Defense Acquisition University

American Society of Military Comptrollers

Professional Development Institute

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Earned Value Management (EVM) and the Acquisition Program

Workshop #102

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In a Nut Shell…..*focus points*

- Maximize the use of EVM Data
- Tailor the Integrated Program Management Reports (previously know as CPR & IMS)
- Evaluating a program's status and developing trends
- Estimate at Completion (EACs)
- Incentivize the contractor to provide accurate/timely EVM data

EARNED VALUE CONCEPT

A Management Technique

Emphases Disciplined Integration of Technical Performance to Associated Cost & Schedule

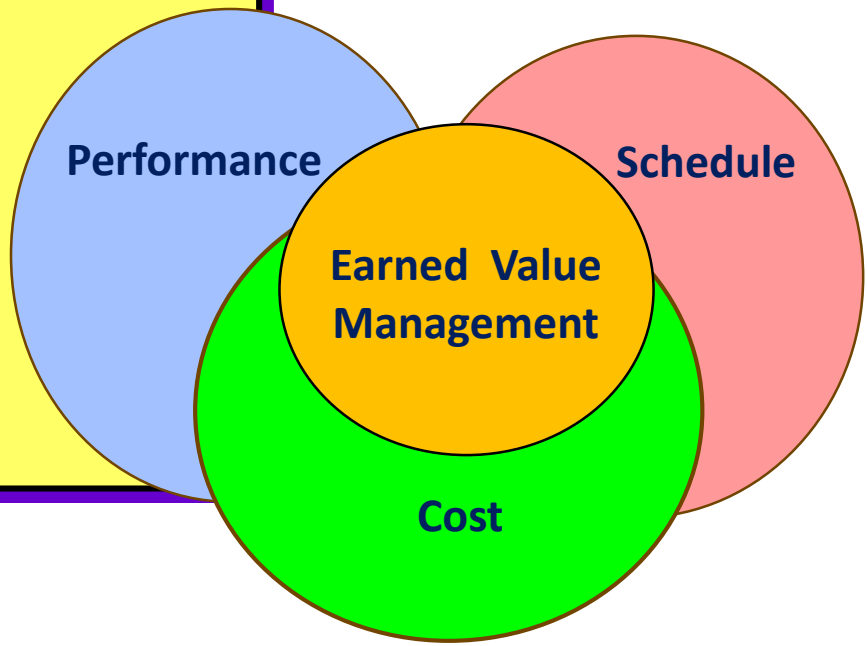
Objectively Measures Work Progress

States Value of Work Completed in $s

Provides Objective Cost & Schedule Metrics

Enables Trend Analysis & Forecasting

Industry Standard EIA-748



DoD & Industry embrace EARNED VALUE as a Risk Management tool

Traditional Measurement

PLANNED

2 | 2

10 | 10

5 | 5 | 5 | 5

3 | 3

BUDGET = $50

ACTUAL COST

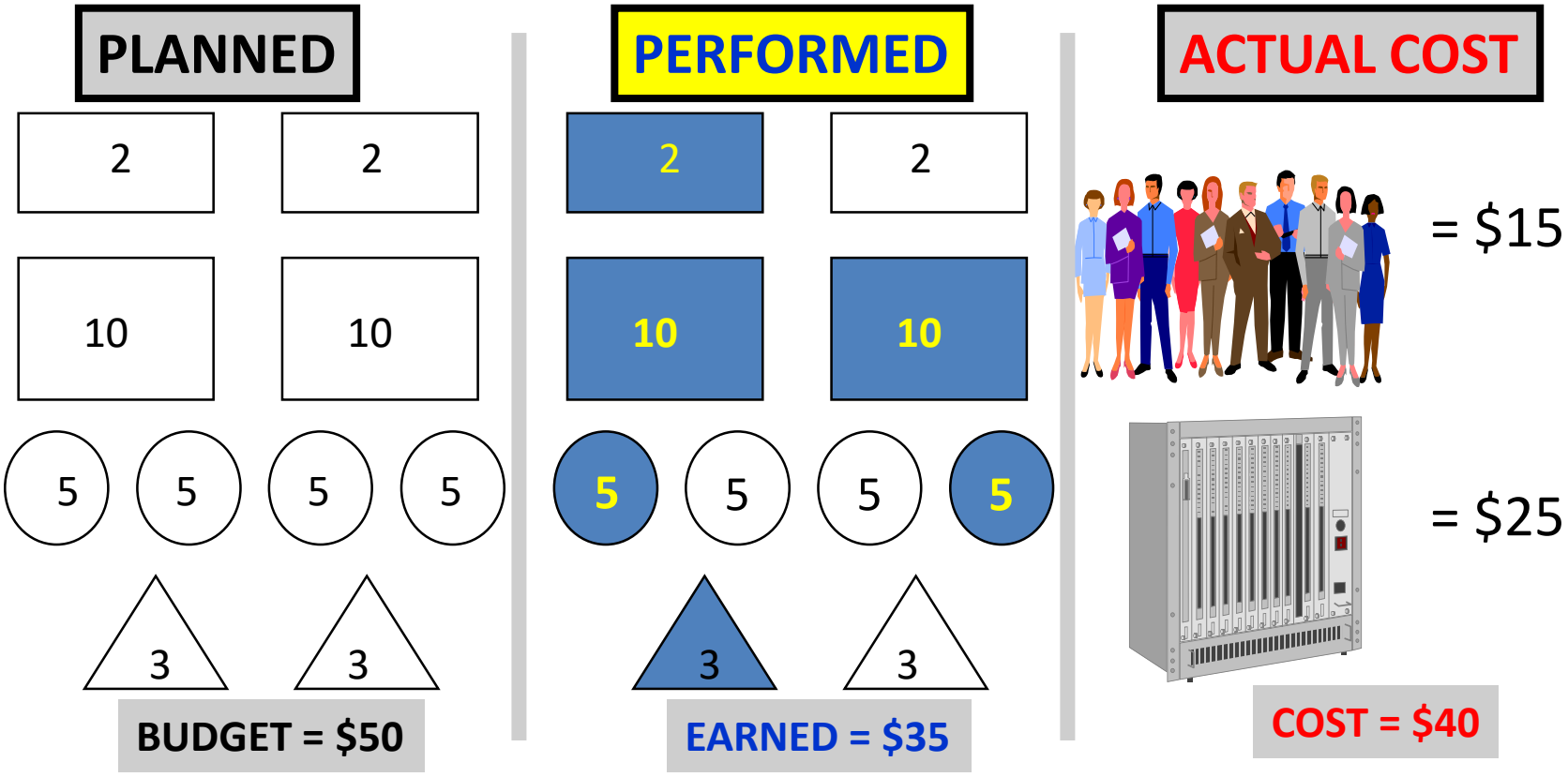
= $15

= $25

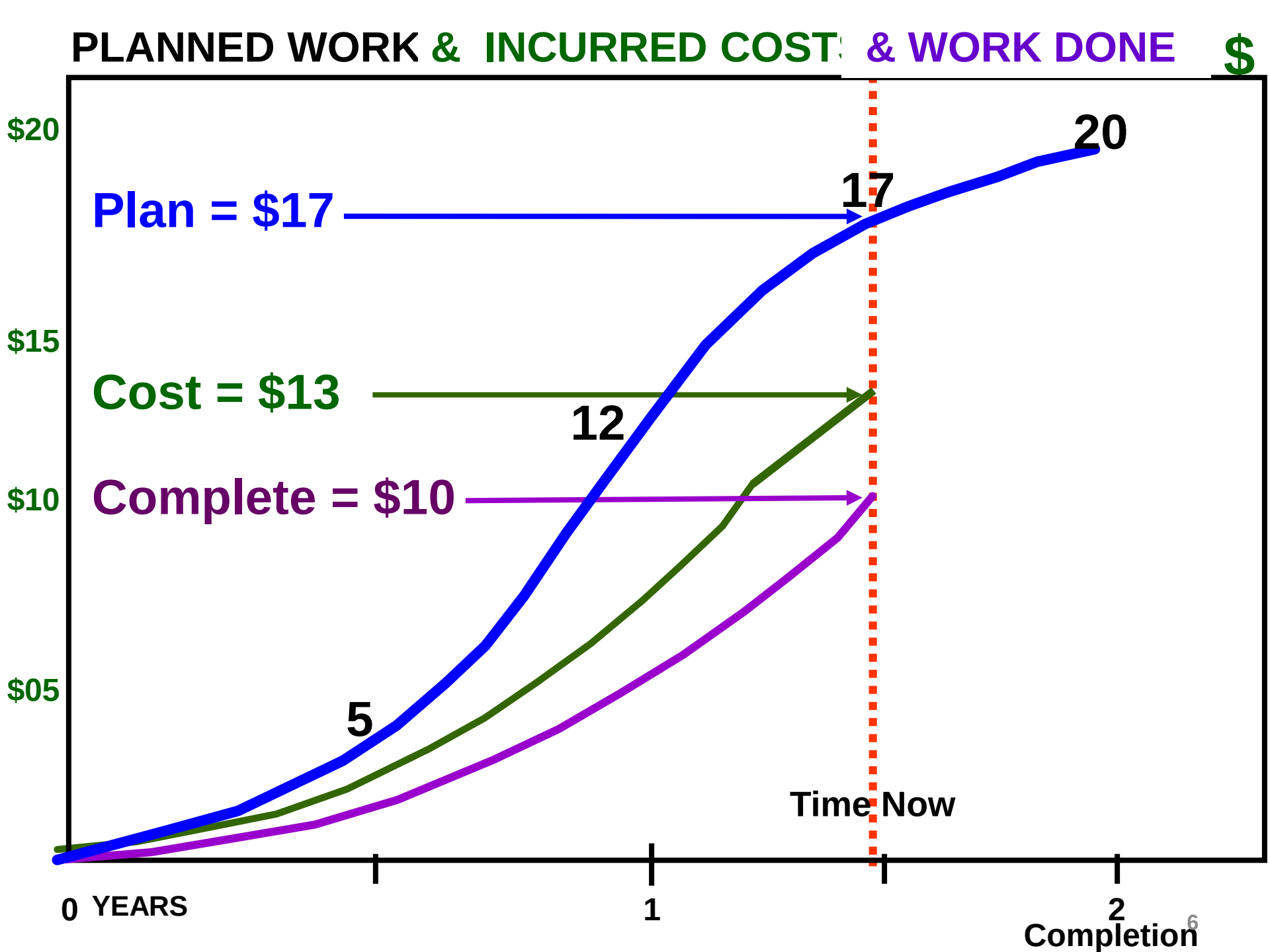
COST = $40

STATUS: Variance = Budget - Actual = + $10 **Favorable**

Earned Value Measurement



STATUS: Schedule Variance = Earned - Budget = -15 **Unfavorable**
Cost Variance = Earned - Actual = - 5 **Unfavorable**


PLANNED WORK & INCURRED COST & WORK DONE
$
$20
$15
$10
$05
Plan = $17
Cost = $13
Complete = $10
20
17
12
5
Time Now
0 YEARS
1
2
Completion

Earned Value Terminology Review

Acronym	Term	Meaning
BCWS	Budgeted Cost for Work Scheduled	Plan – Baseline - PMB
BCWP	Budgeted Cost for Work Performed	Earned Value
ACWP	Actual Cost of Work Performed	Actuals
BAC	Budget At Completion (Cost)	Planned Cost
EAC LRE	Estimate At Completion (Cost) Latest Revised Estimate - Contractors'	Forecasted Cost Forecasted Cost
SV	Schedule Variance	Accomplishment Variance
CV	Cost Variance	Earned Value vs Actual Cost
VAC	Variance At Completion (Cost)	Forecasted Overrun / Under-run

Maximizing EVM Data

Using the EVM data to manage a program – forward looking analysis to manage performance, not just report the status and problems to date.

Basic Objectives of Performance Data Analysis

