

Earned Value Management (EVM)

*Tracking cost and schedule
performance on projects*

“What are my chances?” / “Not good.” / “You mean, not good like one out of a hundred?” / “I’d say more like one out of a million.” / ... “So you’re telling me there’s a chance!”

- Jim Carrey as Lloyd Christmas to Lauren Holly as Mary Swanson

Dumb and Dumber, <http://www.imdb.com/title/tt0109686/>.

Acknowledgments

- ICEAA is indebted to TASC, Inc., for the development and maintenance of the Cost Estimating Body of Knowledge (CEBoK®)
 - ICEAA is also indebted to Technomics, Inc., for the independent review and maintenance of CEBoK®
- ICEAA is also indebted to the following individuals who have made significant contributions to the development, review, and maintenance of CostPROF and CEBoK®
- Module 15 Earned Value Management (EVM)
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EVM Overview

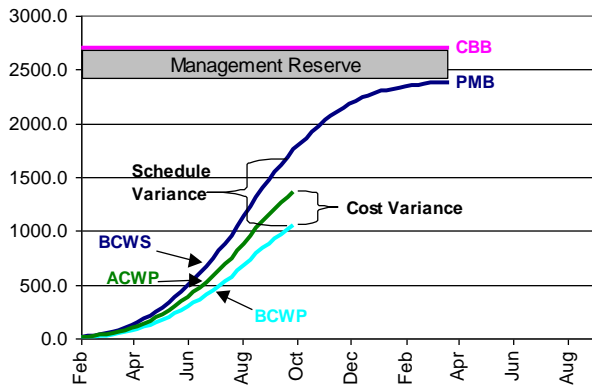
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|--|--|
| <ul style="list-style-type: none"> • Key Ideas <ul style="list-style-type: none"> - Integrated baseline <ul style="list-style-type: none"> • Resource-loaded schedule - Earned value <ul style="list-style-type: none"> • Objective progressing - Extrapolation from Actuals - Cost and schedule performance | <ul style="list-style-type: none"> • Practical Applications <ul style="list-style-type: none"> - EACs - risk-adjusted rollups - EACs - alternative formulae - Performance measurement <ul style="list-style-type: none"> • Contract vs. technical |
| <ul style="list-style-type: none"> • Analytical Constructs <ul style="list-style-type: none"> - AC (Actual Cost) = actuals to date - EV (Earned Value) = value of work performed - PV (Planned Value) = budget - $EAC = AC + \underbrace{(BAC - EV) / PI}_{BCWR}$ | <ul style="list-style-type: none"> • Related Topics <ul style="list-style-type: none"> - Risk Management - Project Management - Schedule Analysis / Risk |

Tip: This formula, while intuitive, may not be the best predictor of EAC!

EVM within the Cost Estimating Framework

Past

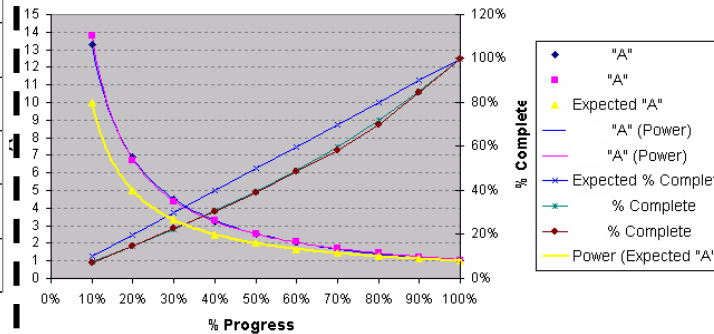
Understanding your historical data



Present

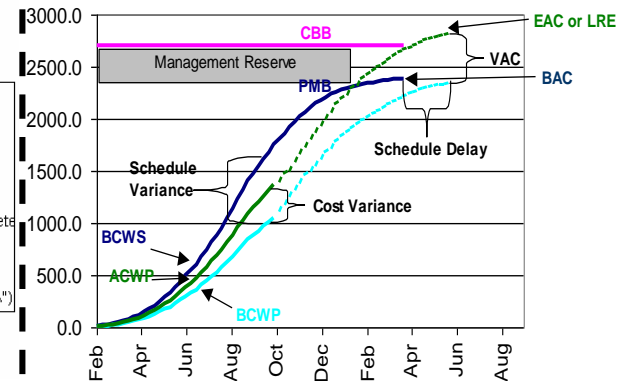
Developing estimating tools

"A" & % Complete vs. % Progress



Future

Estimating the new system



Earned Value data elements

Estimate At Complete (EAC) formulae

EAC and Predicted Schedule

EVM and Cost Estimating

- How should Cost Estimators be involved in EVM?
- Verify Realistic Baselines
 - Control Accounts that trace to BOEs
 - Cost Estimator participation in IBRs
- Develop Accurate EACs
 - Statistical and risk-based methods
- Gather Cost Data to Support Estimating
 - IPMR and other EV data serve as data sources for estimating analogous efforts

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Earned Value Data Elements

- Earned Value has five basic data elements:

Element	Title	Common Terminology
BCWS	Budgeted Cost of Work Scheduled	Planned Value (PV), Performance Measurement Baseline (PMB), plan, baseline
BCWP	Budgeted Cost of Work Performed	Earned Value (EV)
ACWP	Actual Cost of Work Performed	Actual Cost (AC), actuals
BAC	Budget at Complete	Planned Cost
EAC / LRE	Estimate at Complete / Latest Revised Estimate	Forecasted Cost

Tip: EAC generally refers to the Government's independent assessment of the estimate at complete while LRE refers to the Contractor's estimate at complete

BCWS (The Plan)



