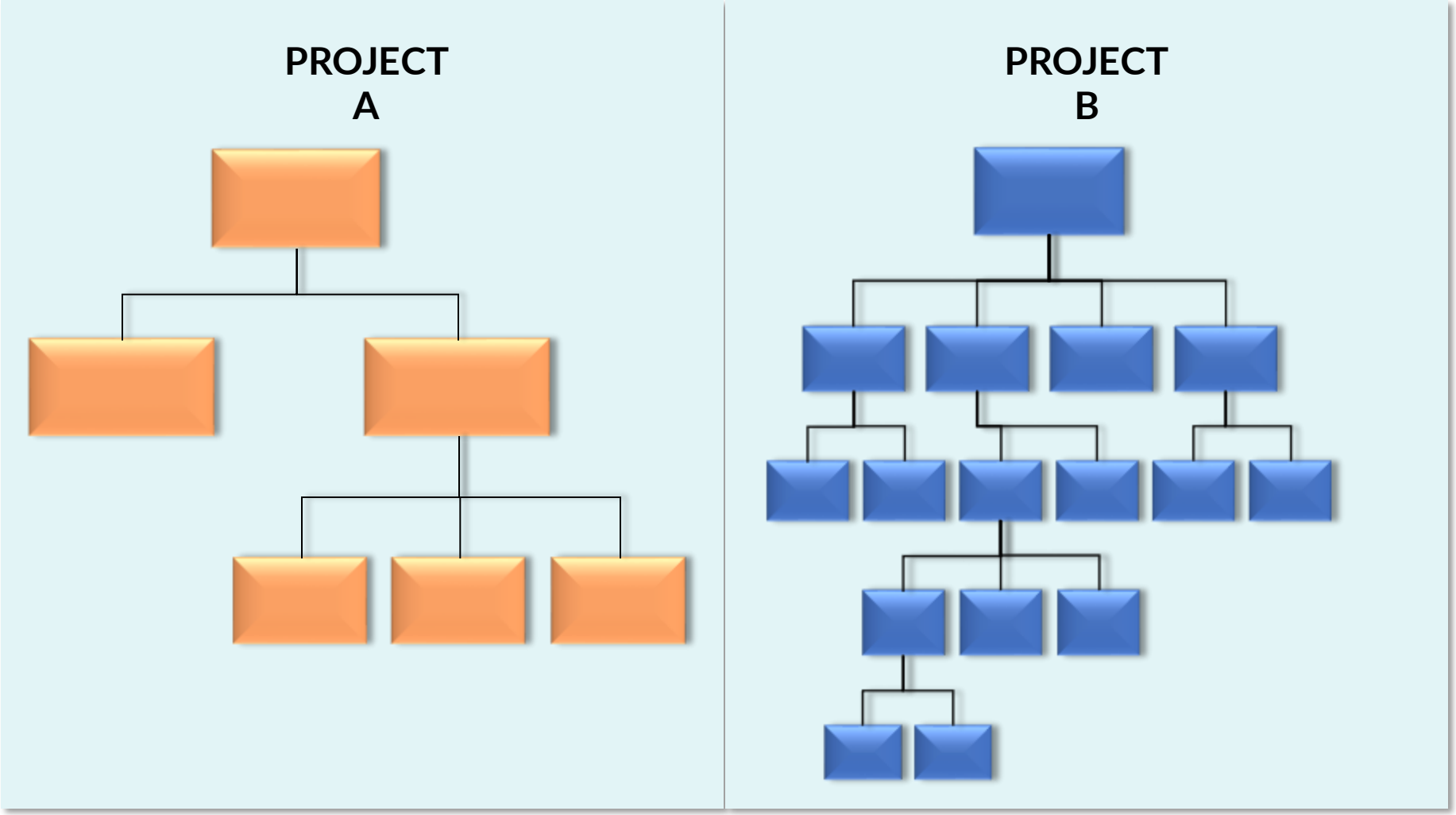
Work Breakdown Structure (WBS)

- A “product-oriented” family of hardware, software, services, and other elements which collectively represent total scope of project/program
- Amount of sub-element definition should be related to risk/complexity



