

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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16. Cost Management

EVM Overview

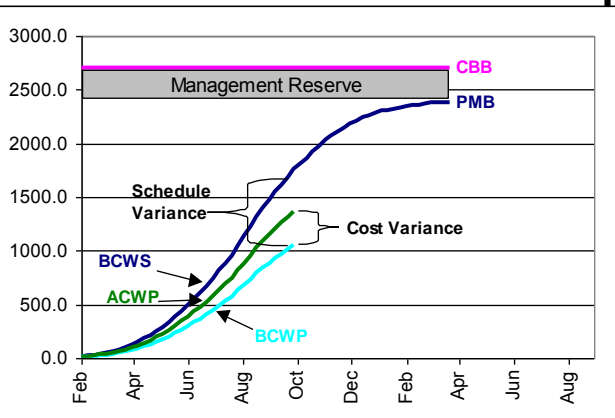
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|--|--|
| <ul style="list-style-type: none"> • Key Ideas <ul style="list-style-type: none"> - Integrated baseline <ul style="list-style-type: none"> • Resource-loaded schedule - Earned value <ul style="list-style-type: none"> • Objective progressing - 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

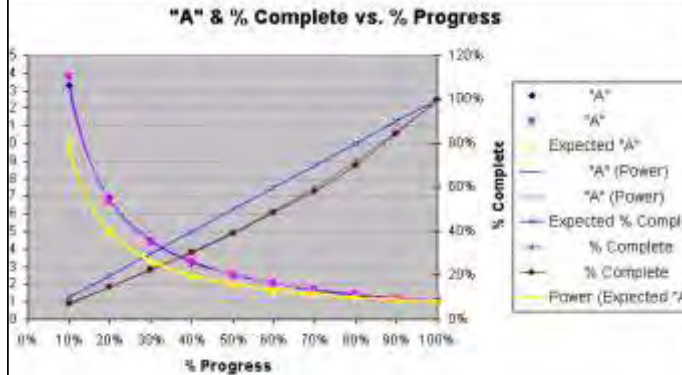
Past

Understanding your historical data



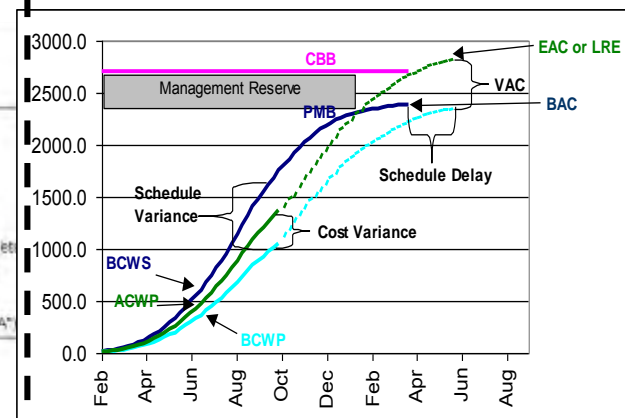
Present

Developing estimating tools



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
 - 20 - 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

EVM Outline

- Core Knowledge
 - Introduction to Earned Value
 - Earned Value Management (EVM) Components
 - Earned Value Analysis
- Summary
- Resources
- Related and Advanced Topics

Introduction to Earned Value

- EVM Objectives
- The EVM Bottom Line and Benefits
- EVM Not Universally Right
- EVM Guidance and Contract Requirements

What?

EVM Objectives



- Earned Value Management (EVM) integrates Technical Scope, Schedule, and Cost for definitized contract work



- Earned Value Management System (EVMS)
 - Planning tool
 - Reporting tool
 - Analysis and Decision Making tool
- Provides for integrated management of program planning and execution, which can enable...
 - Accomplishment of Technical Scope within Cost and Schedule parameters
 - Reduced or Eliminated Schedule Delay
 - Reduced or Eliminated Cost Overrun



Why?

The EVM Bottom Line

- Yeah, yeah...“integrated management” is great, but costs \$\$\$. Why should I really do it?
 - The cost avoidance window of opportunity is BEFORE contract is 15% complete
 - According to a study of more than 700 major DoD programs, percent overrun at completion will be within 10% of percent overrun at 20% complete

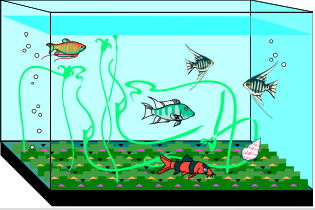
“Cost Performance Index Stability,” David S. Christensen and Scott Heise, National Contract Management Journal, 1993

- If you can't plan the near-term work well, you won't plan the far term work any better
- EVM requires all work *on contract* to be planned before beginning
 - Can provide early insight into areas of concern and opportunity

Key EVM Benefits

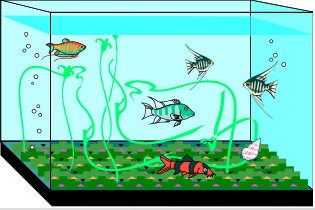
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- Imposes discipline on resource planning process through the development of work and planning packages
- Provides disciplined, standardized approach to measurement and terminology
- Ties cost and schedule performance to technical accomplishment of work
- Provides objective analysis of performance



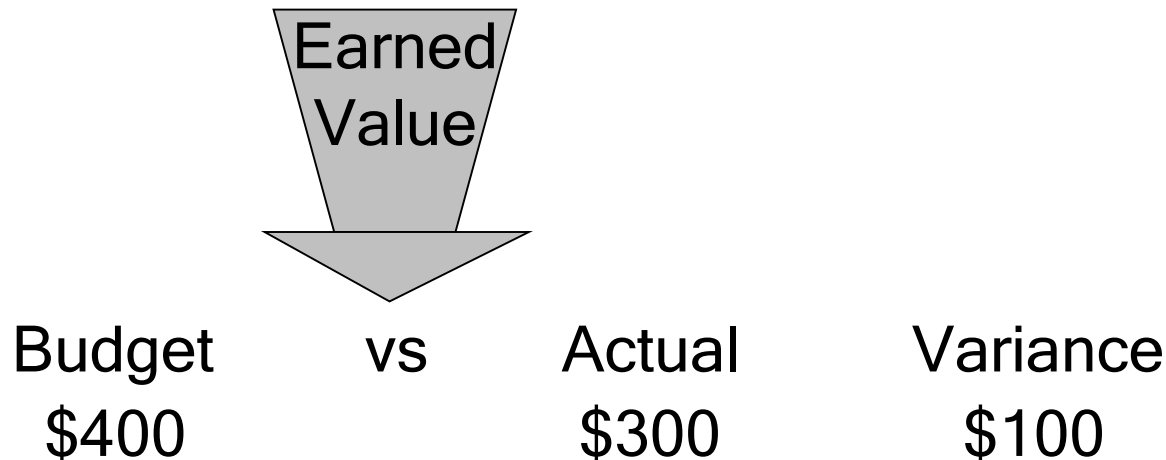
Basic EVM Example

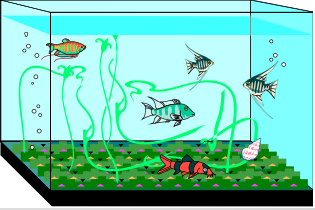
- Managing projects without earned value provides only part of the picture
- Traditional approach:
 - Budget work
 - Record Actual expenses
- Example:
 - Budgeted for 4 Aquaria to be built in November at \$100 each
 - At end of November, spent \$300
 - Great! I am \$100 under budget...or am I?



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!

When?

EVM Not Universally Right

- EVM costs time and money to implement
- EVM is not the best management tool for all projects
- EVM is best suited/most beneficial for projects with:
 - Defined deliverables/products
 - Longer durations
 - Guidance varies by organization
 - Due to set up time required
 - Strict budget limits or Firm Fixed Price (FFP) contracts
 - A single contract encompassing all or most of the effort
 - Few to no interfaces with or dependence on efforts contracted separately
- EVM less suited for projects with:
 - Difficult to define or open-ended objectives
 - Shorter durations
 -  Level of Effort (LOE) support hours as the primary deliverable

EVM is required on DoD and other government contracts above a certain threshold

EVM Guidance

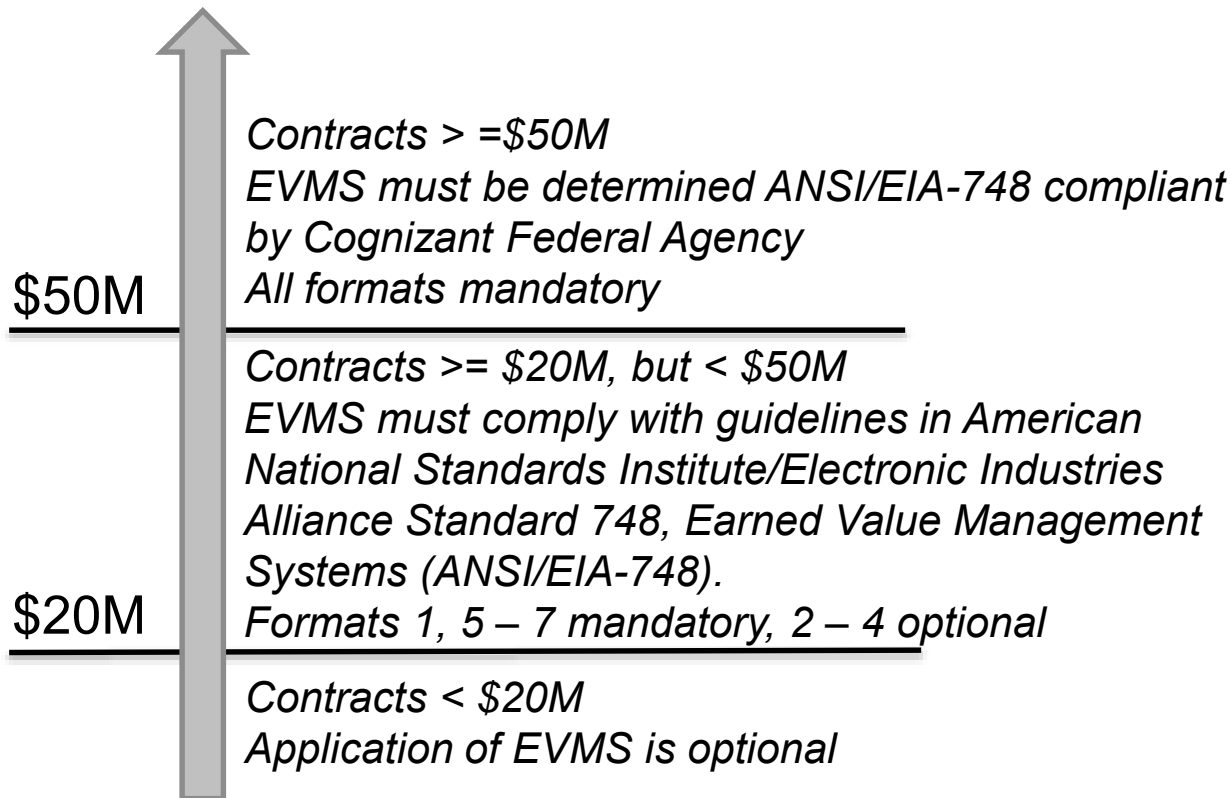
Policy Updated June 2012

How?