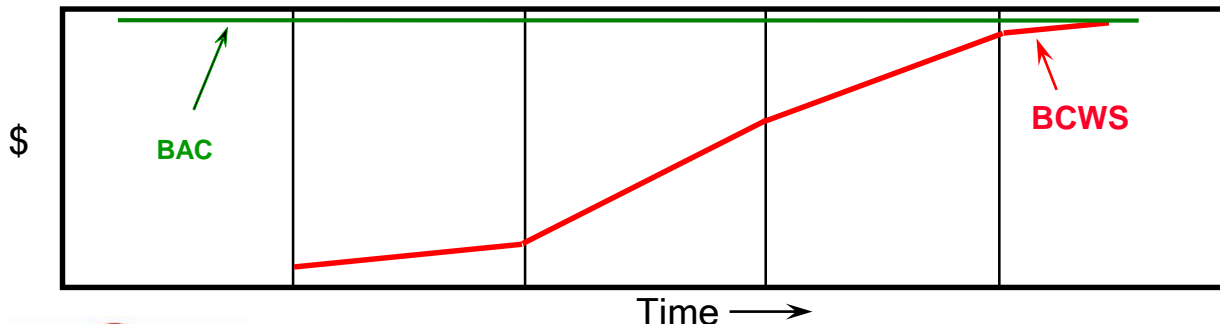
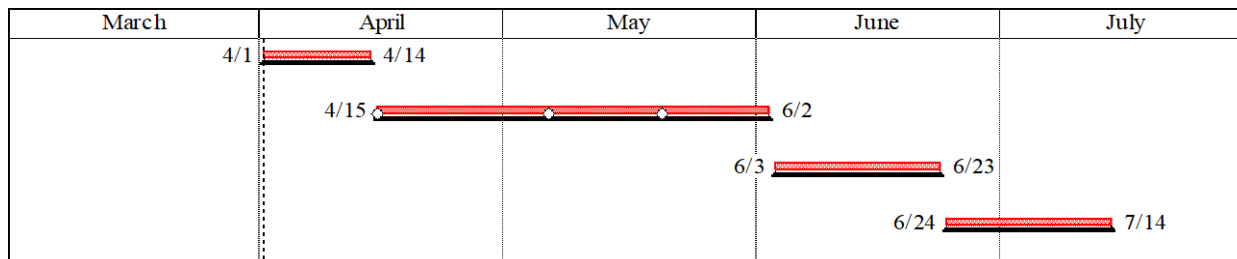
Budgeted Cost of Work Scheduled (BCWS): The sum of the budgets for all work packages, planning packages scheduled to be accomplished within a given time period

- The value of the work scheduled
- The baseline used to measure all performance
- The resource-loaded schedule



AKA Planned Value (PV)

- Picture a Gantt chart



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BCWP (What Work Was Performed?)

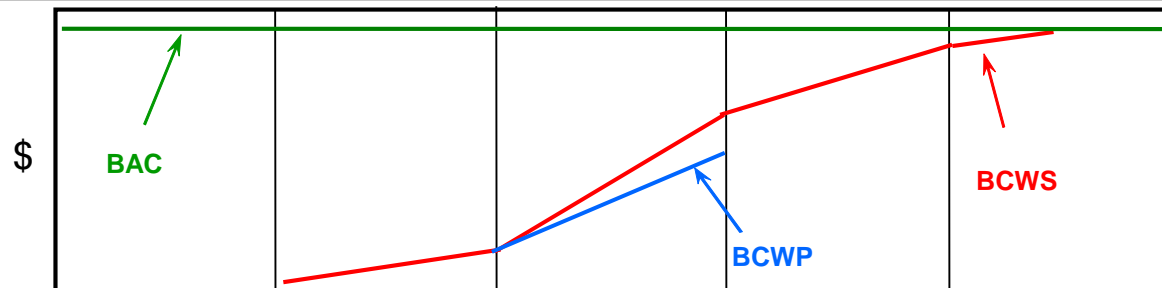
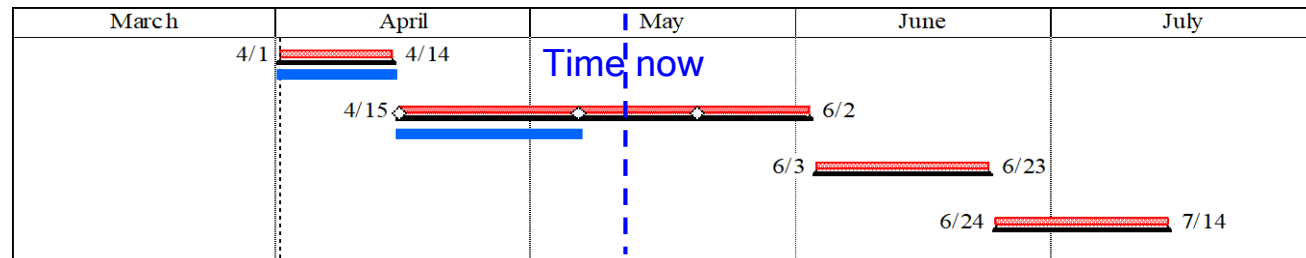


Budgeted Cost of Work Performed (BCWP): The sum of all budgets for completed work packages and completed portions of open work packages

- The value of the work performed
- Dependent on BCWS - can only earn as much \$ as is loaded in the completed BCWS tasks



AKA Earned Value (EV)