- Determine current status
  - Where are we today?
- Identify trends
  - Where are we headed?
- Forecast the future status
  - What is the impact of the variances?
- Propose management action
  - Where do we need to do something?

What level of the WBS should I be analyzing?

Earned Value Metrics

- Variances
  - Cost and schedule
  - Current month and cumulative
- Performance indices
  - Cost Performance Index (CPI)
  - Schedule Performance Index (SPI)
  - Percent complete
  - Percent spent
  - To Complete Performance Index (TCPI)

Variances

Schedule Variance:

Formula: SV = BCWP – BCWS

Example: SV_{cum} = \$6,900 – \$7,300
= –\$400

Negative SV indicates the effort is a *Behind* Scheduled Work.

Positive SV indicates the effort is *Ahead* of Scheduled Work.

Note: SV should be used as an indicator only – check your **Integrated Master Schedule** for actual schedule status

-- Misleading Negative Schedule variances

-- Misleading Positive Schedule variances

Cost Variance:

Formula: CV = BCWP – ACWP

Example: CVcum = \$6,900 – \$7,400
= –\$500

Negative CV indicates a Cost Overrun.

Positive CV indicates a Cost Underrun.

Variance Analysis

Analyzing the Cost Variance of Direct Labor

CV for labor can be analyzed as follows:

Formula: **CV** = Rate Variance + Usage Variance

Rate Variance Formula: = (rate difference) x (actual number of hours)
= (planned labor rate – actual labor rate) x actual number of hours

Usage Variance Formula: = (usage difference) x (original rate)
= (earned hours – actual hours) x original labor rate

Examples

Direct Labor: The contractor used 10 more hours than planned for the work performed (30 vs. 20 hours), and the actual hourly labor rate was $5.00 more than planned ($45 vs. $40).

Rate Variance:	= ($40 - $45) x 30 hours	= -$150
Usage Variance:	= (20 – 30) x $40	= -$400
Total Cost Variance:	= -$150 + -$400	= -$550

Direct Material: The contractor used 10 more widgets than earned (60 vs. 50), and spent $30 more per unit than planned ($330 vs. $300)

Price Variance:	= ($300 - $330) x 60	= -$1,800
Usage Variance:	= (50 - 60) x $300	= -$3,000
Total Cost Variance:	= -$1,800 + -$3,000	= -$4,800

Variances

Variance at Completion:

Negative VAC indicates a projected Cost Overrun at Completion.