Contract Type	Risk Based Decision	Cost Reimbursement & Incentive Contracts (EVM on FFP, LOE & T&M Contracts Discouraged)		
Acquisition Funding	No Mandatory Requirements	Dollar thresholds are the same for all budget appropriation categories. Color of money is no longer an EVM discriminator.		
EVM System Requirements		Conformance with ANSI / EIA 748 Formal EVMS validation not required	Conformance with ANSI / EIA 748 Formal EVMS validation required	
EVM Data Requirements		Pre 7/1/2012	Contract Performance Report (DI-MGMT-81466) (Tailored) Integrated Master Schedule (DI-MGMT-81650) (Tailored)	Contract Performance Report (DI-MGMT-81466) (5 formats) Integrated Master Schedule (DI-MGMT- 81650)
		Post 7/1/2012	Integrated Program Management Report (DI-MGMT-81861)	Integrated Program Management Report (DI-MGMT-81861)
Contract Value 0 20 50				
(Then Year \$M)		Earned Value and the Acquisition Program, Prof Roberta Tomasini, DAU, 2008		

EVM Contract Requirements

- Per DFARS 252.234 and the DoD IPMR Implementation Guide, EVMS is required for cost and incentive contracts and subcontracts as follows:



Note: EVMS is less frequently used on Firm-Fixed Price, Level of Effort, and Time & Material efforts regardless of cost, as well as short duration contracts (e.g., $<$ 1 yr)

EVM within the Acquisition Process

GOVERNMENT

ACQUISITION STRATEGY

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NEGOTIATION
SOURCE SELECTION
AWARD PROJECT

DEVELOP
RFP

PROVIDER

DEVELOP
PROPOSAL

MGT VOLUME

TECH VOLUME

COST VOLUME

ESTABLISH
Perf Meas.
BASELINE

ASSESS RISK

DEVELOP MR

ASSIGN BUDGETS

Program Execution
& Performance
Measurement

STATUS
REPORTS

Earned Value and the Acquisition Program, Prof Roberta Tomasini, DAU, 2008

Earned Value Management (EVM) Components

- Integrated Baseline Overview
- Work Breakdown Structure
- Assignment of Work
- Earned Value Data Elements
- Baseline Development
- Performance Measurement

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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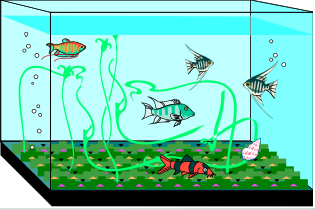
- Work Breakdown Structure (WBS): Product-oriented division of material and work tasks
- Used to organize and define product/work to be accomplished
- Different forms:
 - Program Summary WBS (Government), usually referred to as WBS
 - Contractor WBS, usually referred to as CWBS
 - Cost Element Structure (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=GuideBookIG_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

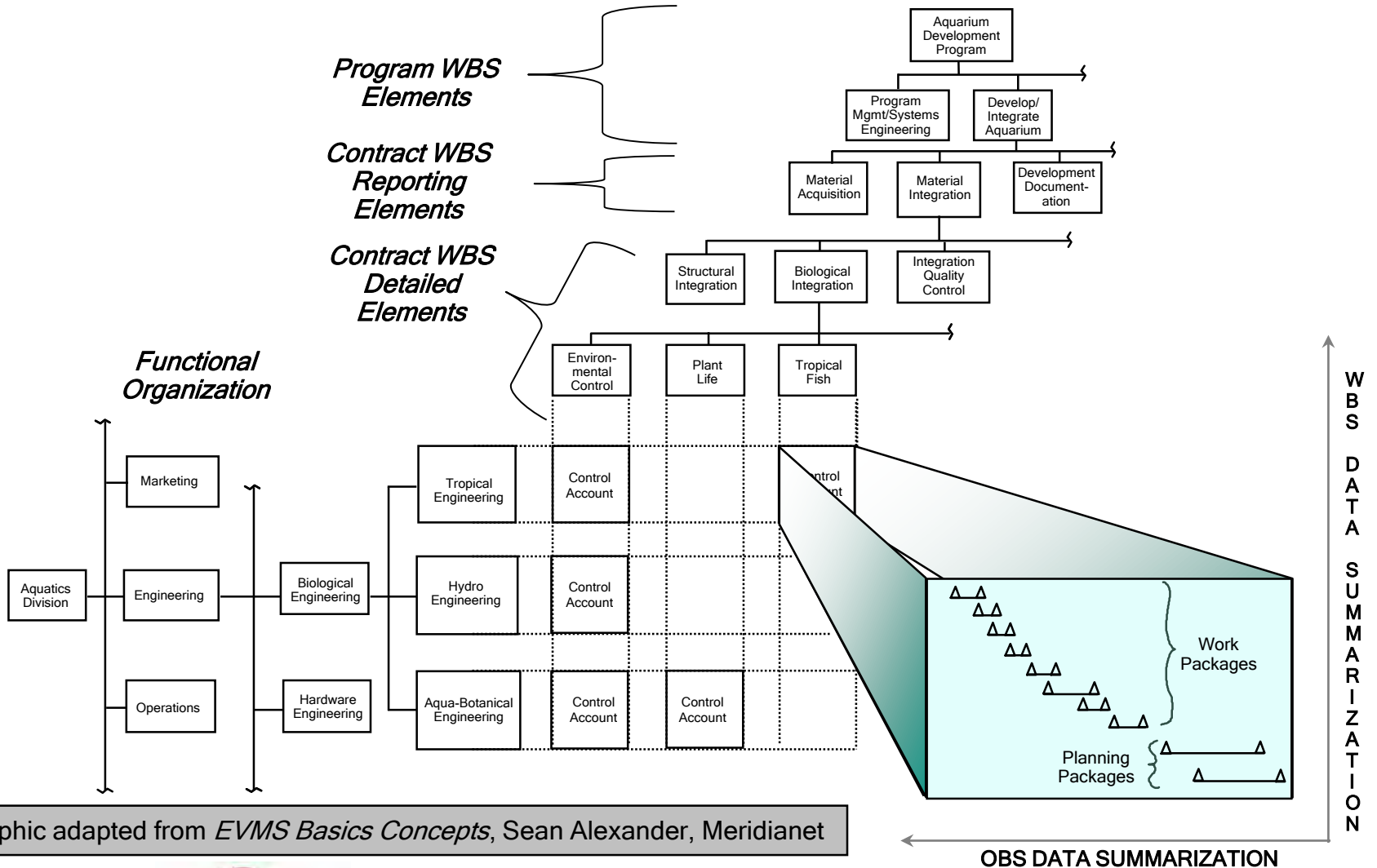
Assignment of Work - Work Packages

-  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

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

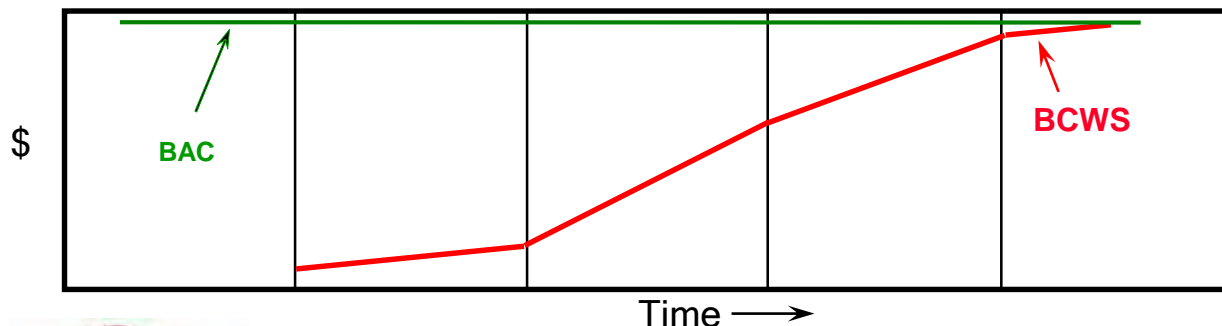
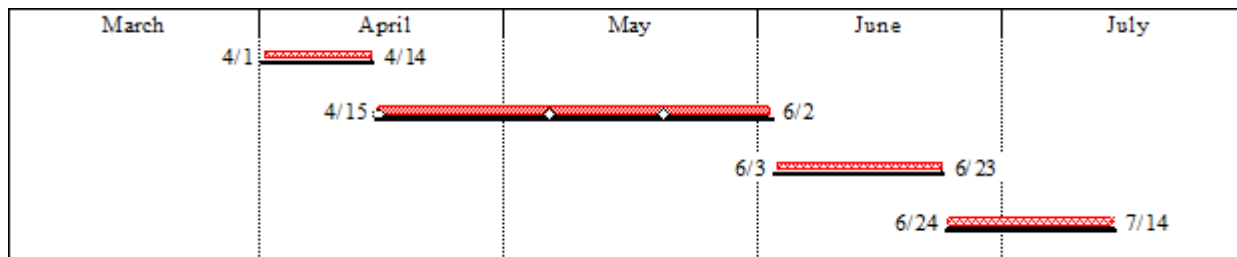
- The value of the work scheduled
- The baseline used to measure all performance
- The resource-loaded schedule



AKA Planned Value (PV)

- Picture a Gantt chart 

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Unit V - Module 15

BCWP (What Work Was Performed?)

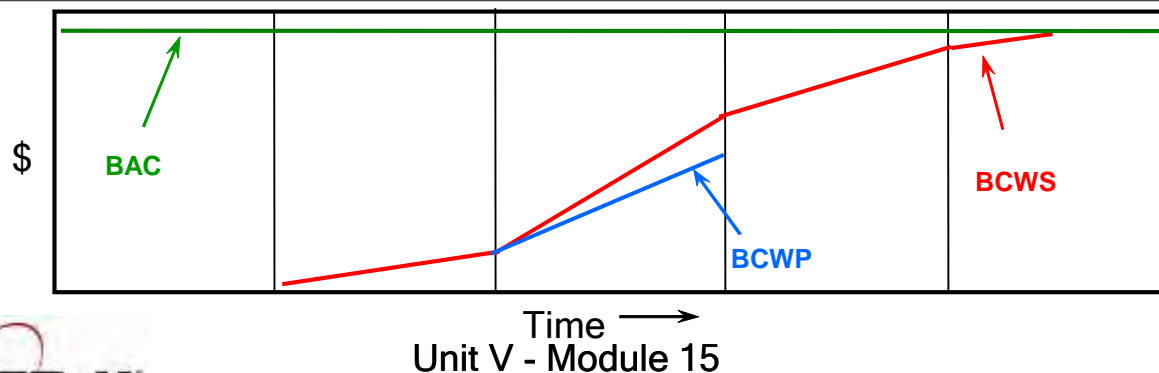
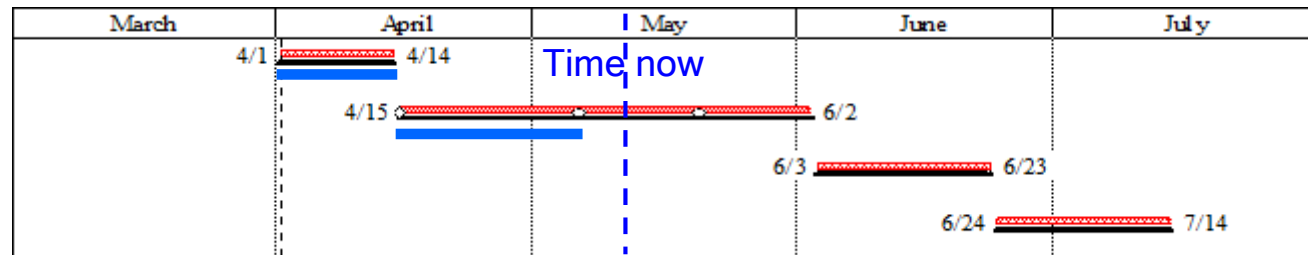


Budgeted Cost of Work Performed (BCWP): The sum of all budgets for completed work packages and completed portions of open work packages

- 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)



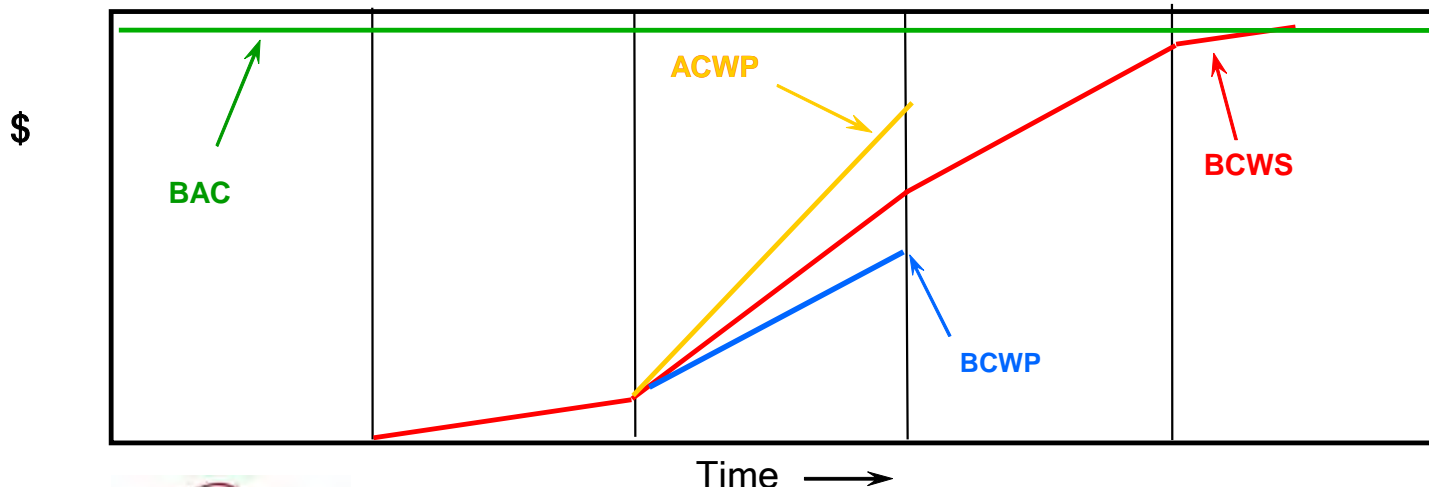
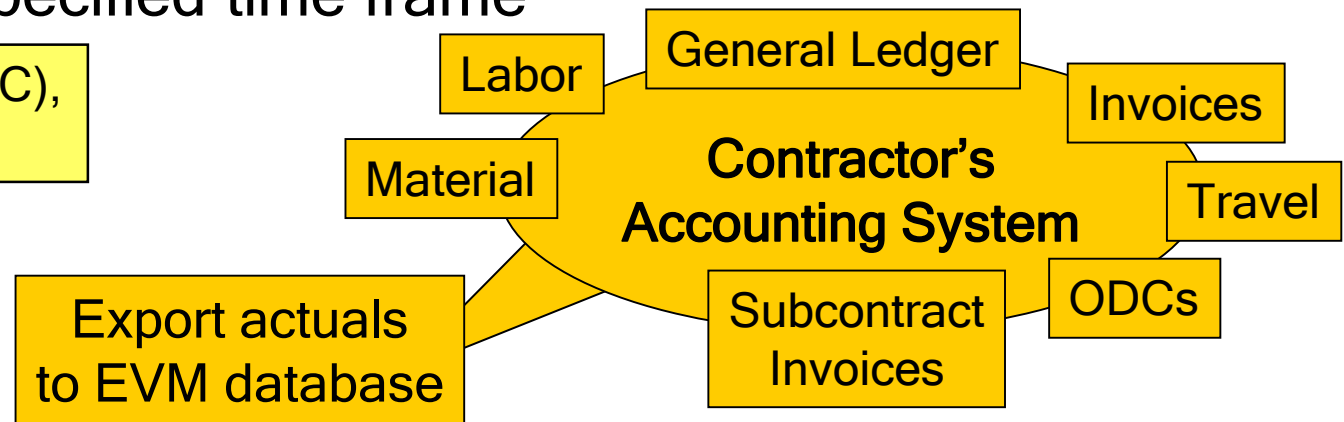
ACWP (Cost Incurred)