Time →
Unit V - Module 15

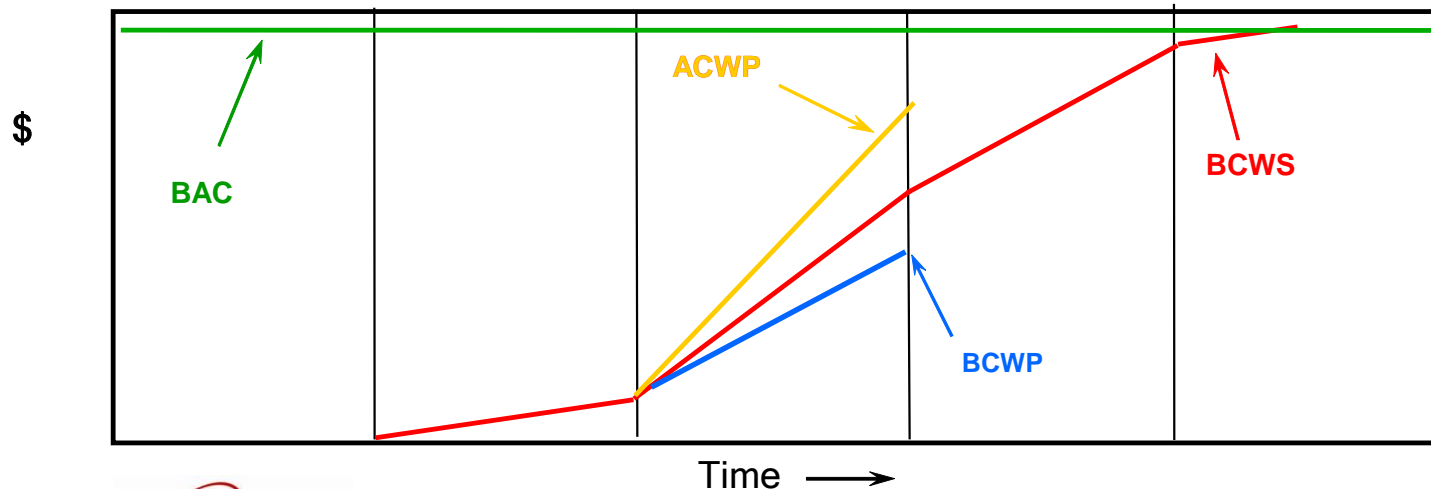
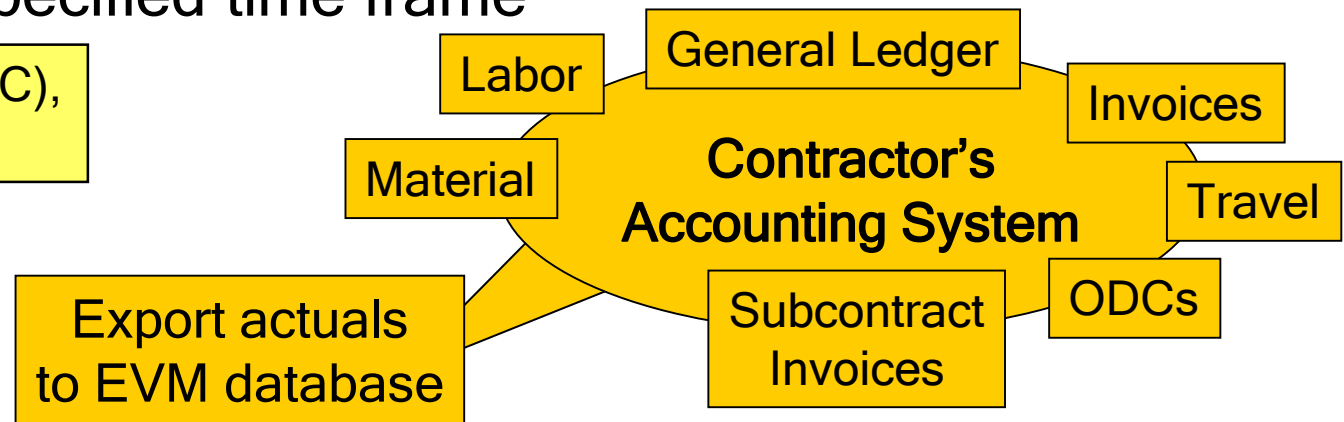
ACWP (Cost Incurred)



- Actual Cost of Work Performed (ACWP): The costs actually incurred to accomplish the work earned within a specified time frame