It completely defines the project…

Project-Specific WBS Examples



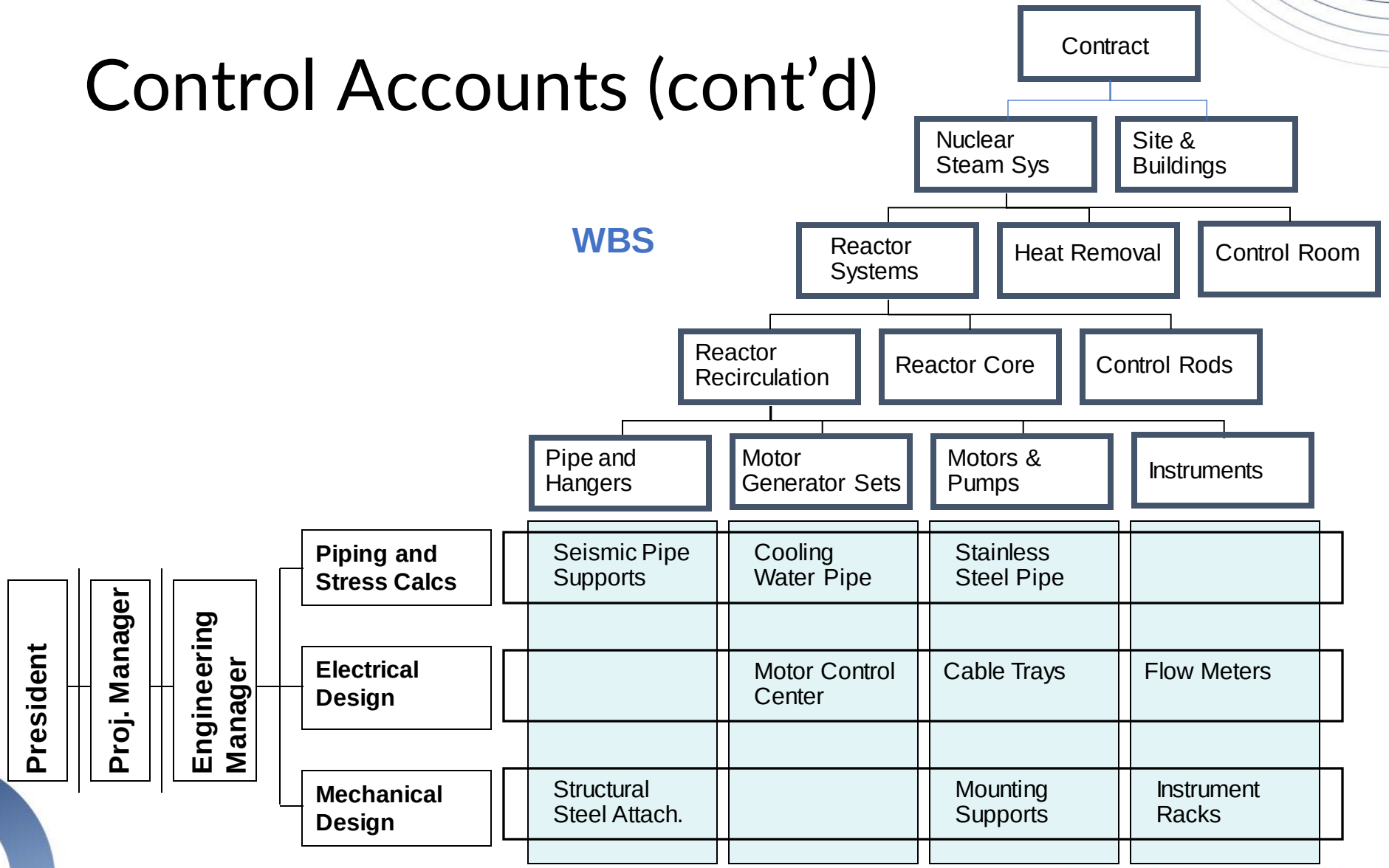
WBS Standards

- Ideally product (or deliverable)-oriented
  - Can also incorporate project phasing (e.g. design and build)
- Reflects ALL work scope associated with project
  - Even far-term effort not planned in detail
- Clearly identifies every element as to content
  - Distinguishes from all other elements
- Correlates every element to statement of work
- Provides necessary framework to identify effort to performing organization(s)
- Detailed enough to support effective management

Control Accounts

A key management control point established where the OBS intersects with the WBS

Control Accounts (cont'd)



Organizational Breakdown Structure (OBS)

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Control Accounts (cont'd)

The Key Management Control Point for…

- Management responsibility
- Work planning, assignment, and constraints
- Cost element delineation (labor, material, equipment, subs, ODCs)
- Cost collection
- Variance calculation
- Variance analysis
- Corrective action
- Data summarization - WBS/functional

Control Accounts (cont'd)

- Characteristics
  - Represent natural decomposition of WBS
    - Designed to support responsibility assignment and accountability for cost, schedule, and technical performance
  - Assigned to only one responsible manager ("CAM" or similar)
    - CAM may rely on one or more organizations to execute CA work
  - Detailed plans should be established and documented ("CAP" or similar)

The Role of the “CAM” vs. Project Controls

- Who is the CAM?
  - The key role within a compliant EVMS environment
  - A technically qualified staff member, chartered to use EVM information to make decisions regarding CA work execution
    - First line supervisor, cognizant engineer, second line manager
- Who are Project Controls?
  - Responsible to Project Manager for ensuring EVMS provides valid, timely, and accurate information
    - Facilitators of entire EVMS process
  - Support CAMs’ planning, scheduling and reporting needs

Work Packages

- A Work Package (WP) is a natural subdivision of work within a control account
  - A task or grouping of work items
  - Represented by one or more activities in detailed CA schedule
  - Has scope of work with time-phased resources
  - Has method for assessment of accomplishments while in process
    - Earned value techniques discussed previously

Earned value is typically calculated at the work package level, while variances are assessed at the control account level

Typical Work Packages

Engineering

- Design drawing package
- Develop quality plan
- Fire protection design basis
- Conduct design review
- Develop computer simulation

Construction

- Construct concrete wall
- Place concrete slab, Area 31
- Install 3" pipe, Area 2c
- Install stack liner
- Test instrumentation equipment

Performance Measurement Baseline (PMB) Concept

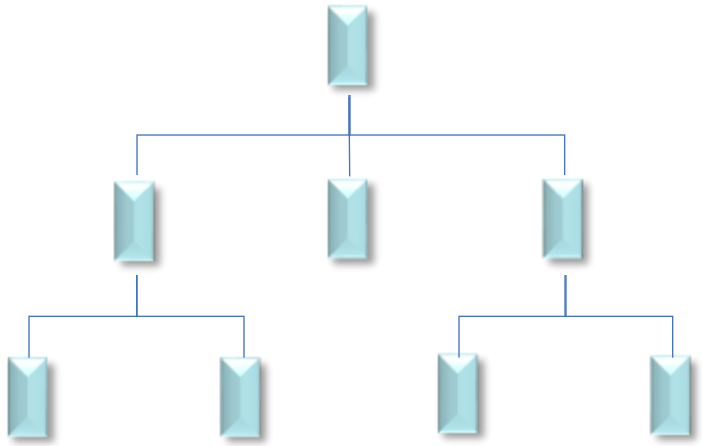
- There is a single, integrated baseline
- The baseline represents “time-phased” resource plan for work to meet contractual milestones
- Baseline and current work plan normally [slightly] different
- Baseline altered only through formal change control process