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



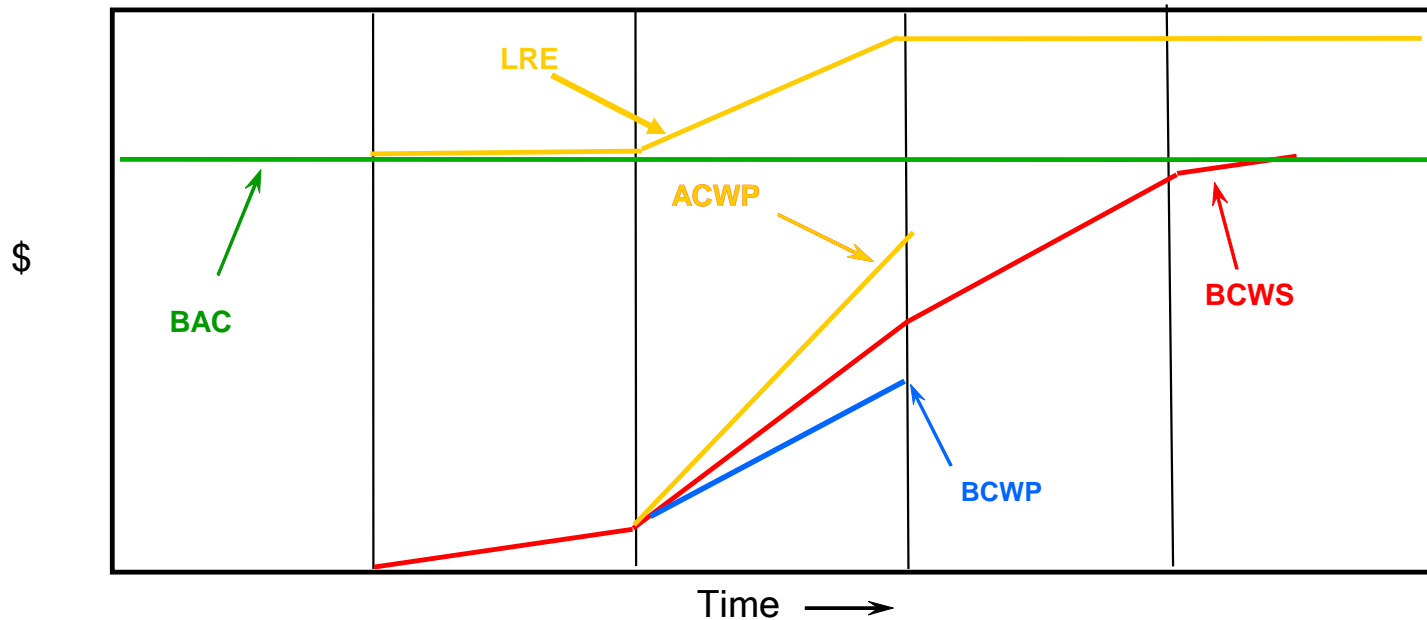
AKA Actuals (AC),
Actual Value



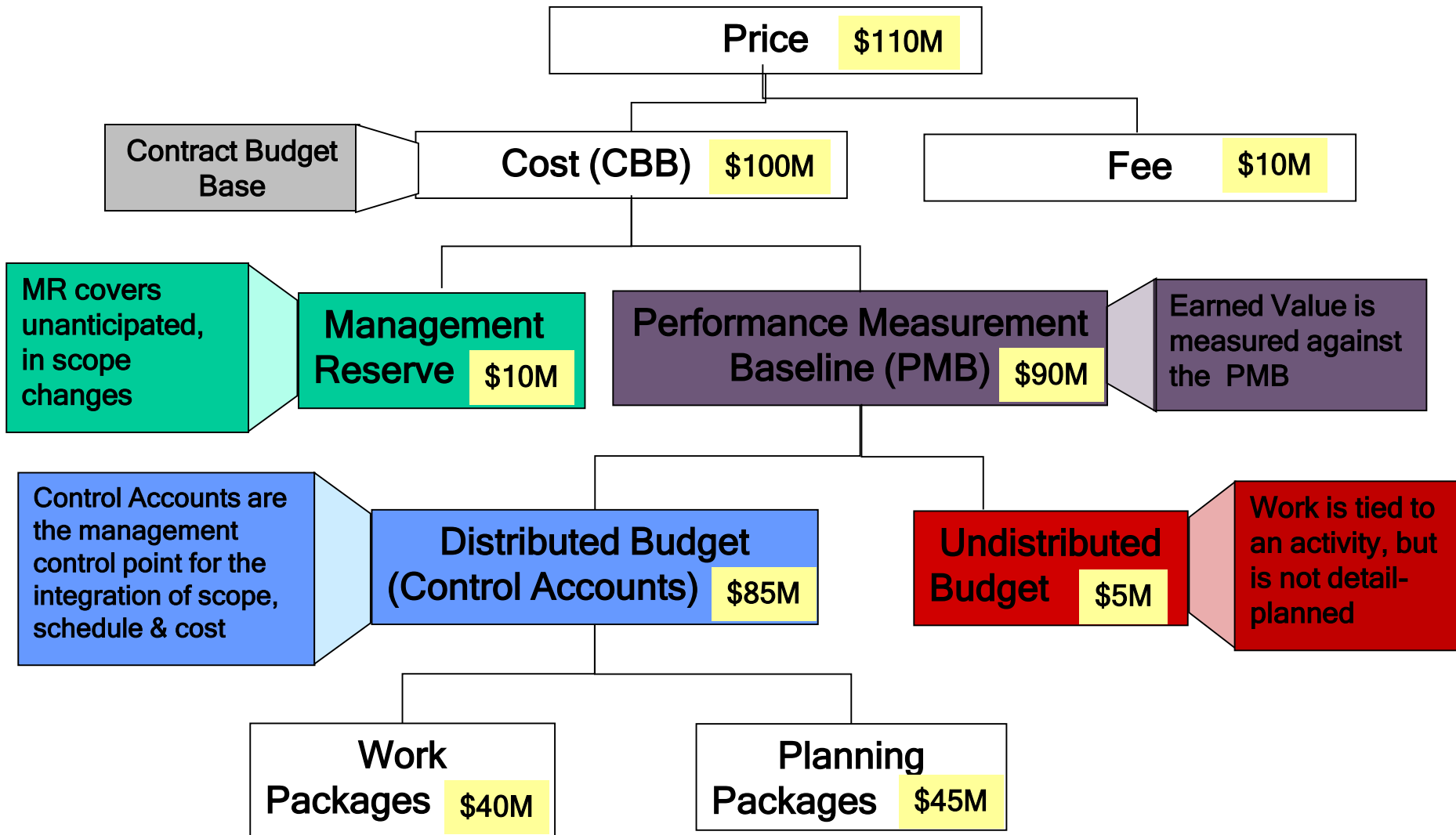
BAC and LRE (End of Work)



- 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



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

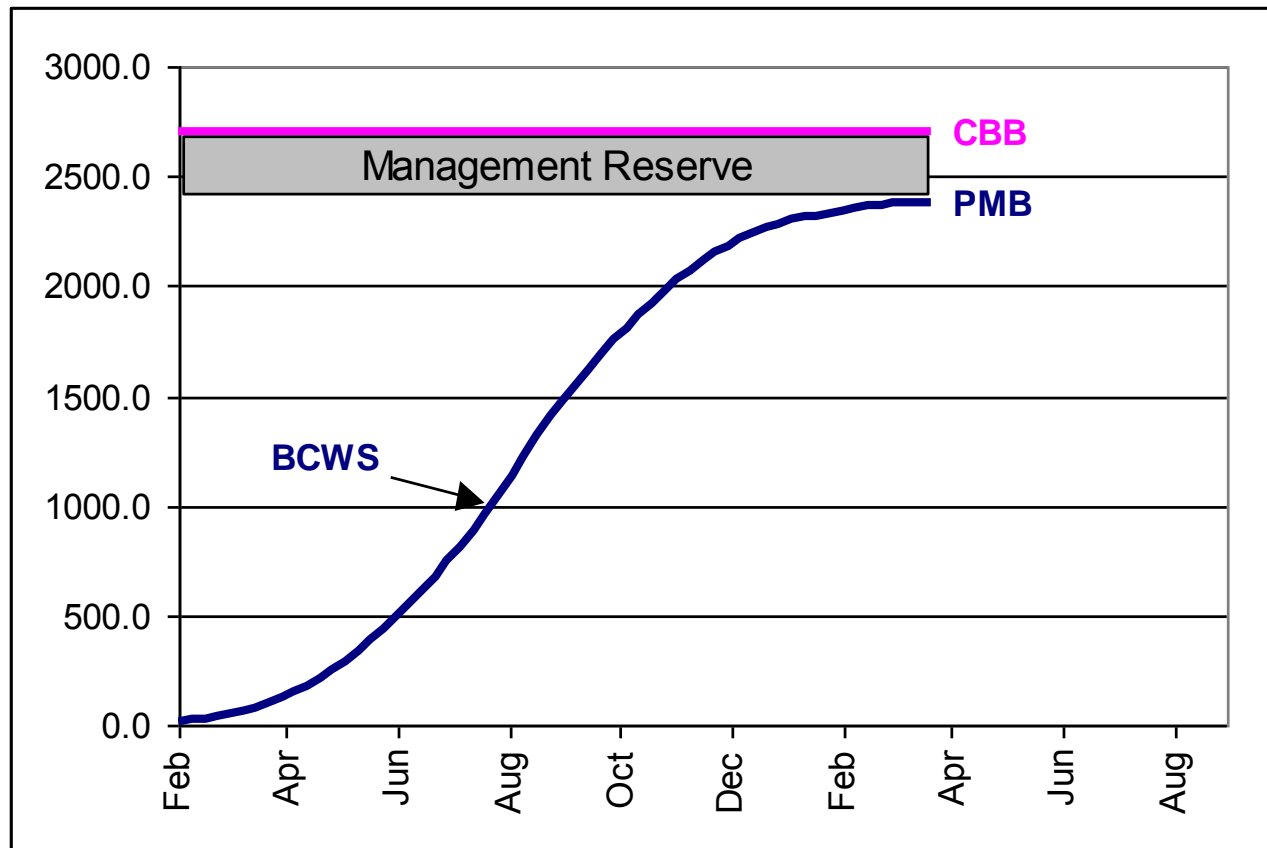
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- PMB and MR together form the Contract Budget Base (CBB) (“Cost”) 
- CBB plus fee yields the Total Contract Value (“Price”)
- A time-phased graphic illustrating PMB and MR forming CBB is on the next slide
- EVM should be complemented by a disciplined 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

Baseline Development


- Typical Phased Baseline (BCWS)




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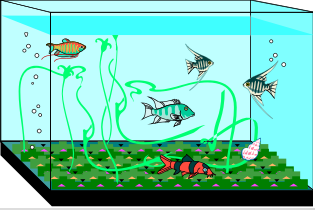
Tip: Cum PMB usually follows an S-curve.