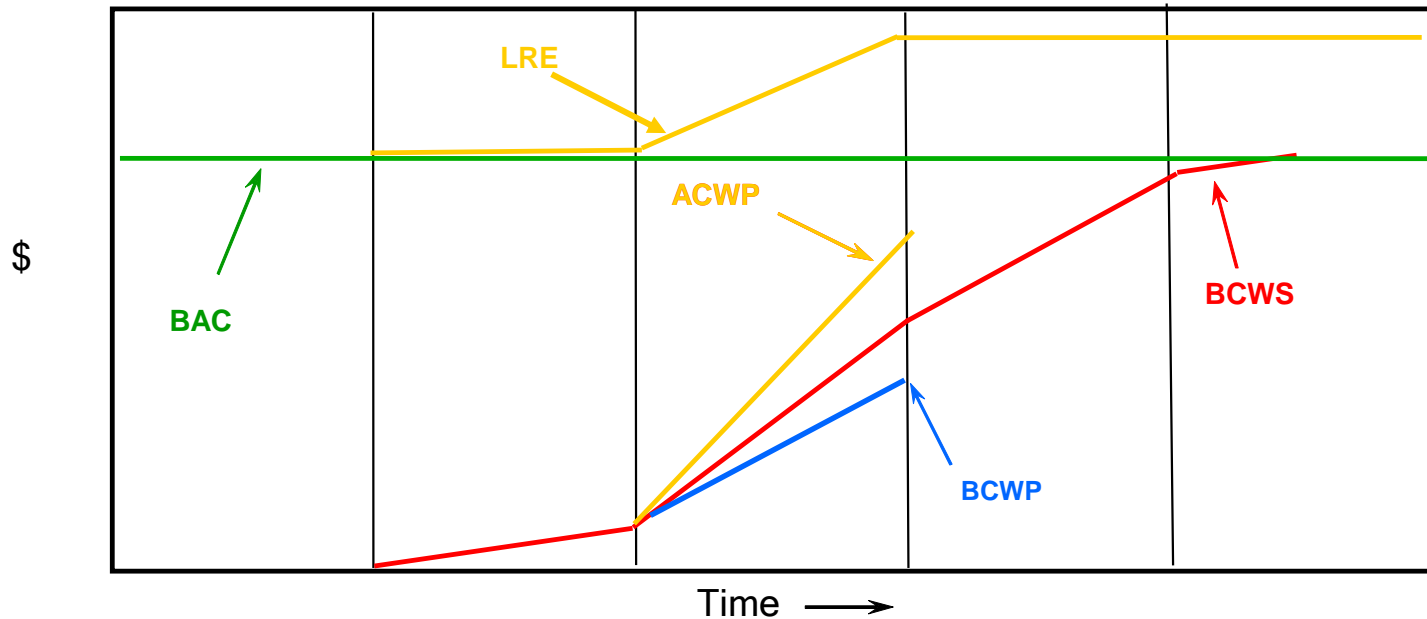
AKA Actuals (AC),
Actual Value

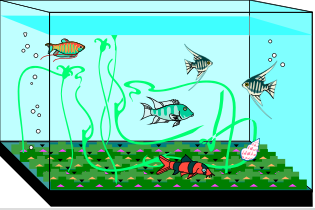


BAC and LRE (End of Work)



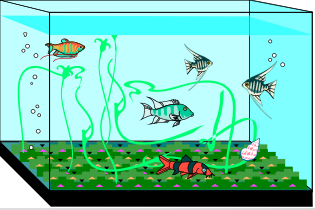
- Budget At Complete (BAC): Cumulative BCWS at the end of the contract
- Latest Revised Estimate (LRE): The contractor's best guess at how much the effort will actually cost at the end of the contract





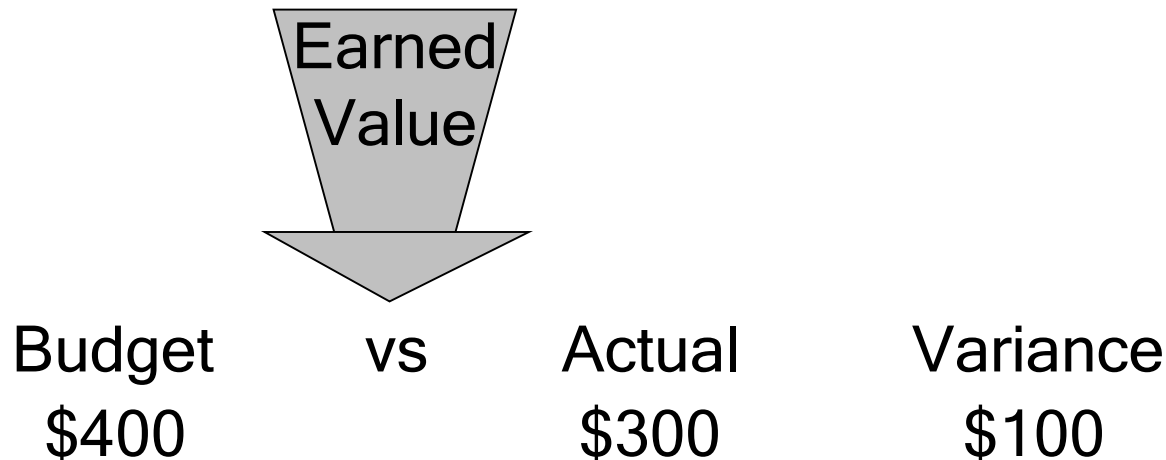
Basic EVM Example

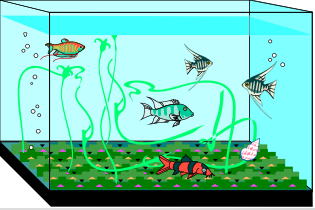
- Managing projects without earned value provides only part of the picture
- Traditional approach:
 - Budget work
 - Record Actual expenses
- Example:
 - Budgeted for 4 Aquaria to be built in November at \$100 each
 - At end of November, spent \$300
 - Great! I am \$100 under budget...or am I?



Basic EVM Example

- Example (continued):
 - Did I accomplish \$400 worth of work while spending only \$300?
 - Earned value adds a new dimension - what is the **VALUE** of work accomplished





Basic EVM Example

- Example (continued):
 - At the end of November I spent \$300 but only completed 2 Aquaria

Budget	Earned Value	Actual	Cost Variance
\$400	\$200	\$300	- \$100

- So I am not only overrunning Cost, I am also behind schedule!