Top Down Planning and Budgeting

Scope

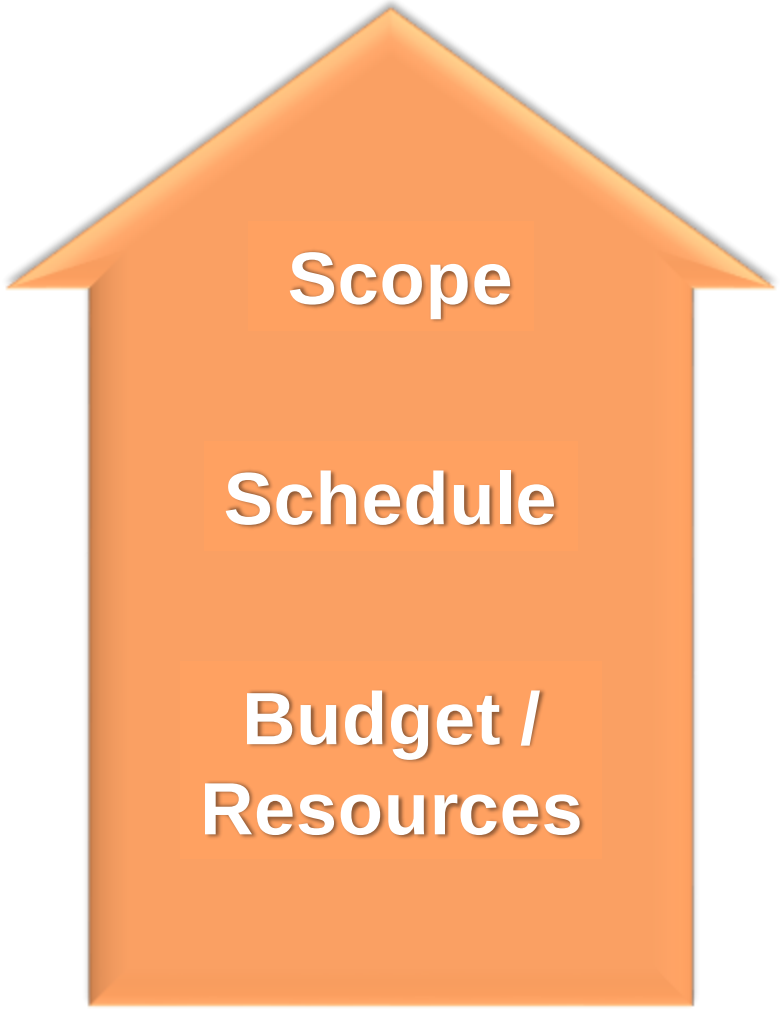
Schedule

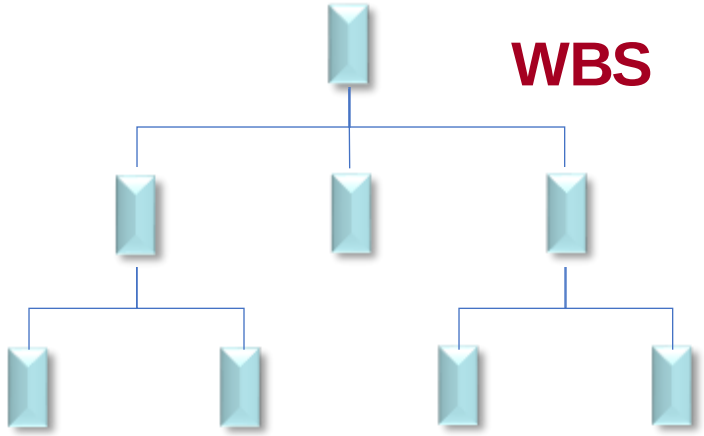
Budget / Resources

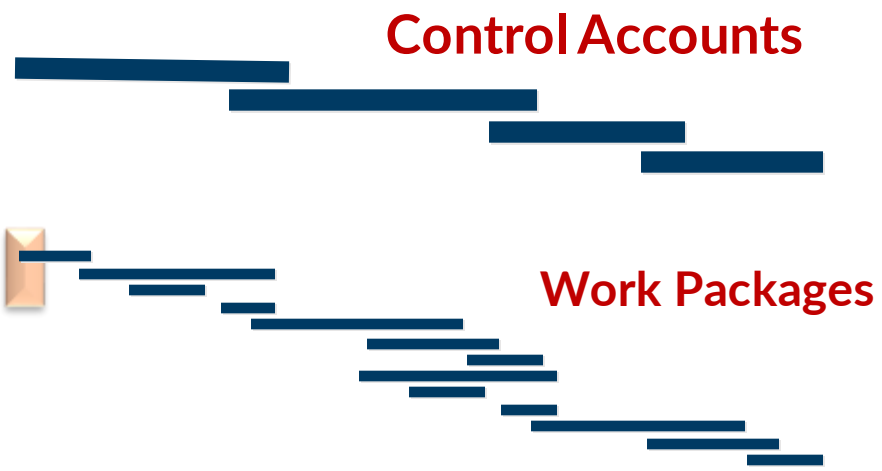


WBS

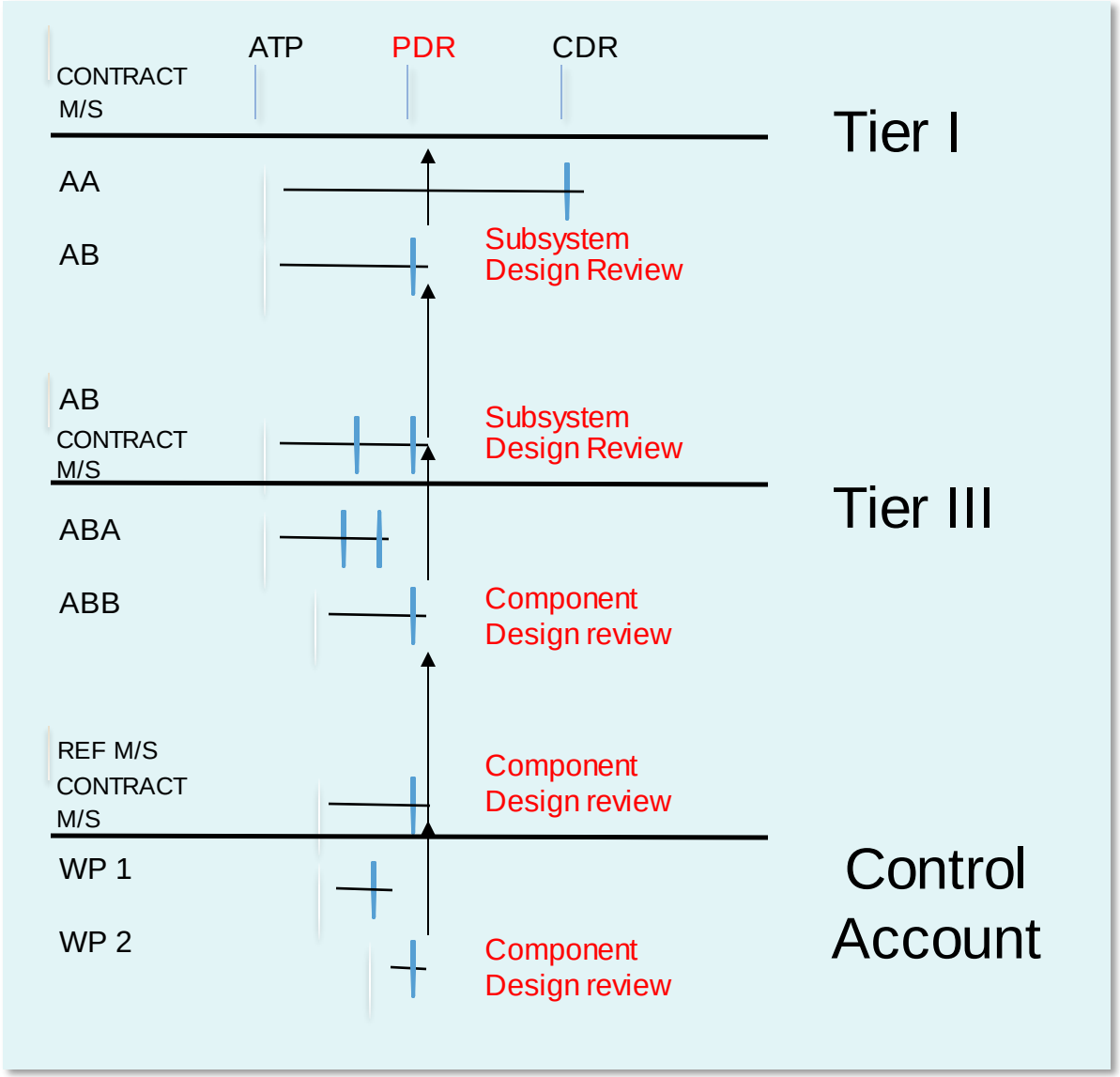
Bottom-up Planning and Budgeting





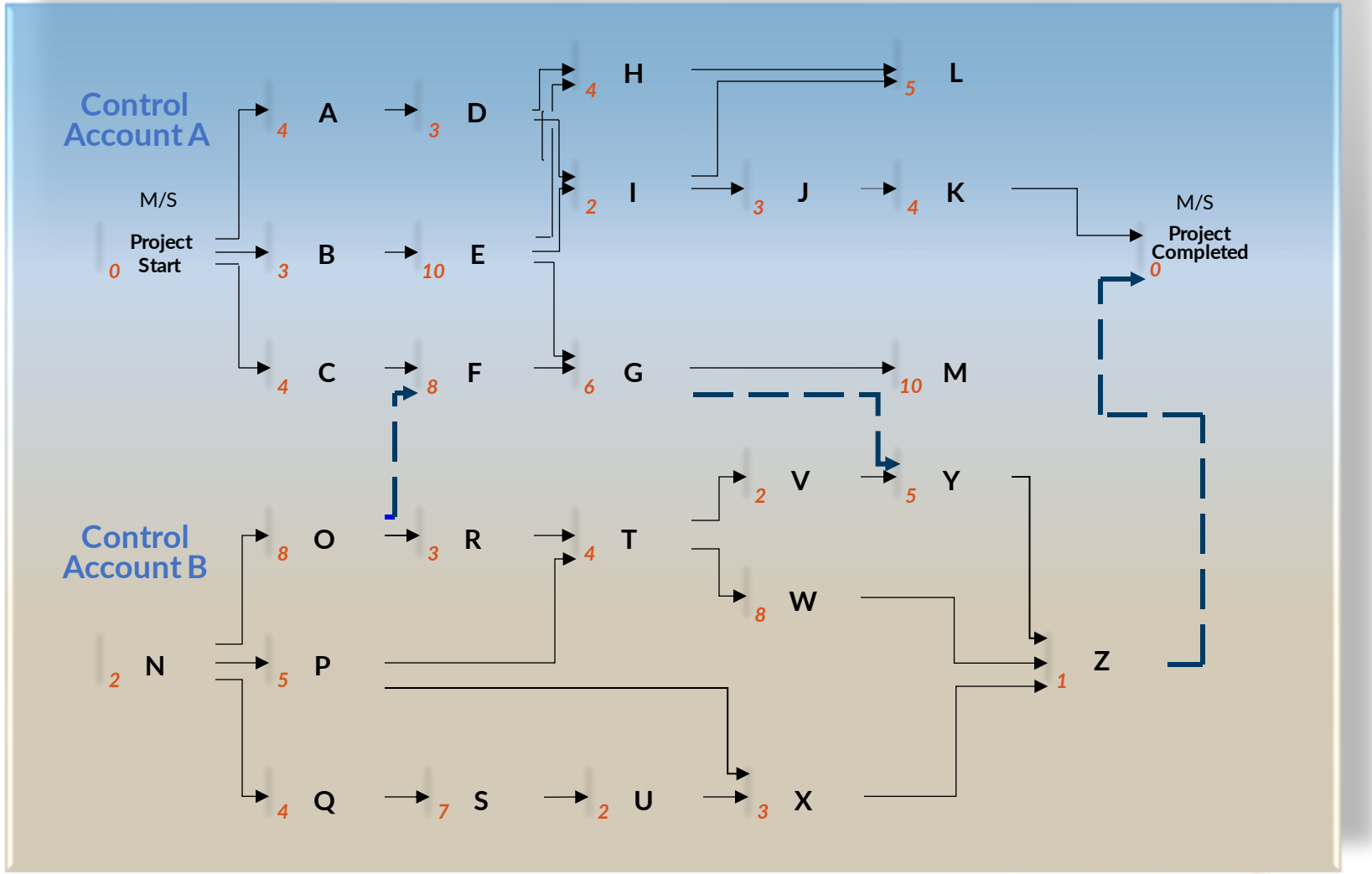


Scheduling Considerations: Vertical Traceability