Positive VAC indicates a projected Cost Underrun at Completion.

Formula: VAC = BAC – EAC

Example: VAC = $20,800 – $21,608

= –$808

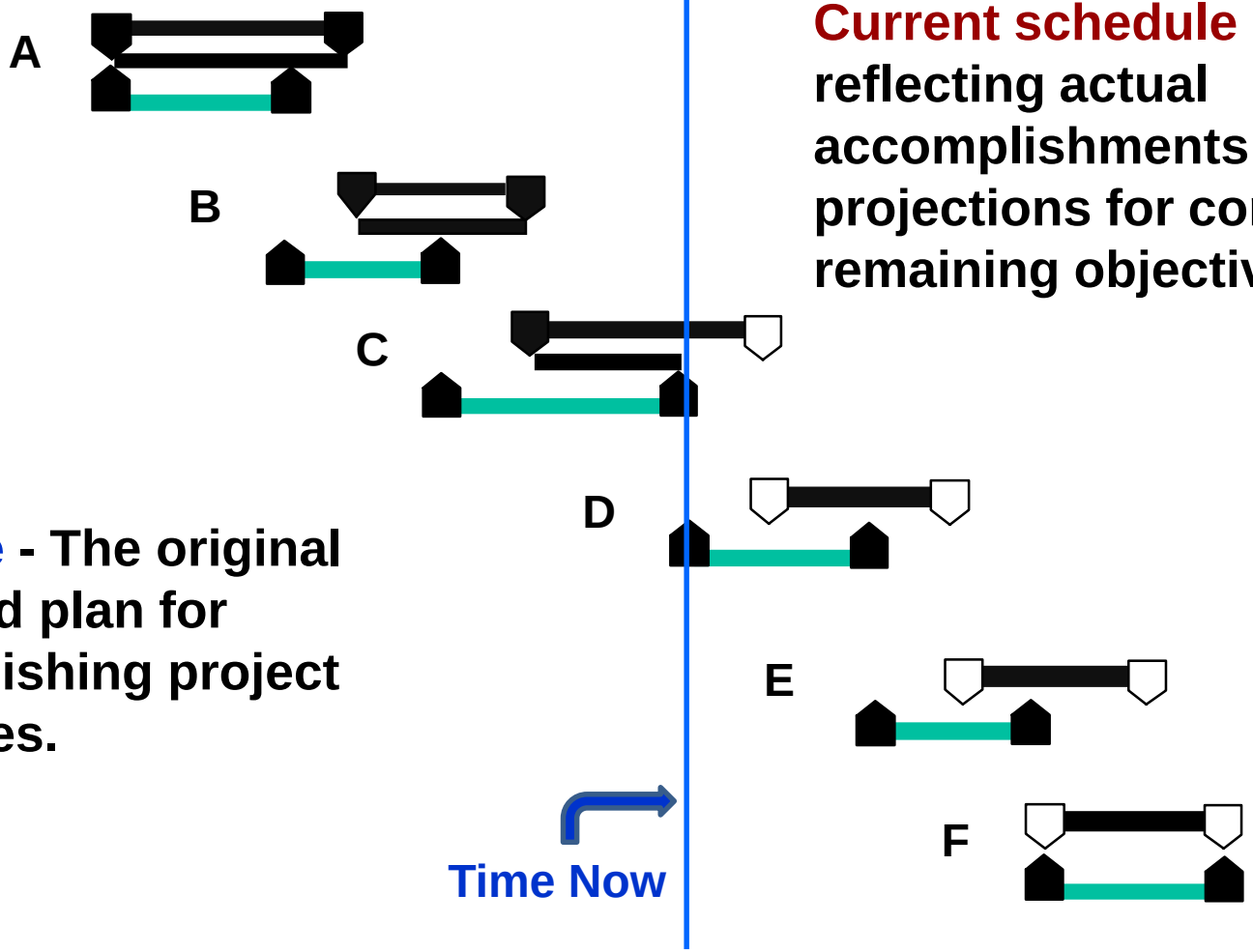
Note: The VAC can be calculated using the Contractor's EAC (also known as the Latest Revised Estimate [LRE]) or the PMO's EAC to determine potential Cost Overruns or Underruns.

Why should care about scheduling?

- **Provides basis for project communication**
  - Identifies key milestones, activities, and interdependencies
  - Provides baseline for performance measurement
  - Provides current status and forecasts completion dates
- **Allows management by exception**
  - Focus on critical path and slipping tasks
- **Supports Cost As an Independent Variable**
  - Basis to analyze Resource leveling and Facility / Range availability
  - Exploration of alternatives in Cost / Time trade-off studies
- **Schedule status reported to management**
  - Through Central Repository and DAES to OSD
  - Through SAR to Congress
  - Program schedule is a key consideration at milestone decisions
- **Schedule slips may result in funding cuts**

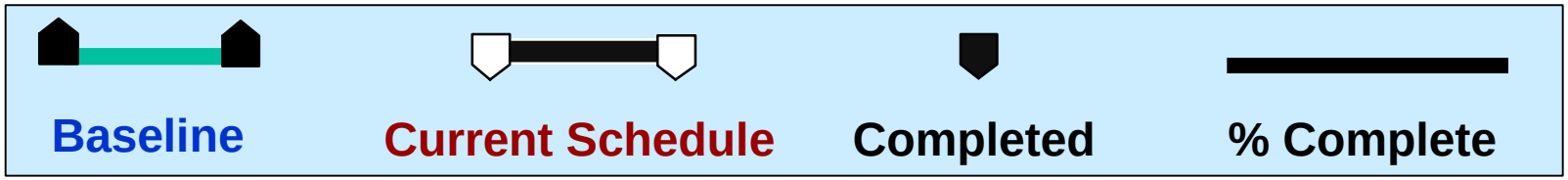
To accomplish project objectives on time

Baseline versus Current Schedule



Current schedule - The plan reflecting actual accomplishments and projections for completing remaining objectives.

Baseline - The original approved plan for accomplishing project objectives.



Variances Summarized

	Positive	Negative
SV	Ahead of schedule	Behind schedule
CV	Underrunning costs	Overrunning costs
VAC	Projected underrun	Projected Overrun

Variances, such as the schedule or cost variances, can be expressed as either **current period** or **cumulative**. Current period data, plotted over time, tends to be more volatile. Cumulative data, when plotted over time, shows a smoothed line and can be used for trend purposes.

Indices

The indices for cost and schedule are constructed so that good performance is indicated by an index greater than 1.0, while poor performance is indicated by an index less than 1.0

	> 1	< 1
SPI	More efficient (ahead of schedule)	Less efficient (behind schedule)
CPI	More efficient (underrunning costs)	Less efficient (overrunning costs)
VACI	Projected to be more efficient at completion	Projected to be less efficient at completion

Compare SPI to IMS Progress

Compare the two—both should reflect either an unfavorable or favorable position. If NOT, further investigation is required.