Integrated Baseline Overview

- Key component of EVM is the Resource Loaded Schedule
 - Elements of the Performance Measurement Baseline (PMB) defined early in acquisition process by Government and Contractor
 - WBS Structure
 - Schedule
 - BOEs (justification for time phased costs and effort)
 - Time-Phased Budget / Resource Loaded Schedule initially defined for proposal and refined/baselined post negotiations
- Government review of PMB occurs via Integrated Baseline Review (IBR)



WBS Definition/Overview

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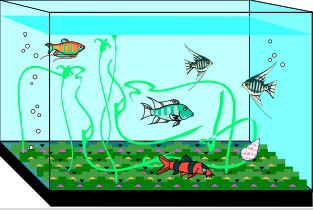
- Work Breakdown Structure (WBS): Product-oriented division of material and work tasks
- Used to organize and define product/work to be accomplished
- Different forms:
 - Program Summary WBS (Government), usually referred to as WBS
 - Contractor WBS, usually referred to as CWBS
 - Cost Element Structure (CES)
 - Level and scope may depend on the underlying data and methodology used in developing the estimate
 - WBS typically several levels higher than CWBS

OSD EVM Website: <http://www.acq.osd.mil/evm/>



WBS Importance to EVM

- WBS provides framework within which all Earned Value planning is accomplished
- WBS must be:
 - Comprehensive
 - Matches program content
 - Hierarchical
 - “Sufficient” level of detail
 - Sufficiency depends on size, complexity, risk, and other factors
 - For EVM, level of detail for *tracking* costs usually lower than level for *reporting* costs



WBS Example

- WBS Sample layout for the aquaria example
 - 1.0 Aquarium Development Program
 - 1.1 Program Management / Systems Engineering
 - 1.2 Design Aquarium
 - 1.3 Develop/Integrate Aquarium
 - 1.3.1 Material Acquisition
 - 1.3.2 Material Integration
 - 1.3.3 Development Documentation
 - 1.4 Test Aquarium
 - 1.5 Deploy Aquarium
 - 2.0 Aquarium Maintenance Program
 - 2.1 Maintain Environment
 - 2.2 Replace Material
 - 2.3 Maintain/replace Fish Population

NOTE: Example WBS is *not* comprehensive or extensively detailed.

This WBS does not adhere to MIL-STD-881C and therefore needs a comprehensive WBS Dictionary.

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Organizational Breakdown



Structure (OBS) Definition



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- Functional breakdown of Organization
 - Identifies the program's organizational structure
 - Supports the identification of the function responsible for controlling overhead costs
- Typically aligns with Company's Org Chart
- One piece of the framework used for planning resources
- One popular organization technique involved Integrated Product Teams (IPTs)
 - Multi-disciplined
 - Overarching IPT and Working-level IPT(s)



Defense Acquisition Guidebook,

https://akss.dau.mil/dag/DoD5000.asp?view=document&rf=GuideBook\IG_c10.3.asp

Assignment of Work - Control Accounts

- WBS cross-walked to OBS → Control Accounts
 - Identifies Responsibility
 - Result is Control Account (sometimes called a Cost Account)
-  Control Account is the focal point for integration of scope, cost, and schedule
-  Control Account Manager (CAM) is person responsible for:
 - Developing plan for Control Account (Technical Scope, Schedule Tasks, Budget/Resources)
 - Work Authorization Document (WAD)
 - Managing Earned Value performance within Control Account
 - Monitoring EVM metrics
 - Analyzing control account performance status
 - Reporting variances
 - Conducting risk management/mitigation as required