Performance Measurement

- There are different ways to estimate progress of a project
 - Key issue is in-process work packages 
- Value is earned (BCWP) when corresponding work is accomplished
- When value will be earned is determined before beginning work using common performance measurement methods
- Assignment of method should strive to reduce subjectivity
- Table on next slide outlines:
 - Most common methods
 - When methods are typically employed

Performance Measurement - EV Methods

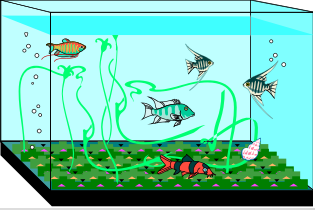
EV Method	Description	Type of Tasks that Use Method
 <u>Milestone</u> (Weighted)	Take performance as defined Milestones (MS) are accomplished. MSs can be weighted if one or more are considered more important	Tasks that can be planned using interim Milestones <div style="border: 1px solid black; background-color: 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:



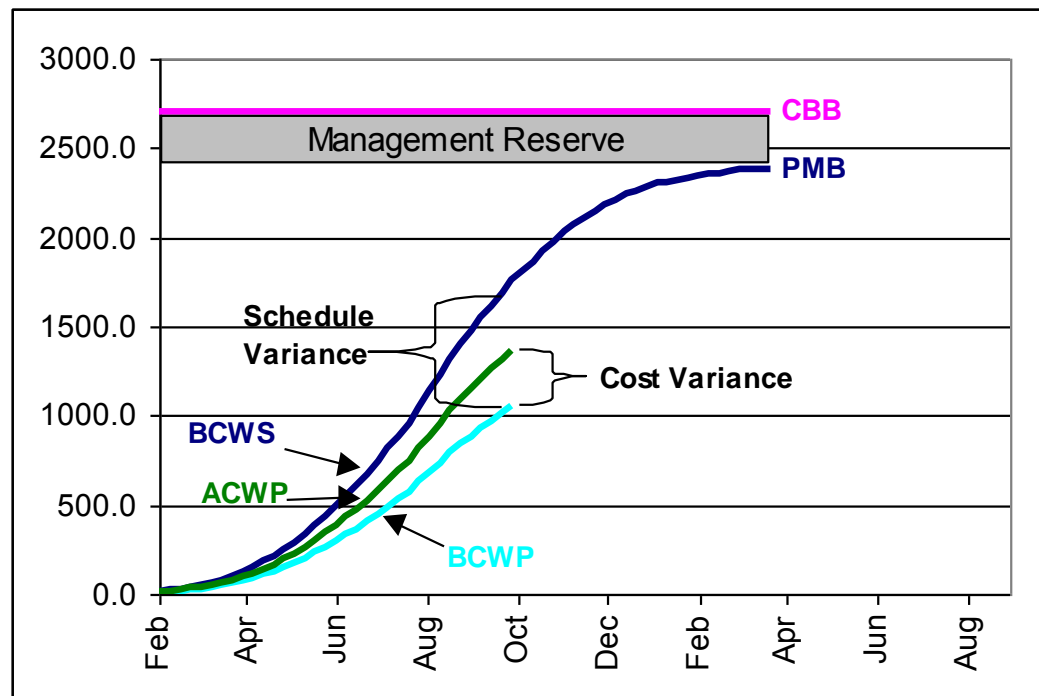
- Schedule Variance (SV) = BCWP - BCWS





AKA
Accomplishment
Variance



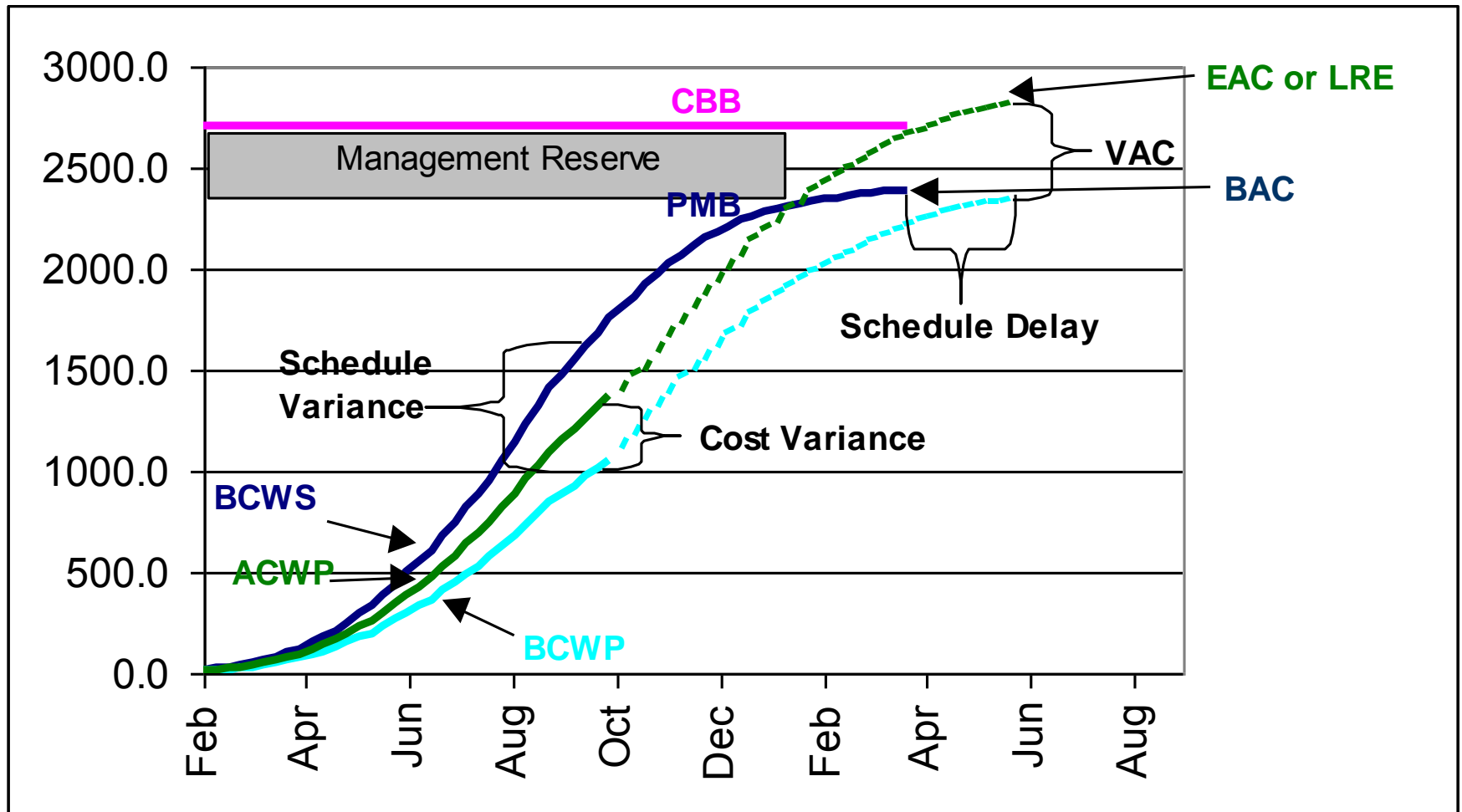
- Cost Variance (CV) = BCWP - ACWP



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



Analysis of Past Performance

- CV, SV, and VAC: Most common and simplest derived earned value data
- Examine current and cumulative data points and trends
 - Cumulative data points good for determining average performance
 - Current data points good for assessing current performance and for highlighting anomalies, errors in data, and error corrections
 - Trend lines good for assessing performance over time - Sudden trend changes should be examined

Analysis of Past Performance

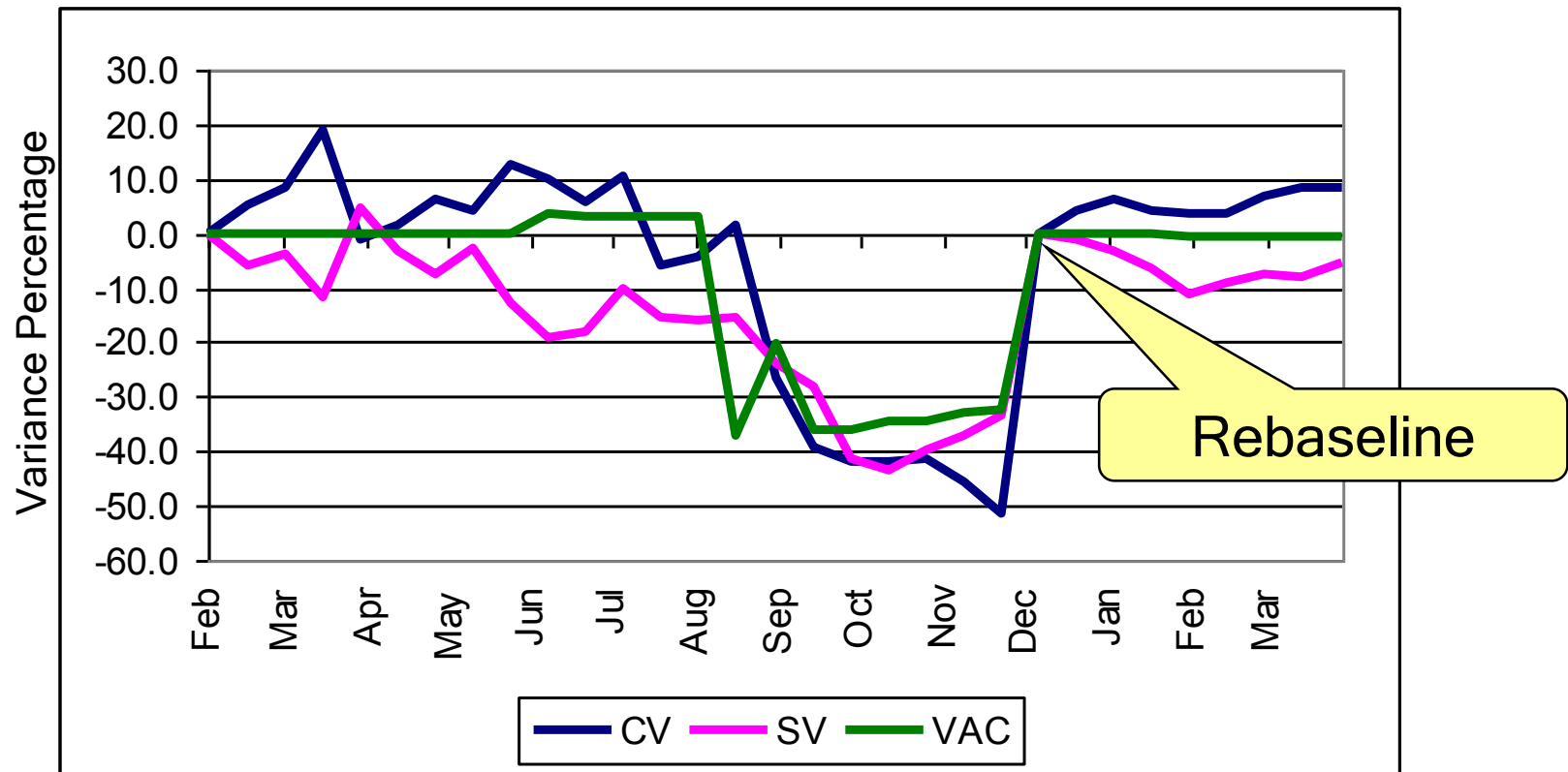
- Any variance over 10% is serious and should be examined
 - $CV \% = CV / BCWP = 1 - 1/CPI$
 - $SV\% = SV / BCWS = SPI - 1$
- Focus on CV and SV (vice VAC)
- Variances are natural
 - Explained and managed, but not eliminated
- Variances, and emerging or present trends, can erase with a rebaseline

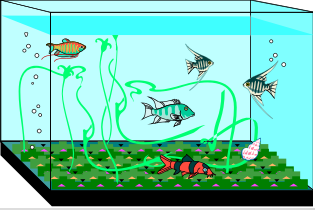
Tip: Sudden “healing” spikes in cum CV/SV typically mean a rebaseline has occurred

“Understanding Program Resource Management through Earned Value Analysis.” Falls Church, Va.: Abba Consulting, June 2006.

Analysis of Past Performance

- CV, SV, and VAC:





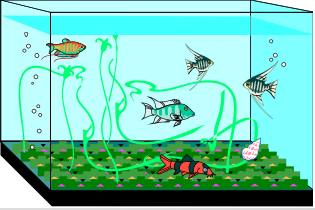
Example - Past Performance

- Sample problem:
 - Building 8 Aquaria
 - Budgeted for 4 to be built in Nov and 4 to be built in Dec at \$100 each
 - At the end of Nov, contractor spent \$300 and completed 2
 - Contractor now expects the project to cost a total of \$1000
 - For Month-end (ME) Nov, what is cumulative BCWS? BCWP? ACWP?
 - For ME Nov, what is cumulative CV? SV? VAC?
 - What are those variances telling us?

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Example - Past Performance

- Answers:
 - BCWS = \$400 BCWP = \$200 ACWP = \$300
 - CV = - \$100 SV = - \$200 VAC = - \$200
 - What are those variances telling us?
 1. Overrunning now, accomplished less than planned, expect overrun at complete, if task on critical path then expect a delay at complete - Facts based on data provided
 2. Do not expect to repeat overrun for Aquaria #3-8 because $VAC \neq 4 * CV$. Ask: Is this realistic? Why do they think overrun will not be repeated?
 3. Built 2 in one month, now expect to build 6 in next month - Unlikely - Ask: How do they plan to accomplish this *and* not spend more \$/system than budgeted
 - Begin to plan for how to cover current overrun *and* expected future overrun

Past Performance - Indices

- Cost Performance Index (CPI) and Schedule Performance Index (SPI) display variances on a units-free scale
 - CV of \$100 out of \$2M is nothing
 - CV of \$100 out of \$200 is significant
-  Cost Performance Index (CPI)
 - Ratio of work performed to actual costs
 - $BCWP / ACWP$
 - Used to determine the *value* of every dollar of work accomplished (bang for the buck)
 - **< 1.0 is unfavorable** **> 1.0 is favorable**
-  Reciprocal of CPI
 - Provides the final cost of dollar's worth of budgeted effort
 - EAC Calculations use reciprocal of CPI to scale budgeted effort up to an expected completion cost

Past Performance - Indices



- Schedule Performance Index (SPI)
 - Ratio of value of work performed to value of work planned
 - $BCWP / BCWS$
 - Used to determine the *efficiency* at which scheduled work is being accomplished
 - **< 1.0 is unfavorable** **> 1.0 is favorable**
- Analysis using CPI, SPI similar to that using CV, SV
- Table on next slide contains *possible* causes for CV/CPI and SV/SPI

Tip: Examine cost and schedule *together* graphically to assess visually how variances may be impacting one another.