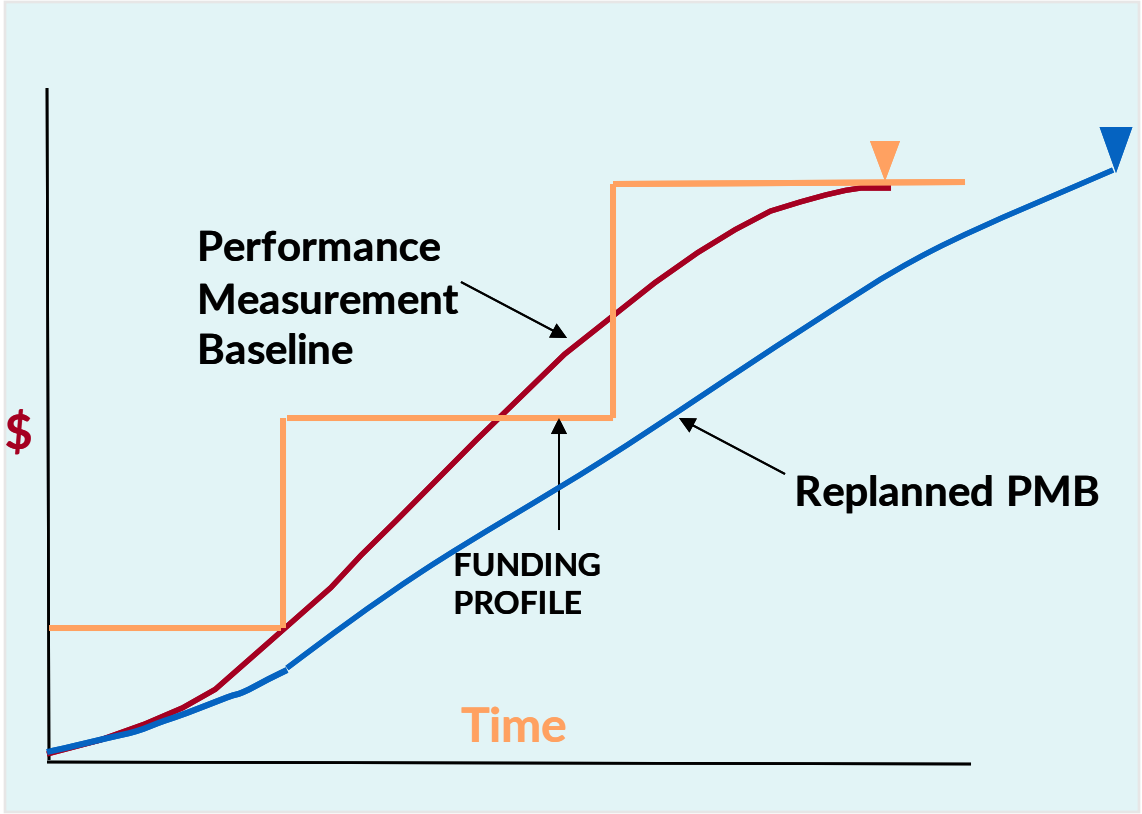
Consistency Between Different Levels of Detail

Scheduling Considerations: Horizontal Traceability



Budget vs. Funds

- Budget: Management-sanctioned estimate for total task phased over baseline schedule; basis for EVM-based performance measurement