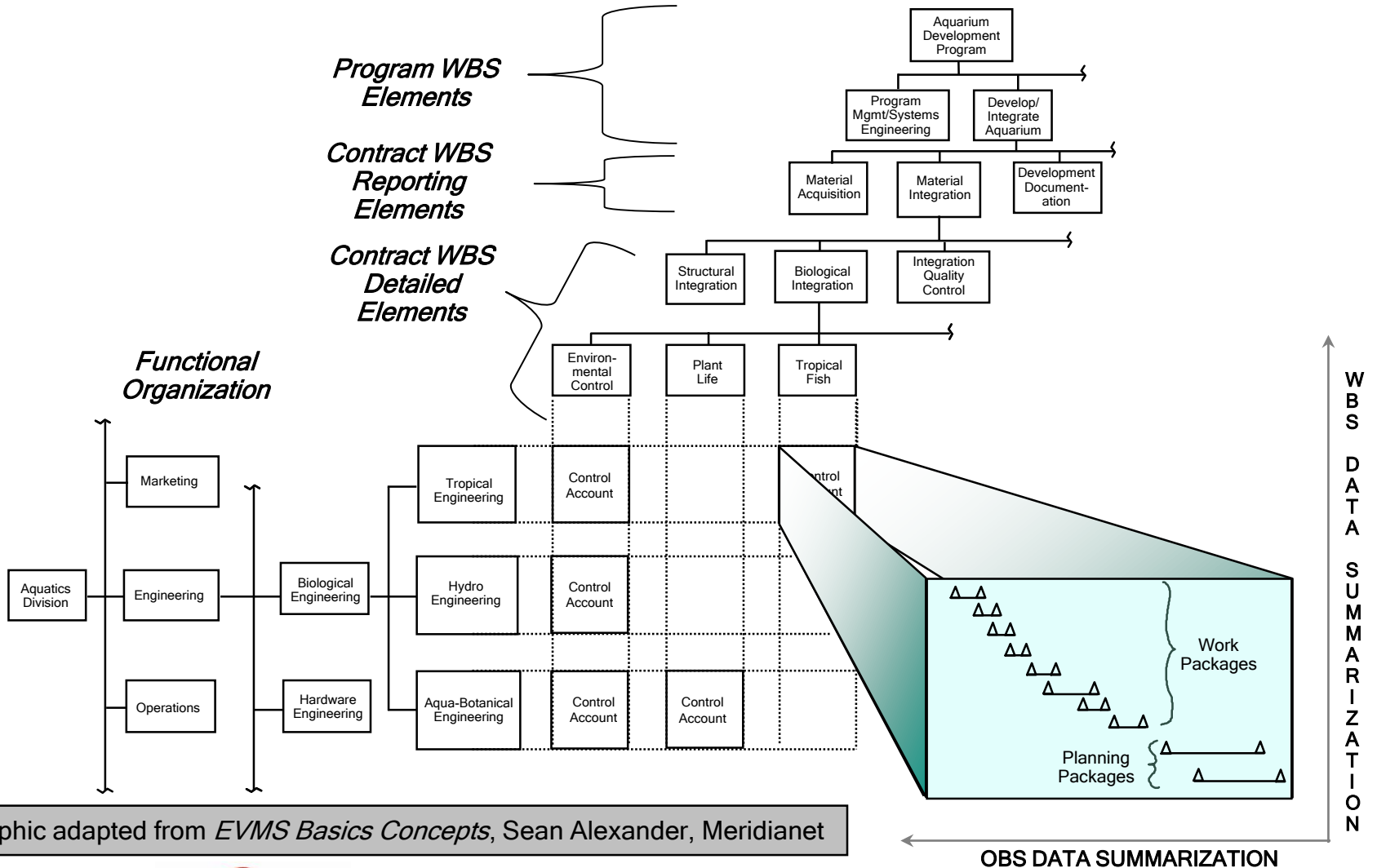
Assignment of Work - Work Packages

-  Work Packages are the lowest level at which resources are allocated
- Within Control Accounts, work and planning packages defined at lowest level of detail
 - Work packages for near-term work
 -  - Planning packages for far-term work
 - Planning packages become more detailed work packages as time progresses
- Resources allocated to each work/planning package
 - Direct Labor
 - Material
 - Other Direct Charges (ODCs)

Tip: Typically 4-6 weeks long

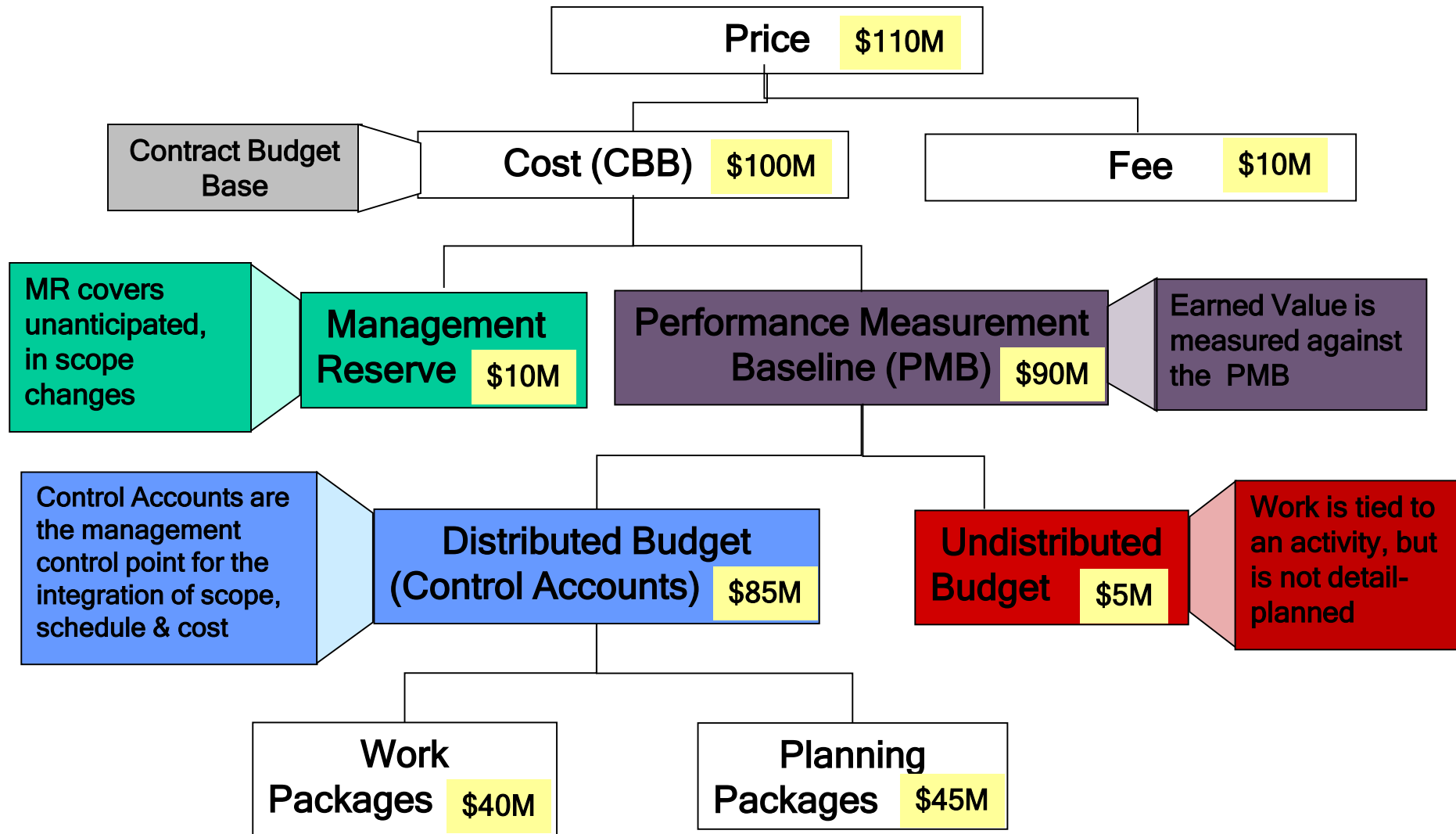
Tip: Detail plan typically 6 months out

Assignment of Work Illustration



Graphic adapted from *EVMS Basics Concepts*, Sean Alexander, Meridianet

Baseline Development



Baseline Development - PMB

- Performance Measurement Baseline (PMB) developed

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- Sum of all Work/Planning Package Budgets + UB



- Undistributed Budget (UB) is:

- Work tied to an activity, but not detail-planned
- Used most often when new work added to contract