Past Performance - Root Causes

+CV / CPI > 1.0	-CV / CPI < 1.0	+SV / SPI > 1.0	-SV / SPI < 1.0
<p><u>Work is costing less than planned:</u></p> <ul style="list-style-type: none"> - More efficient & using fewer hours/mat'l - Using less expensive labor category/mat'l - Achieved a technical breakthrough <p><u>Delay in payment.</u> Work complete but actuals have not hit ledger yet</p> <p><u>Incorrect status.</u> Took credit for work not actually completed</p> <p><u>Improper charging.</u> Took credit for work yet actuals were charged against the wrong account</p>	<p><u>Work is costing more than planned:</u></p> <ul style="list-style-type: none"> - Less efficient & using more hours/mat'l - Using a more expensive labor category/mat'l - Additional travel (ODCs)/Rework incurred - Rates (OH, G&A, inflation) increased - Encountered Technical problems <p><u>Incorrect status.</u> Did not take credit for work actually completed</p> <p><u>Improper charging.</u> Actuals were incorrectly charged against the account</p> <p><u>Requirements Change.</u> In scope contract requirement changed</p>	<p><u>Work is being accomplished faster than planned:</u></p> <ul style="list-style-type: none"> - More efficient & taking less time - Achieved a technical breakthrough <p><u>Work has been accelerated in the schedule.</u> Due to programmatic events, work has shifted forward</p> <p><u>Incorrect status.</u> Took credit for work not actually completed</p> <p><u>Baseline Mistake.</u> Incorrectly set work to occur later than it was supposed to</p>	<p><u>Work is being accomplished slower than planned:</u></p> <ul style="list-style-type: none"> - Less efficient & taking more time. - Encountered Technical problems <p><u>Work has slipped in the schedule:</u></p> <ul style="list-style-type: none"> - Due to programmatic events (late GFE, GFI, predecessor priorities, etc.), work has shifted right - Due to lack of resources, work has shifted right <p><u>Incorrect status.</u> Did not take credit for work actually completed</p> <p><u>Baseline Mistake.</u> Incorrectly set work to occur before it was supposed to</p> <p><u>Requirements Change.</u> In scope contract requirement changed</p>

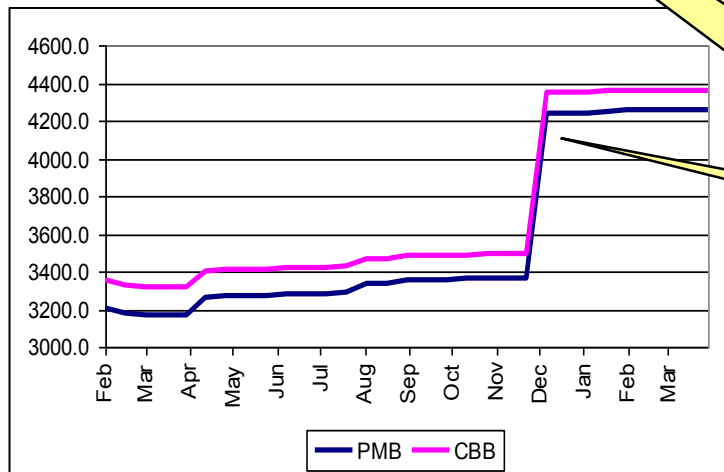
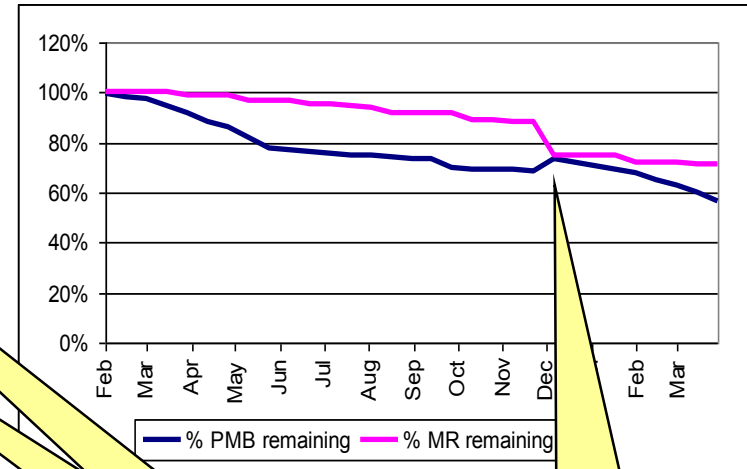
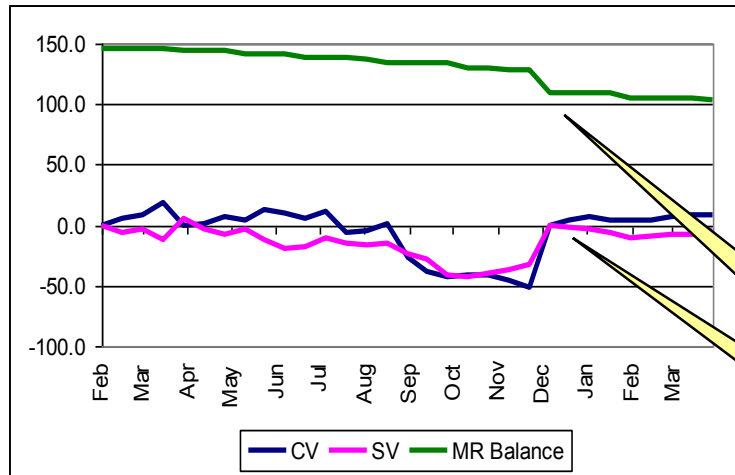
Past Performance - MR

- Use of Management Reserve:
 - Should have a technical reason to apply MR
 - Should not be used to fix negative cost variances
 - MR usage could be an indicator of problems
 - Helpful MR graphs:
 - MR use with CV and SV to assess visually if MR being used to cover problems
 - % MR remaining with % PMB remaining to assess visually if MR is expended at rate similar to how program is executing (Alternative: MR Balance vs. BCWR)
 - Graph CBB vs. PMB - As MR is used and incorporated into the PMB, the CBB and PMB lines will merge

Tip: It is good to have some MR left at end of contract to cover approved rate changes that can occur 3-4 years later

Past Performance - MR

- Use of Management Reserve:



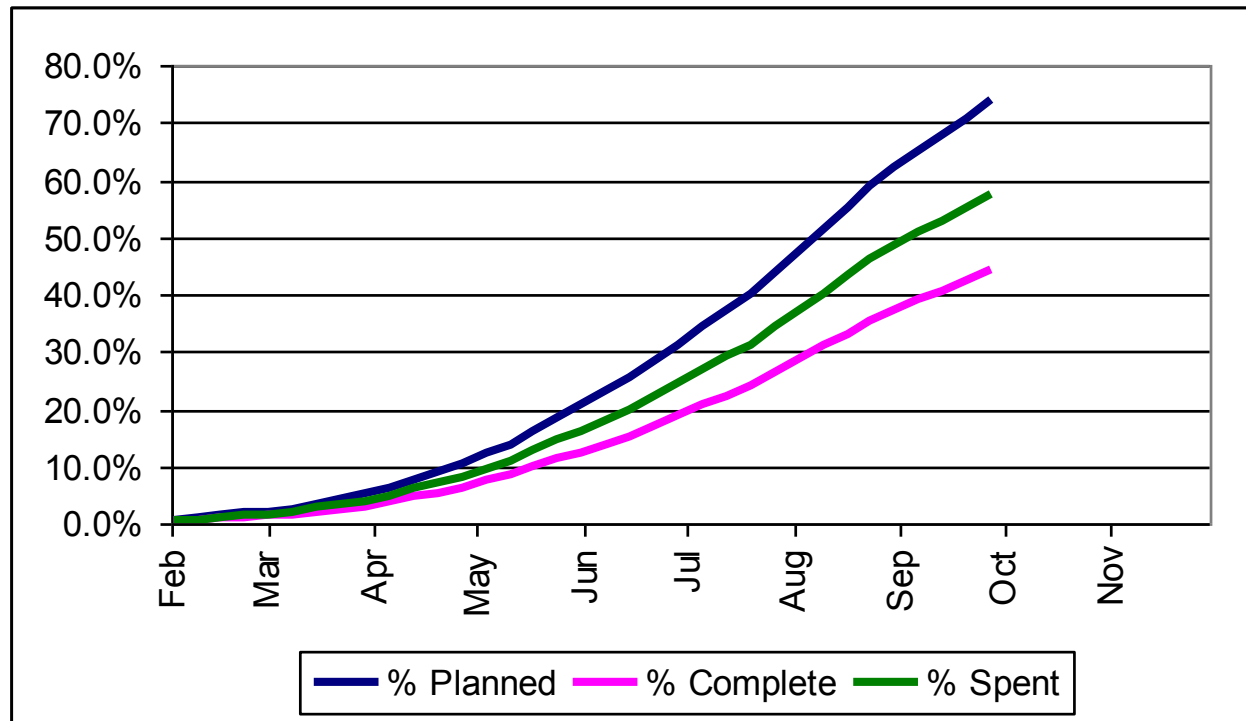
Rebaseline

Past Performance - Percentages

- Other useful data:
 - % planned = $BCWS / BAC$
 - % complete = $BCWP / BAC$
 - % spent = $ACWP / BAC$
- Conduct analysis such as
 - % planned >> % complete? **Problem!**
 - % spent >> % complete? **Problem!**
 - % of MR used >> % complete? **Problem!** (unless % complete close to 100%)
 - Master schedule shows % complete >> or << Earned Value % complete? Possible problem - an indication that Schedule and EV are not in sync

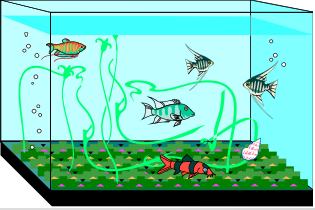
Past Performance - Percentages

- Graph of % planned, % complete, % spent same as graph as BCWS, BCWP, ACWP but on a “unit-free” scale



Past Performance - Anomalies

Anomaly	Concern
BCWS = BCWP = ACWP (and $\neq 0$)	Not really using Earned Value - "Perfect data"
BCWP > 0, ACWP = 0	"Free" performance
BCWP > 0 and BCWS = 0	BCWP is dependent on BCWS, so why is there performance without planned performance
ACWP > 0 and BCWP = 0	What is being paid for without getting any performance?
BCWP or BCWS > BAC	> 100% complete? > 100% planned?
BAC > 0 and EAC = 0	Work is planned (BAC/BCWS), but costs are expected to come in at \$0 (EAC/ACWP)?
EAC > 0 and BAC = 0	Cost (EAC/ACWP) are expected for element that has no planned value (BAC/BCWS)?
BCWS, BCWP, ACWP negative	Negative ("giving back") plan, performance, actuals
BAC < 0 and/or EAC < 0	Negative (contractor giving to Government) total plan (BAC) and/or total expected plan at complete (EAC)



Example - Past Performance

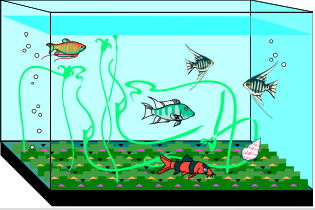
- Sample Problem:

BCWS = \$400 BCWP = \$200 ACWP = \$300

BAC = \$800 LRE = \$1000

- What percent of my budget has been spent to date?
- For every \$ I spend, how much value am I receiving?
- I have used 50% of my MR to date. Should I be concerned about having sufficient MR to complete program?

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Example - Past Performance

- Answers:
 - What % of my budget has been spent to date?
 - % spent = $ACWP / BAC = \$300 / \$800 = 37.5\%$
 - For every \$ I spend, how much value am I receiving?
 - $CPI = BCWP / ACWP = \$200 / \$300 = 0.67$
 - For every \$1 spent, I receive 67 cents of value
 - I have used 50% of my MR to date. Should I be concerned about having sufficient MR to complete program?
 - % complete = $BCWP / BAC = \$200 / \$800 = 25\%$
 - Yes, I should be concerned
 - Using MR twice as fast as I am completing work
 - Only $\frac{1}{4}$ of the way through the program (relatively early)

Variance Reports



- Variance reports (CPR Format 5 or similar report) are critical to earned value analysis process
- Variances should be *explained* at WBS level lower than *reporting* level



Warning: Variance reports written at a summary level make it difficult to pinpoint to which cost element(s) the explanation refers.