- Funds: Current estimate of total dollar requirements, often-times phased by distribution period (“incremental funding”)



Performance Assessment and Forecasting

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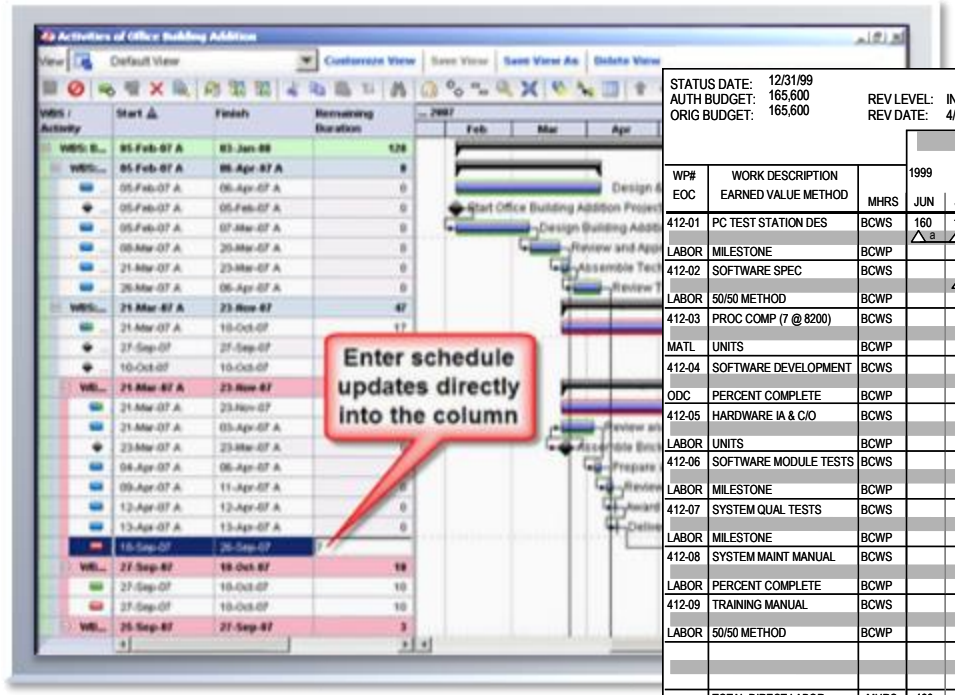
Measuring Progress

- Status activities in schedule
- Calculate/record earned value at WP (activity) level
- Summarize to CA level