- Earned Value is Measured against the PMB
- Work packages and related budget (BCWS) are time phased using logic-driven schedule
 - e.g., PERT chart showing dependencies

Tip: UB usually distributed within 60 days

Baseline Development - MR



- Management Reserve (MR) set aside while developing PMB

- Covers unanticipated, *in scope* changes

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- MR % tied to level of risk and type of contract

- 2-4% low risk and/or Cost Plus

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- 15%+ high risk and/or Firm Fixed Price

- More discussion on MR and its use is covered under the Analysis of Past Performance section

Tip: MR is most commonly 7-9% of CBB


Baseline Development - CBB

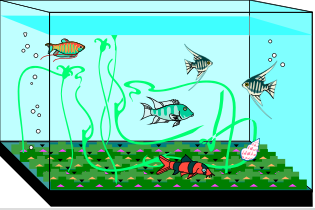
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- PMB and MR together form the Contract Budget Base (CBB) (“Cost”) 
- CBB plus fee yields the Total Contract Value (“Price”)
- A time-phased graphic illustrating PMB and MR forming CBB is on the next slide
- EVM should be complemented by a disciplined Risk Management (RM) approach to identifying, quantifying, and addressing unknown future events

“Integrating EVM and RM: A Statistical Analysis of Survey Results,” Alissa C. Kumley, Northrop Grumman Corporation, ISPA/SCEA Joint International Conference, 2005

Performance Measurement - EV Methods

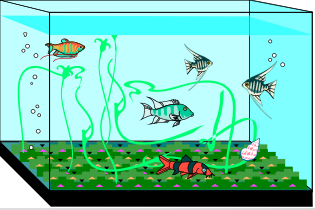
EV Method	Description	Type of Tasks that Use Method
 <u>Milestone</u> (Weighted)	Take performance as defined Milestones (MS) are accomplished. MSs can be weighted if one or more are considered more important	Tasks that can be planned using interim Milestones <div style="border: 1px solid black; background-color: yellow; padding: 5px; display: inline-block;"> Best Method for EVM </div>
Percent Complete	Performance is taken based on Percent of task completed	Work that does not have any reasonable interim measurable MSs
0/100	All performance is taken when task is complete	Short duration tasks - one month or less
50/50 Or X%/Y%	50% (X%) performance taken when task starts; 50% (Y%) performance taken when task is complete	Short duration tasks - two months or less
LOE	Plan based on resource expenditure plan – Performance always equals Plan	Used for tasks that are more time-oriented vice task oriented, such as Program Management



Example - Performance Measurement

- Determine the best earned value measurement technique:
 - Aquarium System Program Management
 - Aquarium Design
 - Aquarium Deployment to Site ATLANTIC

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Example - Performance Measurement

- Valid earned value measurement techniques:
 - Aquarium System Program Management
 - LOE - most common method
 - Milestone
 - Aquarium Design
 - Most likely Design will be divided into smaller work packages and multiple methods will be employed
 - Milestone / Weighted Milestone - most common method
 - Percent Complete
 - Aquarium Deployment to Site ATLANTIC
 - 0/100
 - X%/Y%
 - Milestone

Multiple Answers are Justifiable

Earned Value Analysis

- Elementary EV Analysis
- Analysis of Past Performance
- Variance Reports
- Projection of Future Performance
- Earned Value Review Process

Elementary EV Analysis

- Common calculated Data Elements:



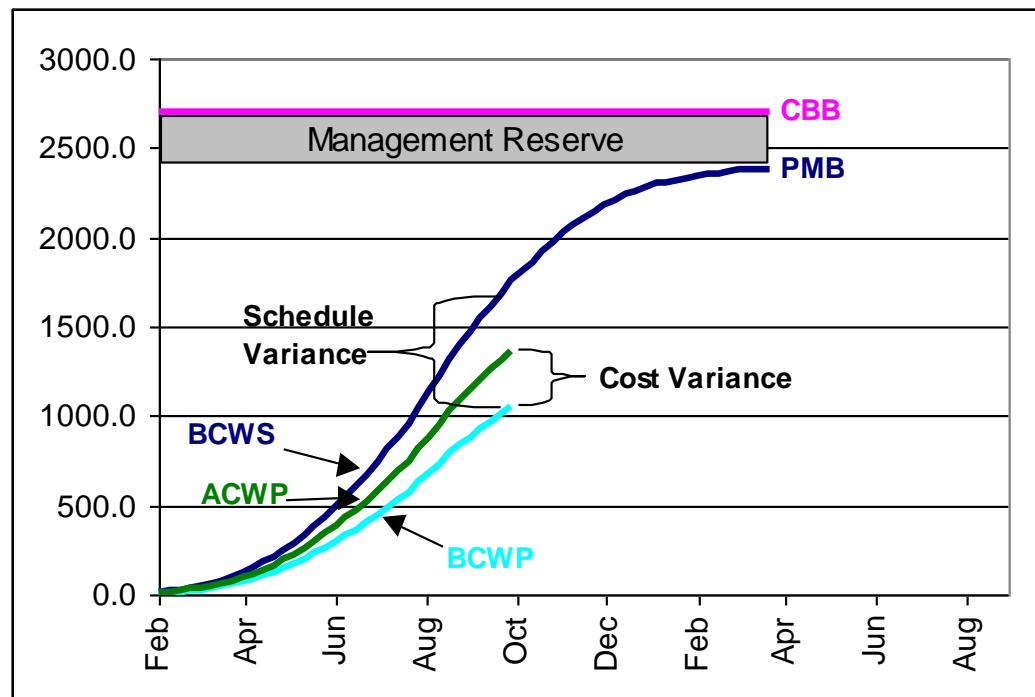
- Schedule Variance (SV) = BCWP - BCWS





AKA
Accomplishment
Variance



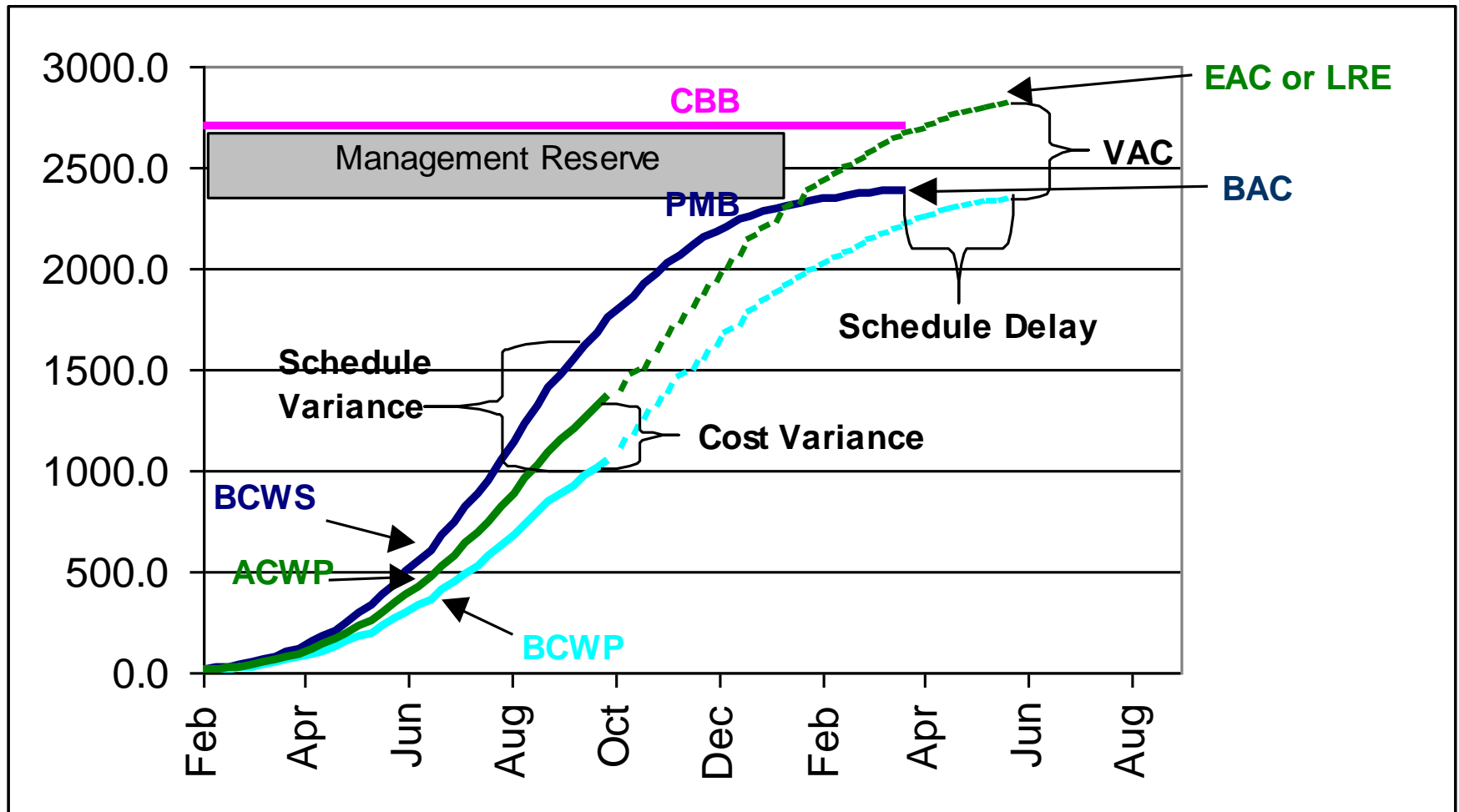
- Cost Variance (CV) = BCWP - ACWP



Elementary EV Analysis

- Common calculated Data Elements:
 -  - Variance at Complete (VAC) = $BAC - LRE$
 - Estimate at Complete (EAC)
 - Forecasting measure
 - Various methods applicable
 - Discussed in more detail later
 -  - Budgeted Cost of Work Remaining (BCWR)
= $BAC - BCWP$
- Analysis of data, including sample problems, in next section

Elementary EV Analysis



Projection of Future Performance

- Strength of EV is it enables the identification of problems early
- Recall that final CV will be worse than the cumulative CV at the 20% completion point
 - Look for tendency to circumvent EVM's purpose as an “early warning system”
 - Delays in admitting/discovering cost growth is likely to result in even greater cost overrun
- Various ways to analyze and project future performance
 - TCPI metric designed to lend credibility (or not) to contractor EAC (see future slide for more details)
 - Formula-derived EAC
 - Example: $EAC = ACWP + (BAC - BCWP) / CPI$
 - Based on EVM performance to date
 - Equivalent to CPI Forecast on next slide

Future Performance - EAC

- Objective, mathematical Estimates At Complete (EACs) can be calculated
- Most common are CPI and CPI * SPI
 - CPI Forecast
 - $ACWP + BCWR / CPI = BAC / CPI$
 - Assumes even cost performance across the entire project equal to performance experienced to date
 - Referred to as “best case” EAC
 - CPI * SPI Forecast
 - $ACWP + BCWR / (CPI * SPI)$
 - Also assumes that past cost and schedule performance are indicative of future performance
 - Adjusts estimate to account for schedule performance experienced to date
 - Referred to as “worst case” EAC

Estimate To Completion (ETC)