Positive SPI or SV($)	Ahead on IMS	Reports comparable
Negative SPI or SV($)	Behind on IMS	Reports comparable
Positive SPI or SV($)	Behind on IMS	Investigate
Negative SPI or SV($)	Ahead on IMS	Investigate

Tailoring IPMR Formats

Monthly Reports providing cost & schedule status

EVM Report Formats

CPR DI-MGMT-81466A (Before 1 July 2012)	Description	IPMR DI-MGMT-81861 (After 1 July 2012)
Format 1	Work Breakdown Structure (WBS)	Format 1
Format 2	Organizational Categories (OBS/IPT)	Format 2
Format 3	Baseline	Format 3
Format 4	Staffing	Format 4
Format 5	Explanations & Problem Analysis	Format 5
IMS DI-MGMT-81650	Integrated Master Schedule	Format 6
N/A	Electronic History and Forecast File	Format 7

Tailoring Flexibility

- Mandatory Format reporting vs optional -- depends on dollar amount of contract
- Dollar thresholds for variances
- Frequency of reports
- Percentage variances thresholds
- Subcontractor IPMR submissions
- Format 1 – G&A and COM levels

Specific Guidance

- Complexity of the program should be considered when determining the degree of tailoring that is appropriate for the IPMR data item for a given contract. The risk inherent to the program should be the prime consideration for tailoring of the IPMR. Other factors to consider are the size of the contract, complexity of integration with other contract efforts, reliance on Government Furnished Equipment/Government Furnished Property (GFE/GFP), technology maturity, and type of contract.

Evaluating Program's Status and Trends

Analyzing past performance to help control future performance

Basic Analysis

- Management Reserve
- Variances and Metrics
- Trend charts
- Leading indicators and Other Metrics
- Analysis of Format 5 – Explanations and Problem analyzes
- DCMA input
- Schedule Performance (IMS)

Examples of Key Metrics

Overall Status

Percent Scheduled: % Scheduled = BCWScum / BAC

Percent Complete: % Complete = BCWPcum / BAC

Percent Spent: % Spent = ACWPcum / BAC

To Complete Performance Index (TCPI)

$TCPI_{BAC}$ = Work Remaining / Budget Remaining
= (BAC – BCWPcum) / (BAC – ACWPcum)

$TCPI_{EAC}$ = Work Remaining / Estimate Remaining
= (BAC – BCWPcum) / (EAC – ACWPcum)

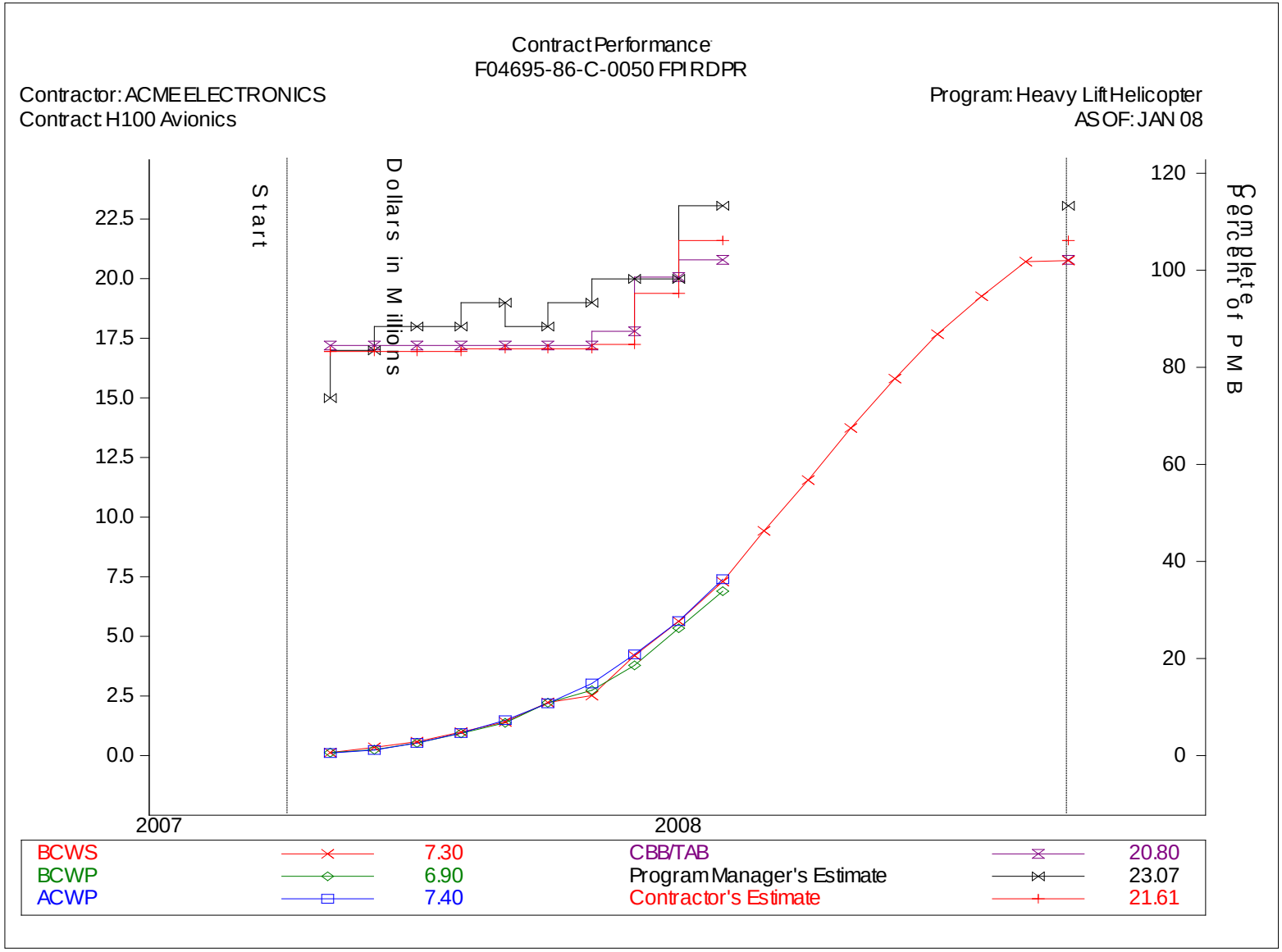
Estimate at Completion (EAC)

EAC = ACWP + [BAC-BCWP)/Performance Factor]