CONTROL ACCOUNT PLAN

PAGE: 1 OF 1

STATUS DATE: 12/31/99
AUTH BUDGET: 165,600
ORIG BUDGET: 165,600

REV LEVEL: INIT.
REV DATE: 4/1/99

CTRL ACCT TITLE: PC TEST STATION
CTRL ACCT MGR: WILL SPENDUM

WBS: 4.1.2
DEPT: 43

TIME-PHASED CONTROL ACCOUNT PLAN

WP# / EOC	WORK DESCRIPTION / EARNED VALUE METHOD	MHRS	1999 JUN	JUL	AUG	SEP	OCT	NOV	DEC	2000 JAN	FEB	MAR	APR	MAY	PAGE TOTAL
412-01	PC TEST STATION DES	BCWS	160 a	160 b	160 c	160 d									640
LABOR	MILESTONE	BCWP													
412-02	SOFTWARE SPEC	BCWS		160 e	160 f										320
LABOR	50/50 METHOD	BCWP													
412-03	PROC COMP (7 @ 8200)	BCWS					8200 (1)	24600 (3)	24600 (3)						57400
MATL	UNITS	BCWP													
412-04	SOFTWARE DEVELOPMENT	BCWS				9680	9680	9680							29040
ODC	PERCENT COMPLETE	BCWP													
412-05	HARDWARE IA & C/O	BCWS					40 (1)	120 (3)	120 (3)						280
LABOR	UNITS	BCWP													
412-06	SOFTWARE MODULE TESTS	BCWS								320 g	320 h	320 i			960
LABOR	MILESTONE	BCWP													
412-07	SYSTEM QUAL TESTS	BCWS										320 j	320 k	320 l	960
LABOR	MILESTONE	BCWP													
412-08	SYSTEM MAINT MANUAL	BCWS								160	160	160			480
LABOR	PERCENT COMPLETE	BCWP													
412-09	TRAINING MANUAL	BCWS											160	160	320
LABOR	50/50 METHOD	BCWP													
CTRL ACCT PLAN DATA	TOTAL DIRECT LABOR	MHRS	160	320	320	160	40	120	120	480	480	800	480	480	3960
	RATE: $20.00/HR	K$	3.2	6.4	6.4	3.2	0.8	2.4	2.4	9.6	9.6	16.0	9.6	9.6	79.2
	TOTAL MATERIAL	K$	0.0	0.0	0.0	0.0	8.2	24.6	24.6	0.0	0.0	0.0	0.0	0.0	57.4
	TOTAL OTHER COSTS	K$	0.0	0.0	0.0	9.7	9.7	9.7	0.0	0.0	0.0	0.0	0.0	0.0	29.0
	CTRL ACCT MO. TOTAL	K$	3.2	6.4	6.4	12.9	18.7	36.7	27.0	9.6	9.6	16.0	9.6	9.6	165.6
	CTRL ACCT CUM TOTAL	K$	3.2	9.6	16.0	28.9	47.6	84.2	111.2	120.8	130.4	146.4	156.0	165.6	

SCHEDULE MILESTONE LEGEND

a - TEST STA. LAYOUT DWGS
b - FACILITY INTERFACE DWGS
c - ELECTRICAL SCHEMATICS
d - RELEASE DRAWING PKG
e - SOFTWARE REQS OUTLINE
f - RELEASE SPECIFICATION
g - COMPL MODULE 1 TESTS
h - COMPL MODULE 2 TESTS
i - COMPL MODULE 3 TESTS
j - FUNCT'L TEST COMPLETE
K - SYSTEM RELIABILITY CMPLT
l - MAINTENANCE DEMO CMPLT

MILESTONE FORMATS
SCHEDULED EVENT
COMPLETED EVENT
FORECAST CHANGE
CONTROL MILESTONE

AUTHORIZING SIGNATURES
CAM:
FM:
PP&C:
PM:

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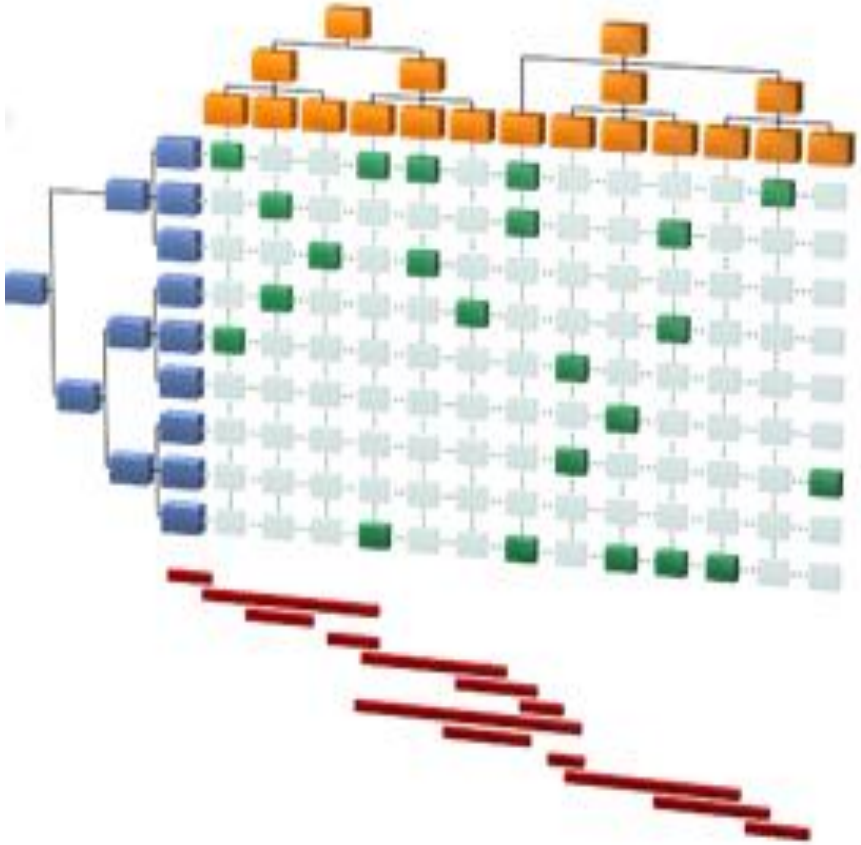
Scheduling Status Questions

- When did activity start?
- If scheduled start date has passed, when will it start?
- What is activity's physical % complete?
- When did activity finish?
- When will activity finish?
- What resources will be required to finish?

Recording Performance Information

- Schedule status and forecasts
- Work accomplished
- Actual resources and costs incurred
- Forecasts of resources and costs remaining
- Updated ETC and EAC



Variance Analysis: How To

- Analyze CV and SV separately
- Analyze Cur period and Cum period separately
- Attempt to understand root cause(s) of each variance
- Emphasize problems at WP level
- Quantify variances
- Be specific, not general

Variance Analysis: Corrective Action

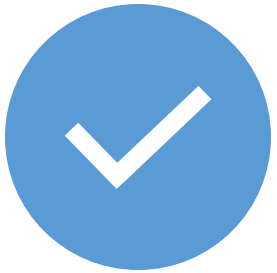
- What actions are/can/should be taken?
- Are any scarce resources needed?
- Who's responsible?
- What are the "get well" dates?
- What are the cost trade-offs?