- Key elements in a variance report include:
 - Where is variance (WBS, labor/material, etc.)
 - Cause
 - Impact (CV or SV, and impact on VAC (Cost) and/or impact on completion date (Schedule))
 - Action plan (what and when)

Variance Reports

- Typical variance reporting thresholds:
 - IPMR Format 5: Top 15 WBS elements
 - (+) / - 10% and/or \$X
 - %/\$ thresholds that increase with % complete
 - PM's "Top 10" or "Critical" tasks
- Focus tends to be on negative (-%/\$)
- Important to look at "good performers" (+%/\$)
 - Areas of opportunity
 - Can reprogram resources to support problems and/or to accelerate schedule
- Variance reports actions should be captured and tracked in risk mitigation process

Future Projections

- Projections of Future Performance
- Estimate at Complete
- To Complete Performance Index
- Latest Revised Estimate
- EAC 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)

Future Performance - EAC

- Emphasis today is for government Program Offices to develop EACs independent of the EVMS
- Contractor LRE includes their assessment of cost risk, optimism, and only covers work on contract
- Independent EAC includes Government assessment of cost risk, less optimism, and work to be put on contract in the future
 - Should have technical input and buy-in from the Program Team
 - Sometimes equivalent to a revised cost estimate

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Future Performance - EAC

- If done correctly, the EAC:
 - Generates a credible story for time phased budget submissions and for providing direction to the contractor
 - Helps avoid FY funding surprises
 - Allows team to focus on corrective actions
- If EAC calculated outside of the EVMS, can use Earned Value data to assess the reasonableness of the EAC

Future Performance - TCPI

- What is our (implicit) predicted future performance based on data reported?
- Use the To-complete Cost Performance Index (TCPI)



Warning: EVA does *not* typically include cost estimating methodologies (e.g., learning curve)

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- $TCPI_{BAC}$ and $TCPI_{LRE}$

- Ratio of remaining work to complete to remaining \$ available to be spent to achieve the BAC (or LRE)

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- $TCPI_{BAC} = BCWR / (BAC - ACWP)$

- $TCPI_{LRE} = BCWR / (LRE - ACWP)$

- Can also calculate TCPI for EAC forecasts

- “Indicator of the goodness” of the LRE/EAC

Future Performance - TCPI and LRE

- $TCPI_{LRE}$ most common to analyze because it reflects what the contractor thinks about their future performance
- Compare TCPI to CPI
 - $TCPI < CPI$
 - Implies lower productivity is assumed for remaining work
 - If significantly lower, Ask: What additional overrun are you anticipating in the future?
 - $TCPI > CPI$
 - Implies higher productivity is assumed for remaining work
 - If significantly higher, Ask: What measures are you taking to improve productivity so greatly?
 - Significantly higher TCPI causes validity of EAC to be in question

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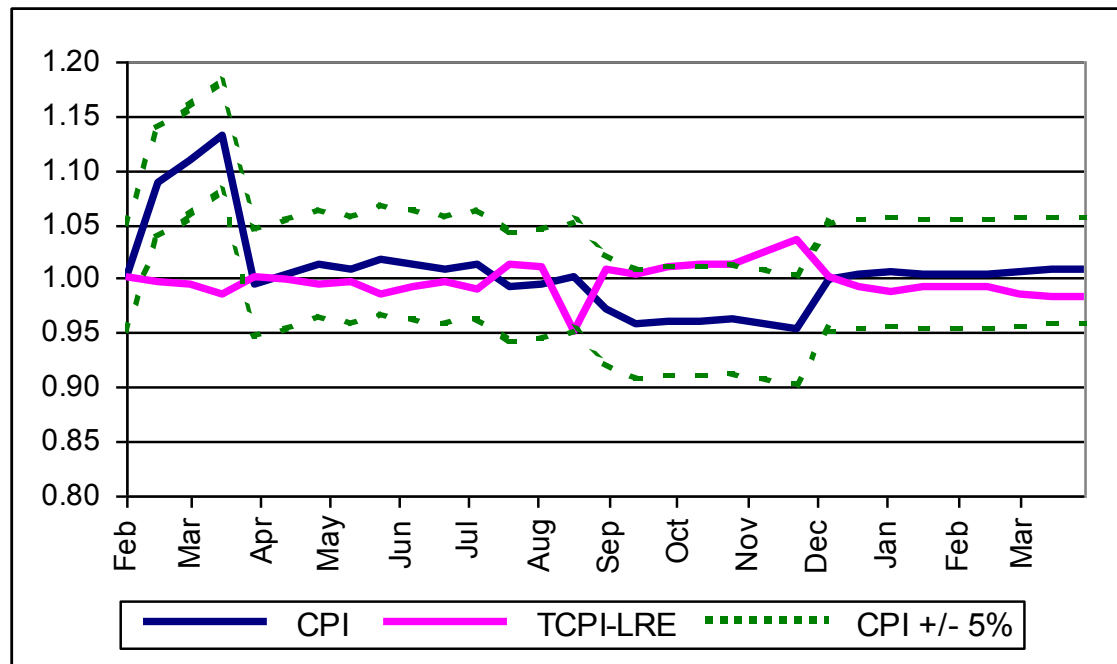
Tip: $TCPI_{LRE}$ greater than Cum CPI by more than 5% (0.05) is excessively optimistic

Future Performance - LRE

- Can use Earned Value data to assess the reasonableness of the Contractor's LRE (e.g., TCPI to CPI comparisons)
- Contractor typically uses estimating methods outside of EVMS to estimate the LRE (e.g., bottom-up analysis of remaining work)
- When analyzing LRE reasonableness, be aware that LRE also typically includes human input regarding future performance
 - Good: can account for special situations
 - Bad: incorporates optimism that may be unintentionally exaggerated

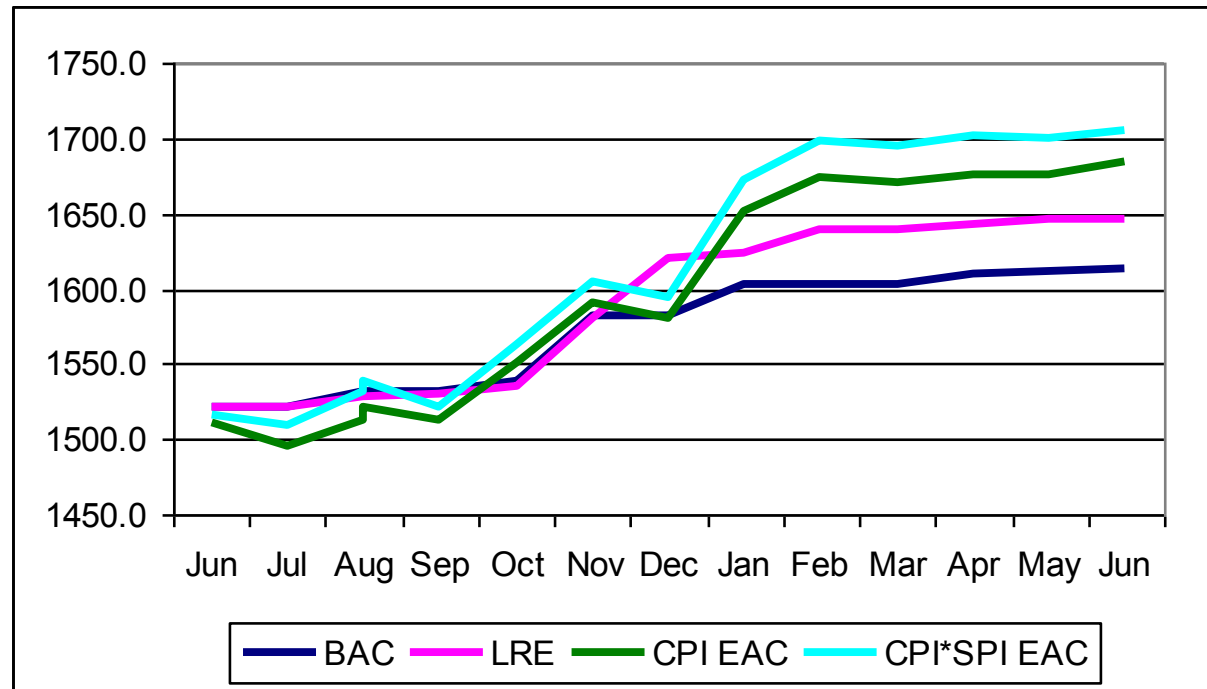
Future Performance - Graph

- Graph CPI and TCPI to see how similar the lines are over time.
- Helpful to include 5% delta line for CPI

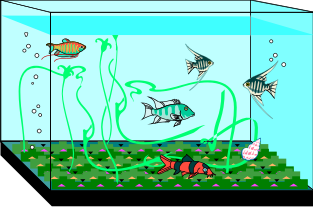


Future Performance - Graph

- Graph EACs with BAC and LRE to view trends



- More information on the EAC is contained in Advanced Topics



Example - Future Performance

- Sample Problem:

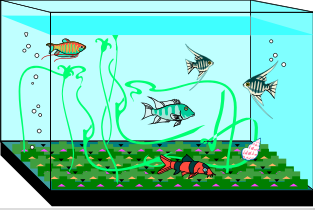
BCWS = \$400 BCWP = \$200 ACWP = \$300

BAC = \$800 LRE = \$1000

- What is the TCPI to achieve the LRE?
- Is the LRE reasonable?
- Using independent forecasts, what is the “best case” EAC? The “worst case” EAC?

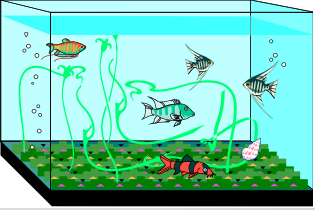
13

Example - Future Performance



- Answers:
 - What is the TCPI to achieve the LRE?
 - $TCPI_{LRE} = BCWR / (LRE - ACWP)$
 $= (800 - 200) / (1000 - 300)$
 $= 600 / 700 = 0.86$
 - Is the LRE reasonable?
 - CPI = **0.67**; TCPI-LRE = 0.86
 - $TCPI_{LRE}$ is more than 5% higher than CPI
 - LRE may not be reasonable
 - Need to investigate reasoning behind CPI and assess the reasonableness of the plans for improving performance so drastically

Example - Future Performance



- Answers (continued):
 - Using independent forecasts, what is the “best case” EAC? The “worst case” EAC?
 - Best Case EAC = CPI Forecast
= BAC / CPI
= $800 / 0.67 = 1200$
 - Worst Case EAC = $CPI * SPI$ Forecast
= $ACWP + BCWR / CPI * SPI$
= $300 + (800 - 200) / (0.67) * (0.5)$
= 2100

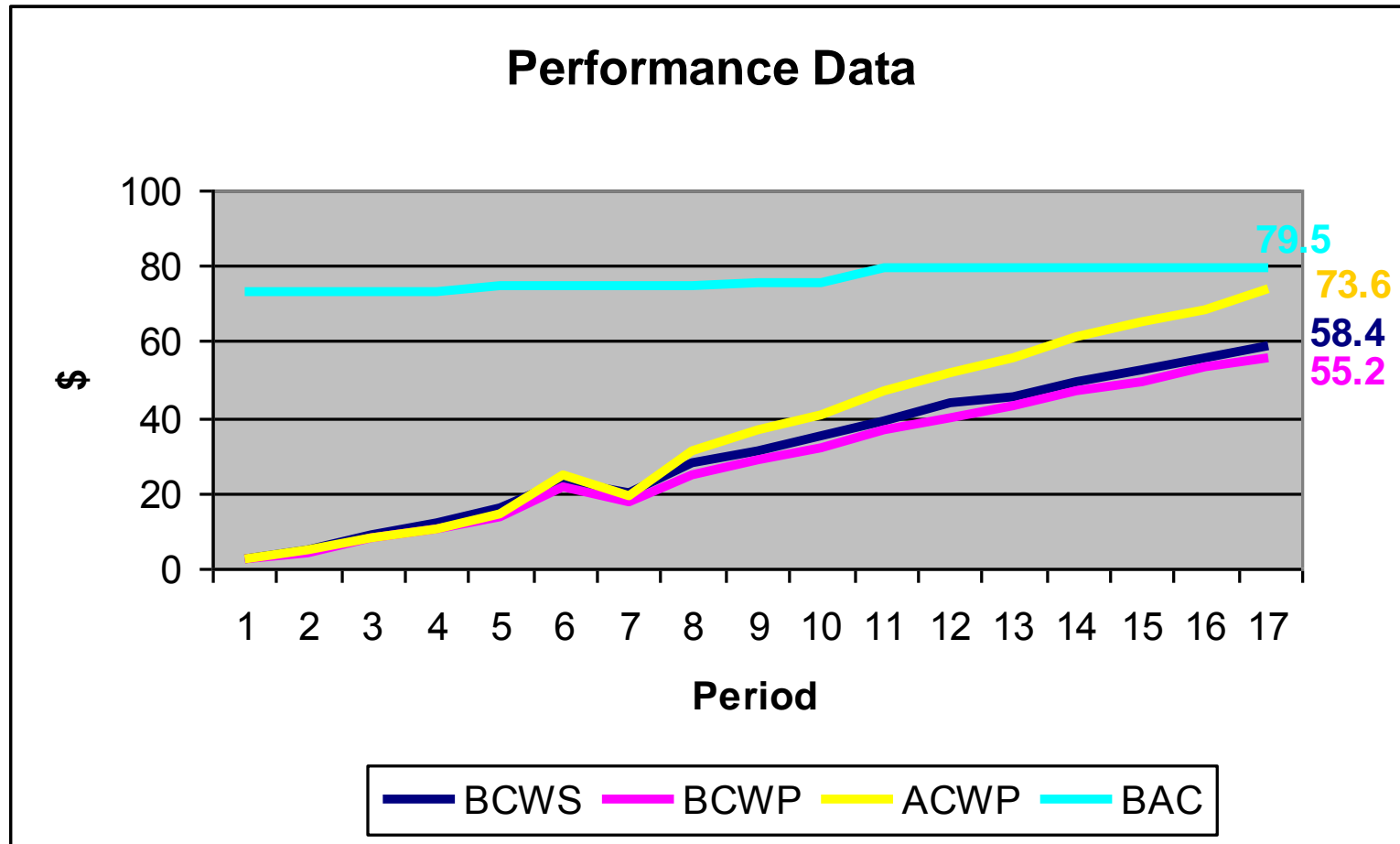
Future Performance - Other

- Other LRE data to consider:
 - ACWP > BAC
 - Is an ECP “in the works” but not yet on contract?
 - Is this all overrun?
 - Happens frequently when % complete approaches 100%
 - Greater concern when % complete < 80%
 - ACWP > LRE
 - Forecast must be updated (also could be “in the works”)
 - Do we expect a corresponding BAC change due to an ECP or is this all overrun?
 - Happens frequently when % complete approaches 100%
 - Should happen less frequently than ACWP > BAC if LRE is updated on a regular basis