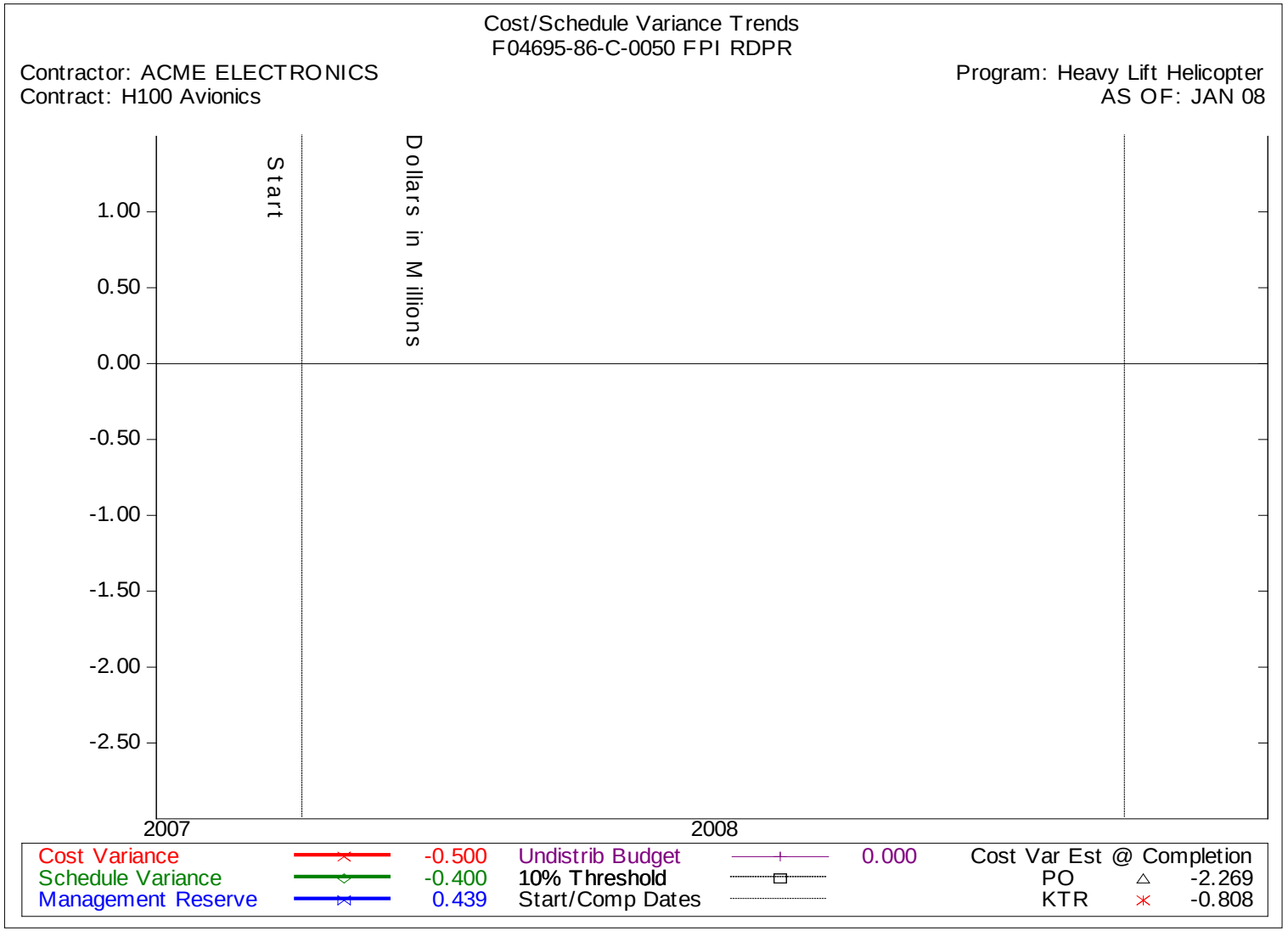
Typical Trend Charts

- Contract Performance
- Cost and Schedule Variance Trends
- CPI and SPI Trends
- EAC
- Cumulative Variance
- Bull's-Eye
- C/S Variance Trends
- Custom

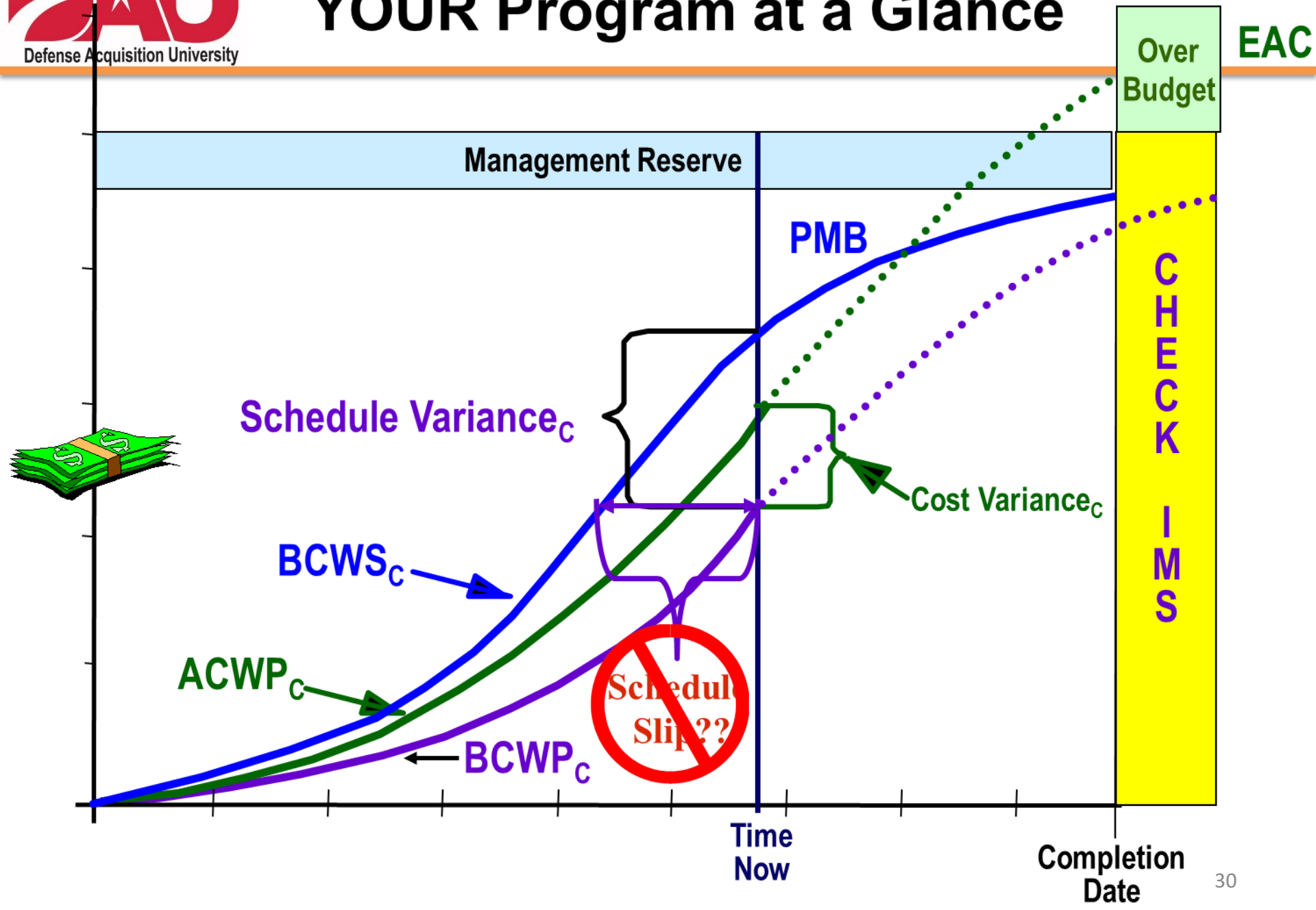
Contract Performance



Cost/Schedule Variance Trends



YOUR Program at a Glance



Estimate at Completion

Using Project Performance Data to Forecast Future Costs (a.k.a. – what do we really think its going to cost?)