Analysis Hints

LOOK FOR OBVIOUS ERRORS

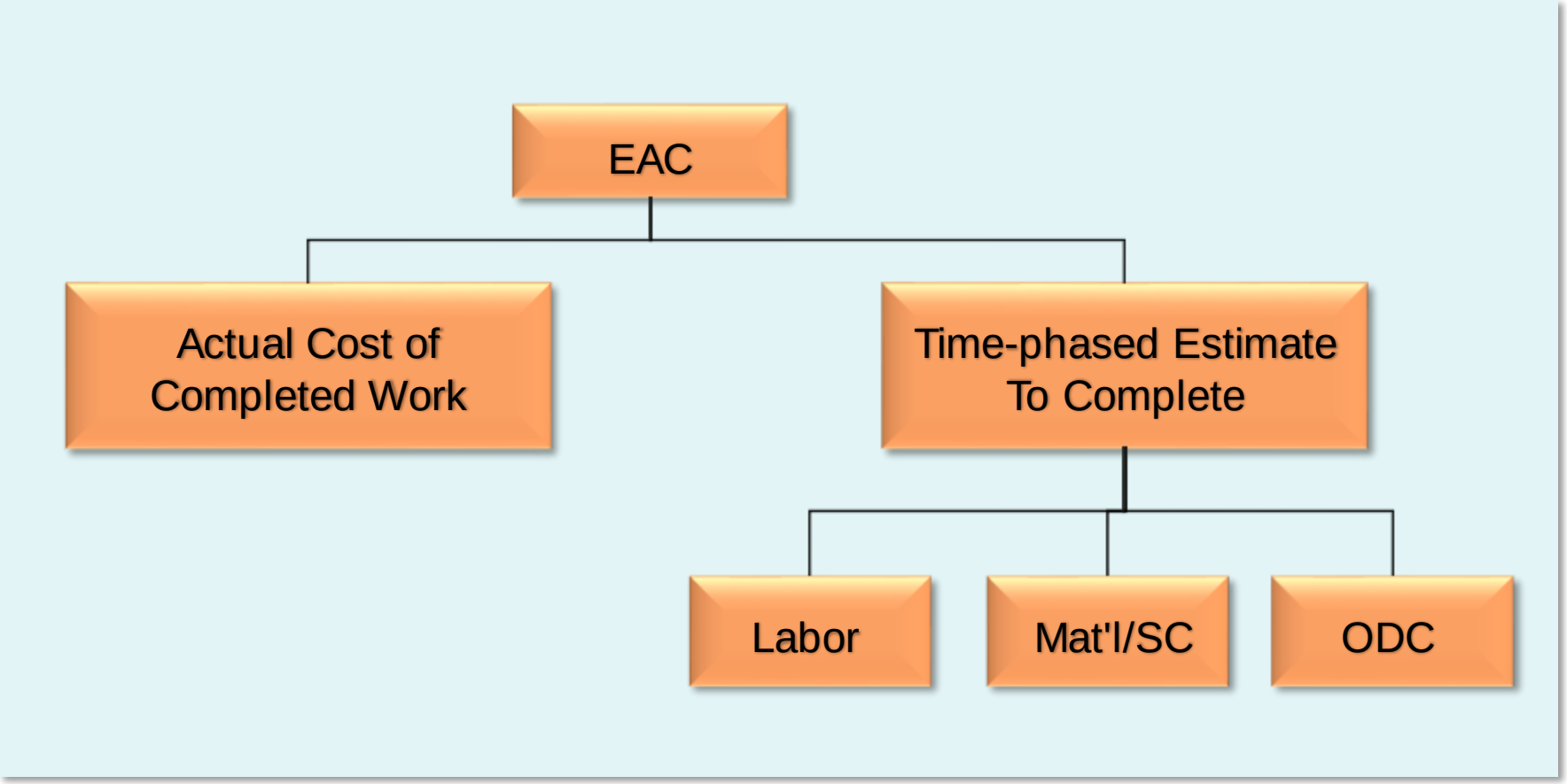
LOOK AT THE **TRENDS**

EAC COMPARISONS



COMPARE WITH OTHER AVAILABLE INFORMATION

Developing the Estimate at Completion



EAC Considerations

- Outstanding commitments?
- Accruals?
- Future resources/rates?
- Scope issues?
- Future risks?

Calculated EACs (to Assess Realism of Manager's EAC)

$$\text{IEAC}^* = \text{ACWP} + \text{Calculated ETC}$$

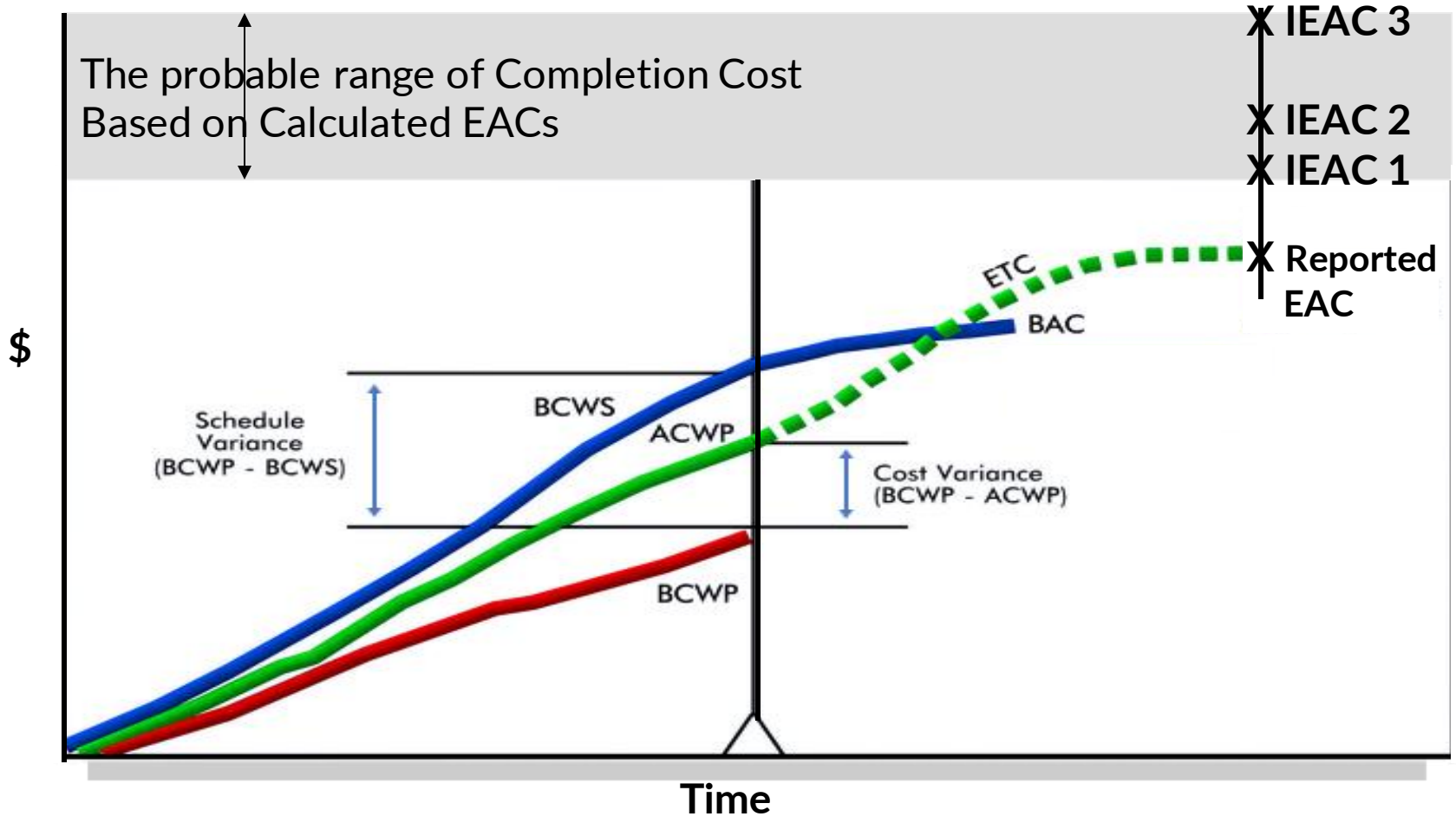
$$= \text{ACWP} + \frac{\text{BAC - BCWP}}{\text{Performance Factor}}$$