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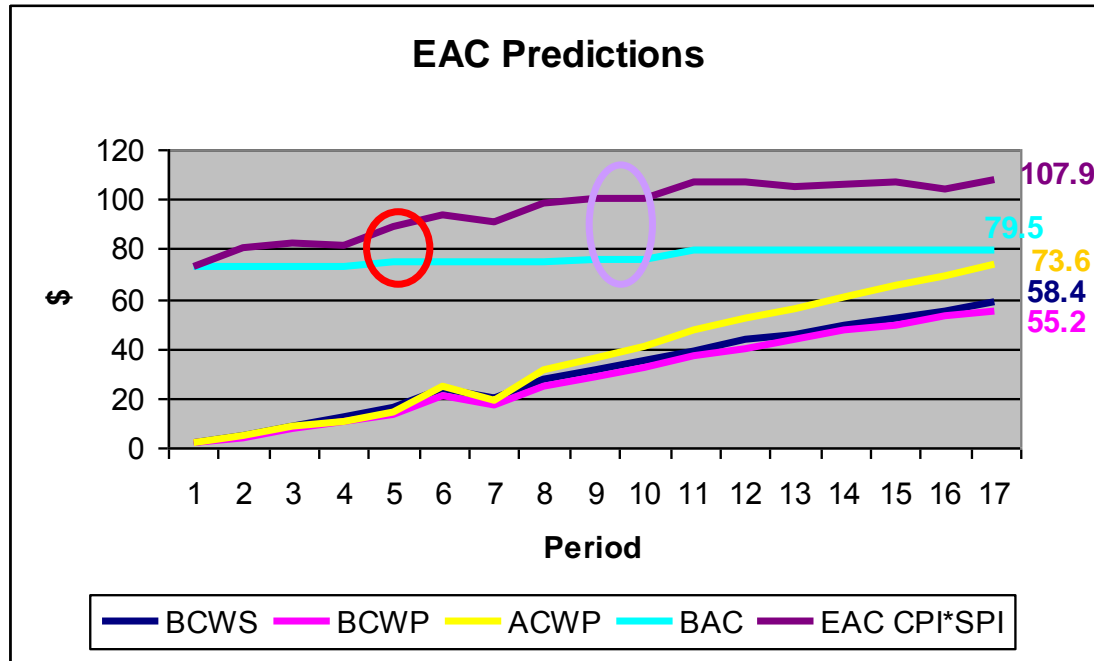
EAC Analysis - Example

- How is this project doing?



EAC Analysis - Interpreting Data

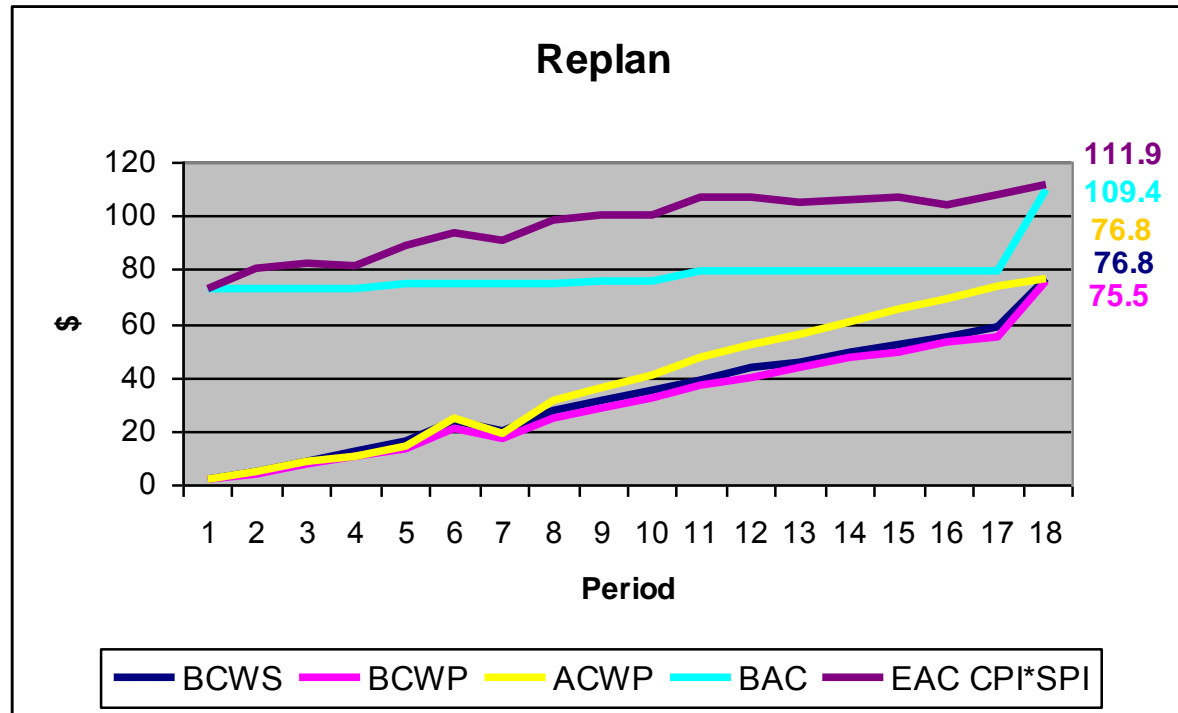
- EAC Predictions:



- Red Circle: ~ 15% complete. Overrun is 15 here
- Purple Oval: ~ 33% complete. Overrun stabilizes here at 24-28
- At 17th period, showing ~ 28% overrun

EAC Analysis - Replan

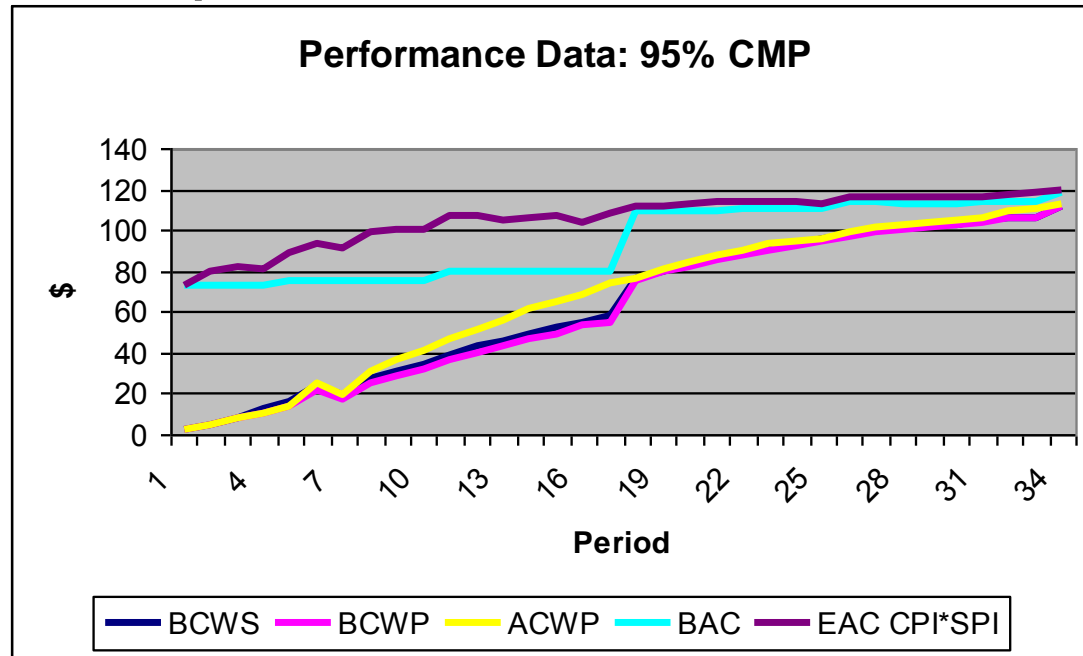
- The replan:



- Variiances almost healed
- BAC close to EAC

EAC Analysis - Outcome

- 95% complete data:



- Established “award milestones” using unearned fee to incentivize contractor
- Also imposed cost-share clause for additional overrun to further incentivize contractor

Earned Value Review Process

- Process Steps
- Analysis “One Chart”

Earned Value Review Process

- How do you get a handle on all this data?
- Steps in a review process
 1. What questions are most important to your organization? (Profitability, Budget, etc.)
 2. What statistics will answer those questions?
 3. What metrics do you like best?
 - Multiple metrics for same basic questions
 - Don't use all - analysis becomes redundant
 4. What is the optimal EV reporting level? What are the variance reporting thresholds?
 - Important to not be too high or too low
 - Let the contractors manage the work
 - Let government have sufficient oversight *and* insight

Earned Value Review Process

Program Management Concerns

1. How much progress have we made to date?
2. Are there any significant deviations from the approved plan?
3. How efficiently are we meeting cost and schedule objectives?
4. What is the trend (getting better or worse)?
5. Do I think program will come in on budget?
6. Does the contractor have a reasonable estimate to complete the authorized scope of work?
7. Do I have a reasonable estimate for completing the authorized scope of work?
8. What actions can we take to get things back on track?

Products of EV Analysis

1. % Complete (vs % spent)
2. CV, SV, VAC
3. CPI & SPI
4. Graphical Trend Analysis
5. $TCPI_{BAC}$
6. $TCPI_{LRE}$
7. Statistical EAC Forecasting Techniques
8. Variance Analysis and Reports

Executive Overview of EVM course, MAJ Dick Cruver, NRO ACE EVMST, 1997

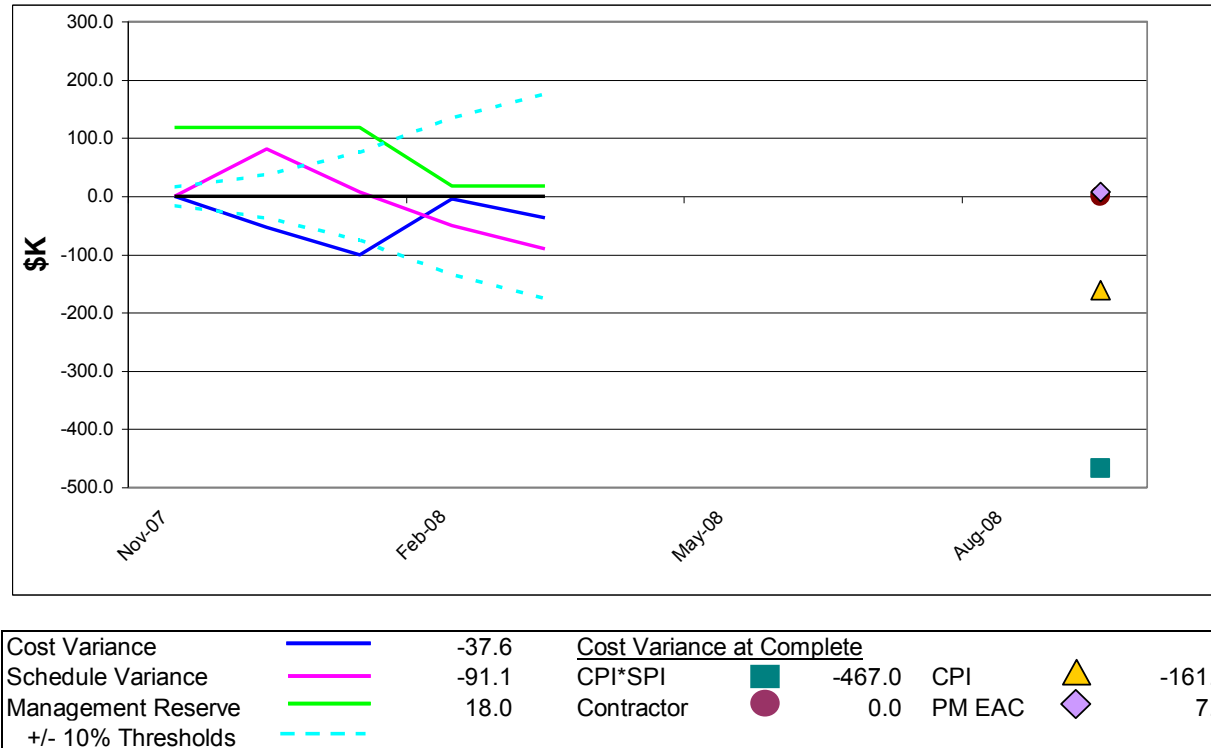
Earned Value Review Process

- Examine trends as well as cumulative data points
- Examine current data for anomalies, errors in data, & error corrections
- Don't use current data for forecasting performance trends - data too volatile
- Keep in mind:
 - Analyzing non-perfect data
 - Errors in data may cause variances and forecasted EACs to appear worse than reality
 - Poor EV data could be the result of using inappropriate performance measurement techniques - Assess need to change technique

Earned Value Review Process

- Use your technical knowledge when examining data
- Always consider your existing knowledge of:
 - What drove past variances
 - What future risks and challenges lie ahead
- See Rules of Thumb in Advanced Topics section
- See DAU Gold Card in Summary section

Analysis “One Chart”



- The “One Chart” captures a lot of valuable information:
 - CV and SV with +/- 10% thresholds to visually see when variances become extreme
 - Comparison to MR allows one to see easily if MR used to heal variances
 - Various VACs with a sense of the time left to reach those EAC.