Types of EACs

- Comprehensive
- Formula based – “statistical” or “mathematical”
- Regression

Note: One study reported by David Christensen in Acquisition Review Quarterly has drawn some significant conclusions about forecasting value of EVM data:

- *The final cost variance will generally be worse (in dollars or as a percentage) than the cost variance at the 20% completion point.*
- *The cumulative CPI will generally not change by more than 0.10 from its value at the 20% completion point, and in most cases, it only worsens.*

Range of EACs

Major programs within DoD must report a range of EACs in various acquisition reports to decision makers.

A general rule of thumb is that the floor of the EAC range is an EAC based on using the CPI_{cum} as the Performance Factor and the ceiling of the range is an EAC based on the Composite Factor (CPI_{cum}*SPI_{cum}) as the Performance Factor.

Contractors are required to provide a Worst Case EAC, Best Case EAC, and a Most Likely EAC when submitting their monthly reports.

Sample Calculations

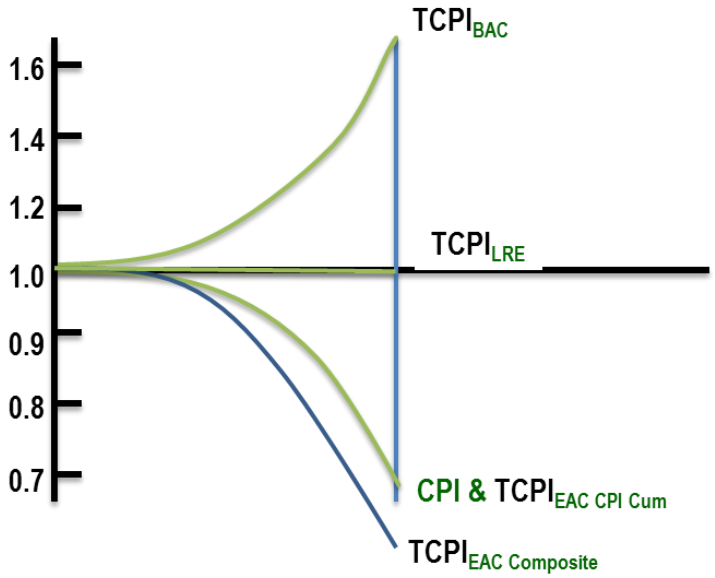
BAC	= $10
BCWS	= $ 6
BCWP	= $ 5
ACWP	= $ 7

CPI_{Cum} = BCWP/ACWP = 5 / 7 = 0.71 % Spent = (7 / 10) * 100 = 70%

SPI_{Cum} = BCWP/BCWS = 5 / 6 = 0.83 % Complete = (5 / 10) * 100 = 50%

$EAC_{(Perf\ Factor)}$	= (ACWP) + { (BAC – BCWP) / PERF FACTOR } =	
$EAC_{CPI_{Cum}}$	= (7) + { (10 - 5) / (0.71) }	= $ 14.0
$EAC_{Composite}$	= (7) + { (10 - 5) / (CPI * SPI) }	= $
$EAC_{Composite}$	= (7) + { (10 - 5) / (0.71 * 0.83) }	= $ 15.5
$EAC_{Ktr's\ LRE}$	= ACWP + (BAC - BCWP)	= $ 12.0

$TCPI_{EAC/BAC/LRE}$	= (BAC - BCWP) / ([EAC or BAC or LRE] - ACWP) =	
$TCPI_{EAC_{CPI_{Cum}}}$	= (10 - 5) / (14.0 - 7)	= 0.71
$TCPI_{EAC_{Composite}}$	= (10 - 5) / (15.5 - 7)	= 0.59
$TCPI_{BAC}$	= (10 - 5) / (10.0 - 7)	= 1.67
$TCPI_{LRE}$	= (10 - 5) / (12.0 - 7)	= 1.00



Estimates at Completion

$$EAC = ACWP + \left[\frac{BAC - BCWP}{\text{Performance Factor}} \right]$$

Performance Factors

Single Index

- CPI_{cum}
- CPI_{cur}
- $CPI_{3\ mth}$
- $CPI_{6\ mth}$
- SPI_{cum}
- SPI_{cur}
- Other

Composite

$(CPI_{cum} \bullet SPI_{cum})$

$MICOM - (CPI_{6mth} \bullet SPI_{cum})$

Weighted

$(.8 \bullet CPI_{cum}) + (.2 \bullet SPI_{cum})$

$(.4 \bullet CPI_{factory}) + (.4 \bullet CPI_{test}) + (.2 \bullet CPI_{quality})$

Warning Signs of Unrealistic EACs

- ACWP>EAC
- CV worse than VAC
- CV trends downward, VAC remains flat
- EAC not updated on routine basis
- CPI versus TCPIEAC inconsistency
- Probable risks not included
- Impact of indirect rates not included
- Inappropriate optimism that things will get better
- Others….

Incentivize the Contractor

Getting the Contractor to provide accurate/timely EVM Data

Incentives Matter

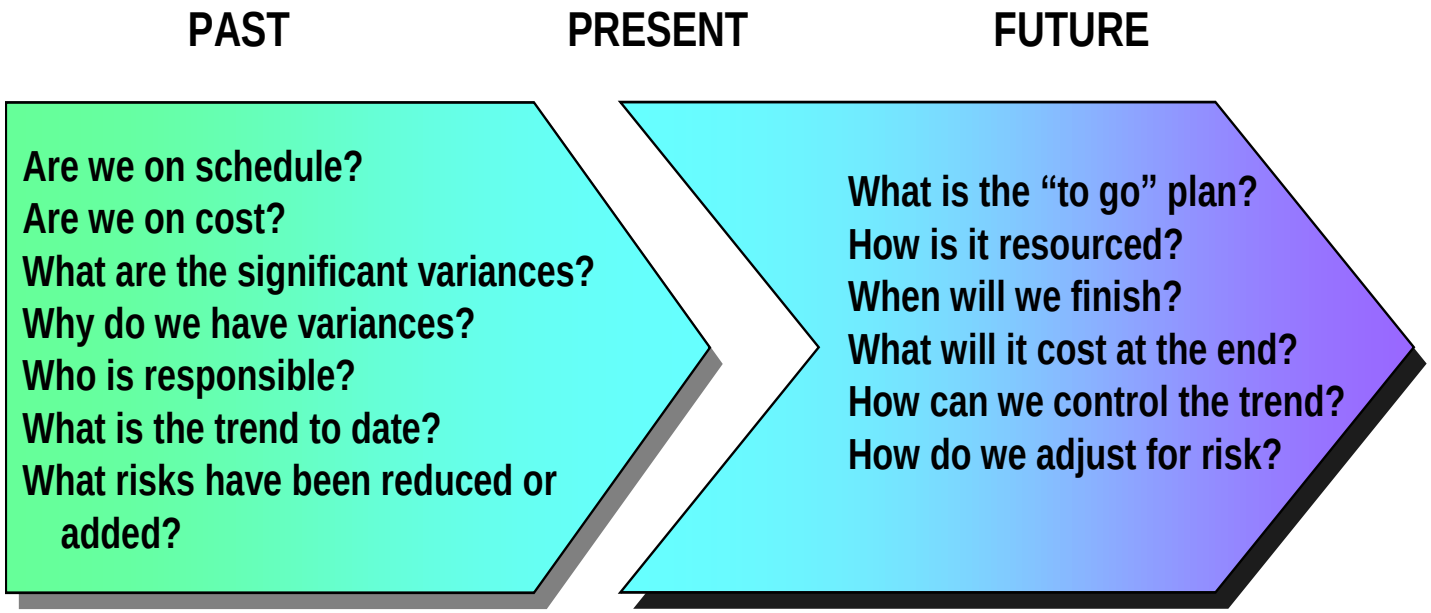
- Must consider type of contract
- Do not incentivize the EVM “metrics”
- Realism and realistic inputs must be the watch words
- Cost
- Schedule
- DCMA
- Program Status Reports