*Independent EAC

Performance Factors

- Cumulative performance
- Recent experience
- Cost and schedule performance
- Other?

EAC Comparisons



A “Mini” Case Study

Strategic Management Solutions LLC

Project Controls EXPO
Washington, DC - USA

Project Objectives

- Scope: 200 drawings
- Schedule: 10 months
- Budget: 30 hours per drawing
- BAC: $300K (6,000 hrs x $50/hr)
- Plan: 20 drawings per month

Month 5 Status

So, how are we doing?

	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
Hours	3,000	2,100	2,450	(900)	(350)	6,000	6,000	0
Dollars	150.0	105.0	127.4	(45.0)	(22.4)	300.0	300.0	0

Percent Variance: Schedule

$$\frac{\text{SV Hours}}{\text{BCWS Hours}} \times 100 = \%\ \text{SV}$$

$$\frac{(900)\ \text{Hours SV}}{3000\ \text{Hours BCWS}} \times 100 = (\ 30.0\%\ )$$

Schedule Performance Index

$$\frac{\text{Work Completed}}{\text{Work Planned}} \text{ or } \frac{\text{BCWP}}{\text{BCWS}} = \text{SPI}$$

$$\frac{\text{2100 Hours BCWP}}{\text{3000 Hours BCWS}} = .70 \text{ SPI}$$

70% "Efficiency to Schedule"

Percentage Variance: Cost

$$\frac{\$ \text{ Cost Variance}}{\$ \text{ BCWP}} \times 100 = \% \text{ CV}$$

$$\frac{(\$ 22.4) \text{ CV}}{\$ 105.0 \text{ BCWP}} \times 100 = (21.3\%)$$

Cost Performance Index

$$\frac{\text{Work Completed}}{\text{Actual Cost}} \quad \text{or} \quad \frac{\$\ \text{BCWP}}{\$\ \text{ACWP}} = \text{CPI}$$

$$\frac{\$105.0\ \text{K BCWP}}{\$127.4\ \text{K ACWP}} = .82\ \text{CPI}$$

82% “Cost Efficiency”

IEAC Based on Performance to Date

$$IEAC = ACWP + \frac{BAC - BCWP}{CPI\ Cumulative} = \frac{BAC}{CPI}$$

$$= \$127.4K + \frac{\$300.0K - \$105.0K}{.82}$$

$$= \$365.2K$$

IEAC Based on Recent Performance

$$IEAC = ACWP + \frac{BAC - BCWP}{\text{3 Month Moving Avg}}$$

$$= \$127.4K + \frac{\$300.0K - \$105.0K}{.85}$$

$$= \$356.8K$$

	BCWP	ACWP
Now	xxx	yyy
Now -1	xxx	yyy
Now -2	*xxx*	*yyy*
	∑P	*/ ∑A*

IEAC Based on Combination of Cost and Schedule Performance – One Option

$$IEAC = ACWP + \frac{BAC - BCWP}{(.2)SPI + \mathbf{(.8)CPI}}$$

$$= \$127.4K + \frac{\$300.0K - \$105.0K}{.80}$$

$$= \$371.2K$$

IEAC Based on Combination of Cost and Schedule Performance – Most "Extreme" Option

$$IEAC = ACWP + \frac{BAC - BCWP}{SPI \times CPI}$$

$$= \$127.4K + \frac{\$300.0K - \$105.0K}{.574}$$

$$= \$467.1K$$

Revisions and Change Control

Revisions and Change Control: Objectives

- Incorporate authorized changes in timely, traceable manner
- Prevent revisions to project baseline (except for authorized changes)
- Document changes to, and maintain integrity of PMB

Re-planning vs. Rebaselining

- Re-planning relates to routine re-planning actions associated with “rolling wave” planning process and routine budgetary shifts
  - Don’t affect any higher level milestones or control account constraints
  - Can lead to minor changes in baseline phasing, but is not “rebaselining”
  - Also considered a form of “schedule revision” in construction

Re-planning vs. **Rebaselining**

- Rebaselining relates to broad (i.e., many control accounts), significant:
  - Increases/decreases to future work and budgets
  - Shifts in phasing of work
  - Shifts in timing of project level milestones

Rebaselining: When?

RESULTING FROM MAJOR CHANGES TO TECHNICAL APPROACH

COMPREHENSIVE EAC

FUNDING CHANGES

SIGNIFICANT RATE CHANGES

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Questions?

THANK YOU

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