Integrated Program Management Report (IPMR)

- Data Item Descriptions (DIDs)
- IPMR Formats
- Contractor Performance Reports (CPRs)
- CPR Formats
- Other Cost Reports

Integrated Program Management Report




- Integrated Program Management Report (IPMR)

- Cost and Schedule reporting format (DI-MGMT-81861) required for solicitations and RFPs issued after July 1, 2012
- Replaces previously required CPR (DI-MGMT-81466A) and IMS (DI-MGMT-81650)
- Formats 1 - 6 are reported monthly and Format 7 is annually
- Formats 1 - 4 remain similar to CPR reporting, Format 5 is revised and Formats 6 - 7 are new

IPMR Formats

- **Format 1 (WBS Report)**
 - Current period and cumulative data by WBS
- **Format 2 (Functional Report)**
 - Current period and cumulative data by functional categories
- **Format 3 (Baseline Report)**
 - PMB changes enacted in current month
- **Format 4 (Manpower Report)**
 - Actual and latest revised manpower reported by functional categories
- **Format 5 (Variance Report)**
 - Narrative summary of top 15 variances, impact, and corrective action
- **Format 6 (Schedule Report)**
 - Program Integrated Master Schedule (IMS)
- **Format 7 (Historical Report)**
 - Time-phased historical & forecast cost submission

Contract Performance Report

-  Contract Performance Report (CPR)
 - DI-MGMT-81466A
 - Typically used for larger, higher interest programs
 - Most common formats requested by Government are Formats 1, 3, and 5
 - Most companies manage by functional categories (Format 2 and 4)

CPR Formats

- Format 1 (WBS Report)
 - Current period and cumulative data by WBS
- Format 2 (Functional Report)
 - Current period and cumulative data by functional categories
- Format 3 (Baseline Report)
 - PMB changes enacted in current month
- Format 4 (Manpower Report)
 - Actual and latest revised manpower reported by functional categories
- Format 5 (Variance Report)
 - Narrative summary of variances, impact, and corrective action


Other Cost Reports



- Cost/Schedule Status Report (CSSR):
 - Similar to CPR Format 1, but reports only cumulative data
 - This report was rescinded with the March 2005 EVM memo from USD AT&L
 - Contracts in place in March 2005 may still use this report



- Contract Funds Status Report (CFSR):
Contractor's estimate for contract funding requirements

- Contractor Cost Data Report (CCDR): 
 - Primary method used to collect historical cost data on DoD programs

Summary

- Summary
- Gold Card

EVM Summary

- EVM is a management technique
 - Integrates technical, cost, and schedule data
 - Facilitates objective, realistic management decisions
- Earned Value Management System (EVMS) is a multi-faceted EVM tool
 - Planning tool
 - Reporting tool
 - Analysis and Decision Making tool

EVM Summary

- Major Benefits of using EVM include:
 - Improved planning
 - Clear definition of work prior to beginning work
 - Accurate level of resources
 - Quick, early problem identification
 - Reduced cost and schedule risks
 - Reduced propensity to add work without adding budget (out of scope changes)
 - Objective performance measurement
 - Provides true cost and schedule condition
 - Encourages accurate forecasting of cost to complete

EVM Summary

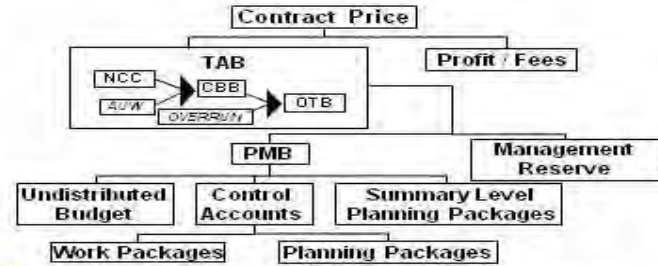
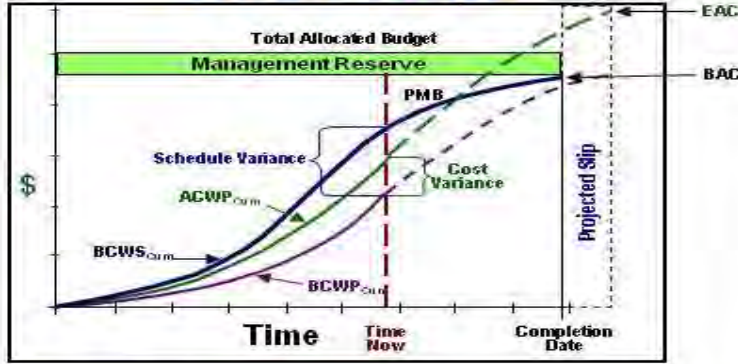
- Major Benefits of using EVM include:
 - Provides repeatable performance and lessons learned data
 - Provides sound data to justify requesting resources
- Successful EVM relies on joint partnership between Government and Contractor

Gold Card

- Earned Value Management Gold Card
 - Published by Defense Acquisition University (DAU)
 - Provides comprehensive, concise summary of major EVM elements
 - <https://acc.dau.mil/CommunityBrowser.aspx?id=19577>

DAU EVM Gold Card

DAU EARNED VALUE MANAGEMENT 'GOLD CARD'



VARIANCES		OVERALL STATUS	
Cost Variance	CV = BCWP - ACWP	% Schedule	= (BCWS _{CUM} / BAC) * 100
CV %	= (CV / BCWP) * 100	% Complete	= (BCWP _{CUM} / BAC) * 100
Schedule Variance	SV = BCWP - BCWS	% Spent	= (ACWP _{CUM} / BAC) * 100
SV %	= (SV / BCWS) * 100		
Variance at Completion	VAC = BAC - EAC		
VAC %	= (VAC / BAC) * 100		

DoD METRICS		
Cost Efficiency	CPI = BCWP / ACWP	Favorable is > 1.0, Unfavorable is < 1.0
Schedule Efficiency	SPI = BCWP / BCWS	Favorable is > 1.0, Unfavorable is < 1.0

BASELINE EXECUTION INDEX (BEI) = A Schedule Metric
 BEI = Tasks with Actual Finish Date / (# of Baseline Tasks Scheduled to Finish Prior to Status Date + Tasks Without Baseline Dates)

Hit / Miss = Month's Tasks Completed ON or AHEAD Baseline / Month's Tasks Scheduled to Complete

ESTIMATE @ COMPLETION # = ACTUALS TO DATE + [(REMAINING WORK) / (PERFORMANCE FACTOR)]
 EAC_{CR} = ACWP_{CUM} + [(BAC - BCWP_{CUM}) / CPI_{CUM}]
 EAC_{Composite} = ACWP_{CUM} + [(BAC - BCWP_{CUM}) / (CPI_{CUM} * SPI_{CUM})]

TO COMPLETE PERFORMANCE INDEX (TCPI) %
 TCPI_{Target} = Work Remaining / Cost Remaining = (BAC - BCWP_{CUM}) / (Cost Target - ACWP_{CUM})
 § To Determine the TCPI IN EACH OF LINE OF EACs, Replace Cost TARGET with BAC or LRE or EAC
 # To Determine the Contract Level TCPI for EAC, You May Replace BAC with TAB

ACRONYMS

- ACWP** Actual Cost of Work Performed = ACTUAL COST
- AUW** Authorized Unpriced Work
- BAC** Budget At Completion
- BCWP** Budgeted Cost for Work Performed = EARNED VALUE
- BCWS** Budgeted Cost for Work Scheduled = PLANNED VALUE
- CA** Control Account
- CBB** Contract Budget Base
- EAC** Estimate At Completion
- LRE** Latest Revised Estimate
- MR** Management Reserve
- NCC** Negotiated Contract Cost
- OTB** Over Target Baseline
- PAC** Price At Completion
- PMB** Performance Measurement Baseline
- PP** Planning Package
- SLPP** Summary Level Planning Package
- TAB** Total Allocated Budget
- TCPI** To Complete Performance Index
- UB** Undistributed Budget
- WP** Work Package

EVM POLICY: DoDI 3000.02, End 4, Table 3. EVMS in accordance with ANS/IEA-748 is required for cost or incentive contracts, subcontracts, intra-government work agreements, & other agreements valued > \$20M (Then-Yr \$). Contracts > \$30M (TY \$) require that the EVM system be formally validated by the cognizant contracting officer. Additional Guidance in Defense Acquisition Guidebook & Earned Value Management Implementation Guide (EVMIG). EVM is discouraged on Firm-Fixed Price, Time & Material Contracts, & LOE activities regardless of cost.

EVM CONTRACTING REQUIREMENTS:
 FAR EVM Clauses NOT Used By DoD 52.234-2 for Solicitation = Pre-Award IBR or 52.234-3 = Post Award IBR 52.234-4 for Solicitation & Contract
 DoD USES OF FAR SC CLAUSES ≥ \$20M 252.234-7001 "NOTICED EVMS" FOR SOLICITATIONS
 252.234-7002 "EVMS" FOR SOLICITATIONS & CONTRACTS
 252.242-7005 "CONTRACTOR BUSINESS SYSTEMS" FOR SOLICITATIONS & CONTRACTS
 CONTRACT PERFORMANCE REPORT DI-MGMT-81466A * 3 FORMATS = UBS, ORGANIZATION, BASELINE STAFFING, EXPLANATION
 INTEGRATED MASTER SCHEDULE DI-MGMT-81630 * MANDATORY FOR FOR DoD EVMS CONTRACTS
 Integrated Program Mgmt Report DI-MGMT-81661 * 7 FORMATS = MIS, DISCIP, BUDGET, SCHEDULE, ANALYSIS, IMS, HISTORY/PERFORMANCE
 INTEGRATED BASELINE REVIEW MANDATORY FOR ALL EVMS CONTRACTS
 * Refer to the EVMIG for CPR & IMS tailoring guidance
 ** Supersedes DI-MGMT-81466A & 81630, Effective July 1, 2012

DAU Home Page = <https://acc.dau.mil/eum>
 eMail Address: EVM.dau@dau.mil
 Revised July 2012



Resources

- Web Resources
- EVM References
- Earned Value Reports

Web Resources

- US DoD Earned Value: <http://www.acq.osd.mil/evm/>
 - Policy, Papers, Tools, Links, and more
 - Earned Value Management Implementation Guide and DoD 5000.2-R (under Policy)
 - Earned Value Glossary and EVM “Gold Card” (under FAQ)
- Society and Company websites often have links to EVMS white papers, user groups, and other useful material
 - Access society websites via OSD EV Links site: <http://www.acq.osd.mil/evm/resources/index.shtml>
- Acquisition Community Connection (ACC), <https://acc.dau.mil/CommunityBrowser.aspx>, “Participate in a Community,” “Earned Value Management”
 - Access company websites via ACC EV Tools site: <https://acc.dau.mil/CommunityBrowser.aspx?id=17809>

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 - *Industry Standard Guidelines for Earned Value Management (EVM)*, American National Standards Institute Standard 748, 2006
 - *Guide to Analysis of Contractor Cost Data*, AFMC, 1994
 - *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP, March 2, 2009
- Books
 - *Cost/Schedule Control Systems Criteria: The Management Guide to C/SCSC*, Quentin W. Fleming, 1992
 - *Earned Value Project Management 3rd Edition*, Quentin W. Fleming and Joel M. Koppleman, 2005
 - *Project Management Body of Knowledge (PMBOK) 4th Edition*, Project Management Institute (PMI), 2008
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