Recommended Award Fee Criteria

- MANAGEMENT #1 EVM is effectively integrated and used for program management.
- MANAGEMENT #2 Management of major subcontractors.
- MANAGEMENT #3 Realistic and current cost, expenditure, and schedule forecasts.
- MANAGEMENT #4 Adequacy of cost proposals submitted during award fee period.
- MANAGEMENT #5 Cost control.
- MANAGEMENT #6 Variance analysis in performance reports.
- DISCIPLINE #1 Accuracy, timeliness, and consistency of billing and cumulative performance data; and integration of subcontractor data. (Sarbanes-Oxley Act – 2002)
- DISCIPLINE #2 Baseline discipline and system compliance.

Wrap UP

- Earned Value Management is a management tool – not a silver bullet.
- Integration of analysis of key programmatic data from a variety of sources is necessary to focus on significant variances and developing trends.
- Keeping the program manager informed and to allow for timely, responsible management decisions is a team effort.



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Questions?

Thank you….

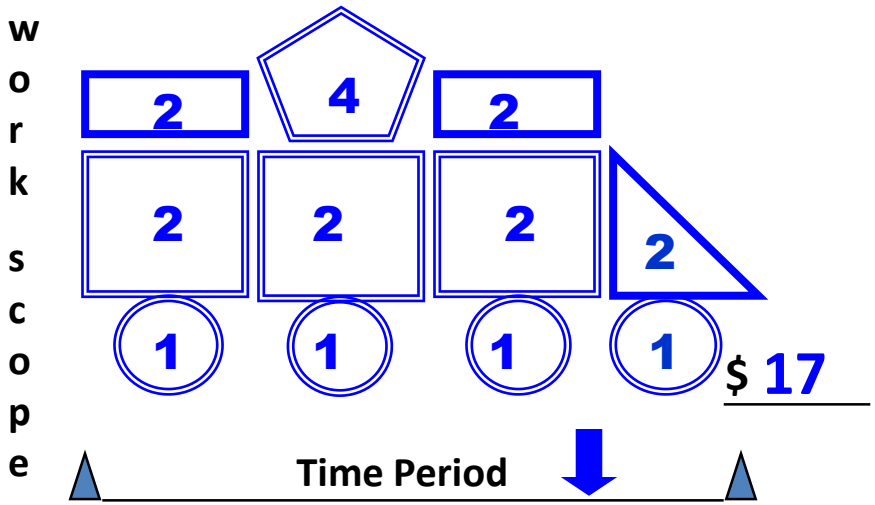
Additional information

Backup Slides

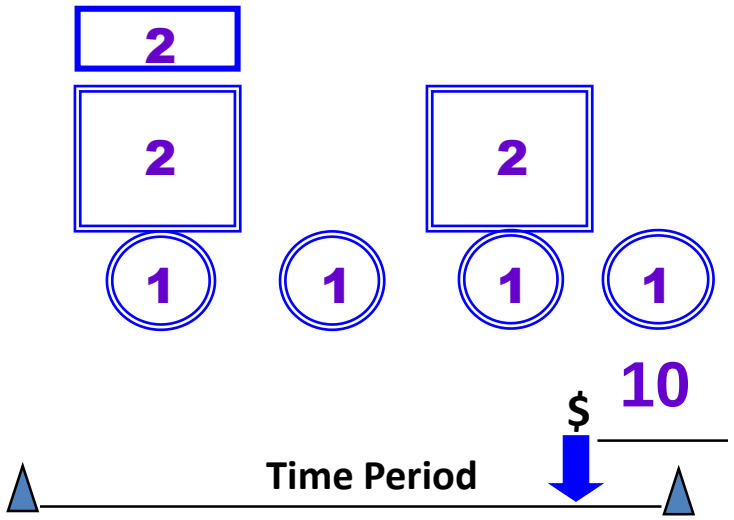
Defense Acquisition University

Plan, Actuals & Earned Value

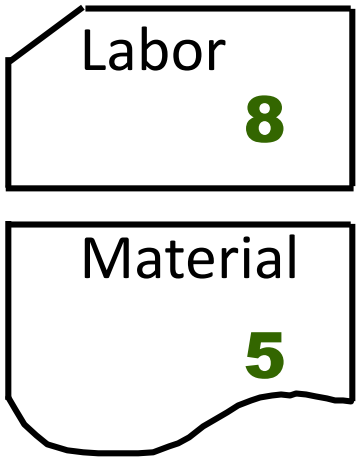
PLAN (BCWS)



WORK PERFORMED (BCWP)



ACTUAL COSTS (ACWP)



$ 13

Time Period

VARIANCES

Schedule Variance = Performed - Plan

SV = $10 - $17

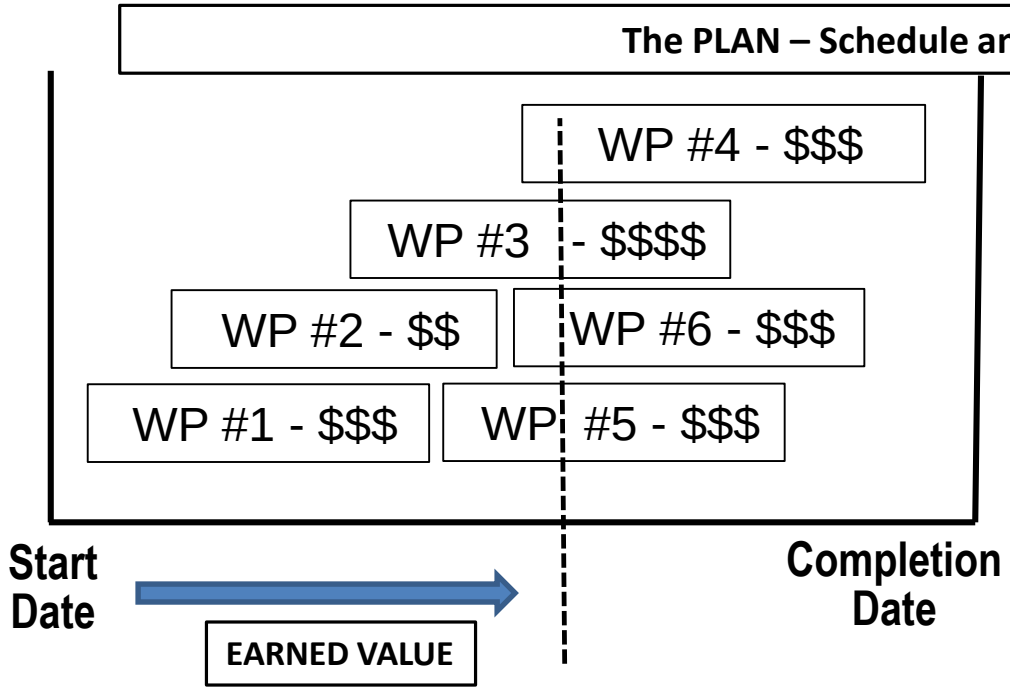
SV = - $7

Cost Variance = Performed - Actuals

CV = $10 - $13

CV = - $3

Earned Value Management System (EVMS)
– using cost to measure cost AND schedule performance



BCWS = The Plan
Budget Cost of Work Scheduled

Work Scheduled[1] – relationships/dependencies
- Finish to Start (FS)
- Finish to Finish (FF)
- Start to Start (SS)
- Start to Finish (SF)

Budgeted Cost – $ for scope of work scheduled

BAC = Sum of budgeted Work Packages (WP) Budgeted at Completion

Periodically WPs are completed and in-progress WPs are measured/credited as EARNED (using pre-established plan criteria such as 0/100, 50/50, % Complete either objective or subjective, units complete etc.)[2].

BCWP = Budgeted Cost of Work Performed - Work that got done per budget value of work package

vs.

ACWP = Actual Cost of Work Performed - Actual cost at that point in time (cost of work that got done)

Estimates at Completion (EACs) need updating for efficiencies/inefficiencies as measured by **CPI** and **SPI.**

E.G. - the EAC_{FLOOR} takes the original BAC and divides by the cumulative CPI by presuming, based on history, that cost efficiency as measured by the CPI will not improve after you get so far (20%) into the program.

[1] Ref: EVM 263, [2] Ref: EVM 101/202, - Also see DAU 'Gold Card' Tool at: https://www.dau.mil/tools/t/EVM-General-Reference-(Gold-Card)

The Performance Metrics: Cost Performance Index (CPI) and Schedule Performance Index (SPI)

BCWP = $600K
ACWP = $700K

$$CPI = \frac{BCWP = \$600K}{ACWP = \$700K}$$

CPI = Budgeted\Actual Cost

CPI = 0.86

BCWP = $50K
BCWS = $150K

$$SPI = \frac{BCWP = \$50K}{BCWS = \$150K}$$

SPI = Work Performed\Scheduled

SPI = 0.33

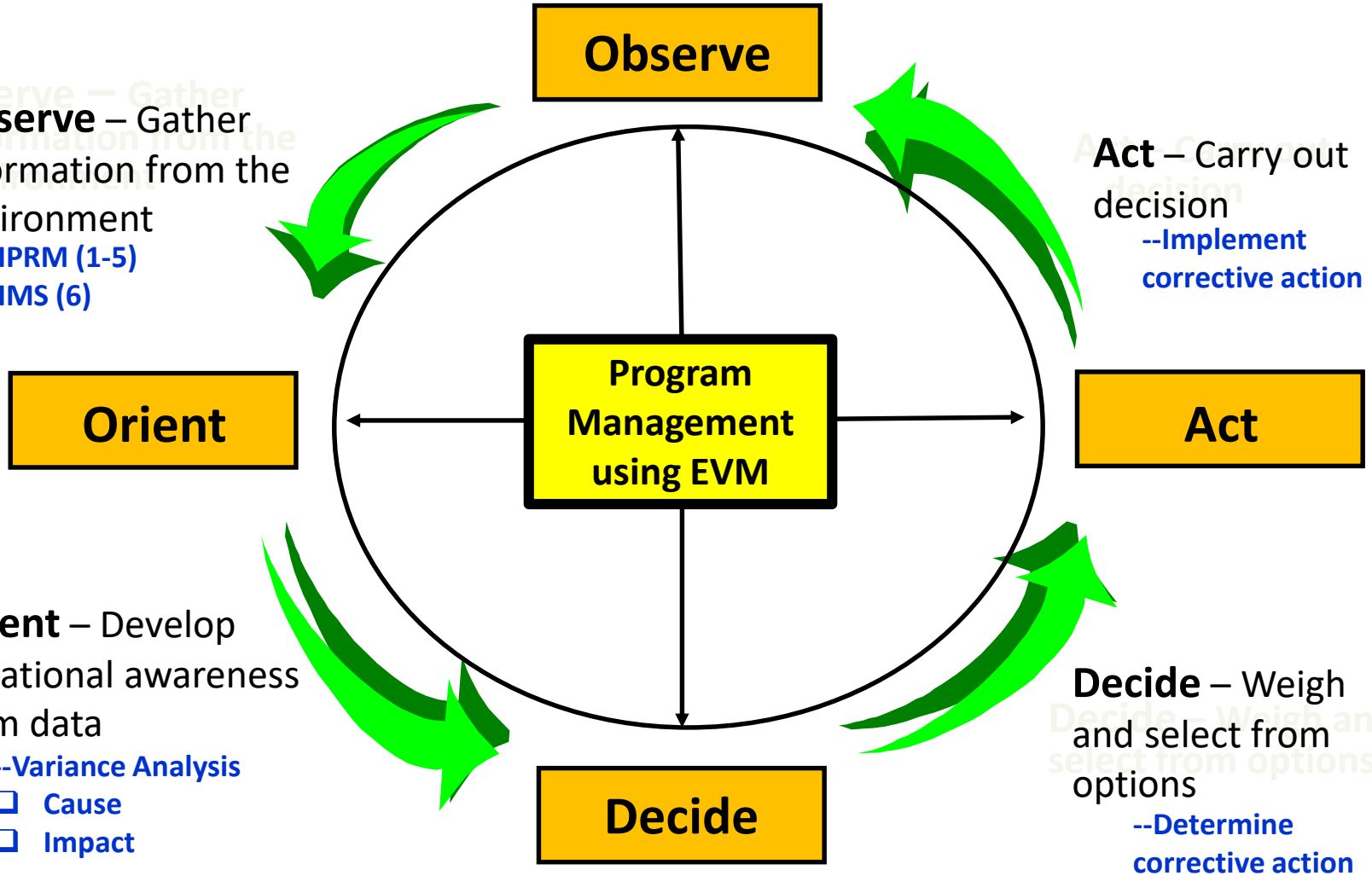
CPI = How much actual work are we getting for each dollar spent
(< 1.0 is unfavorable) ☹ Actual cost of performance > planned

SPI = How efficient is the contractor in terms of schedule
(< 1.0 is unfavorable) ☹ Actual work accomplished < planned

When should a Program Office BFM consider getting more funding?

- Suppose BAC were $100,000 and cumulative CPI were 0.86
- EAC_{FLOOR} = $100,000 ÷ 0.86 = $116,279 – this is now the most likely cost requiring funding (ref. FMR Vol 3, Chapter 8, 080601).

The OODA Loop



Observe – Gather information from the environment
- --IPRM (1-5)
- --IMS (6)

Act – Carry out decision
- --Implement corrective action

Orient – Develop situational awareness from data
- --Variance Analysis
  - ❑ Cause
  - ❑ Impact

Decide – Weigh and select from options
- --Determine corrective action