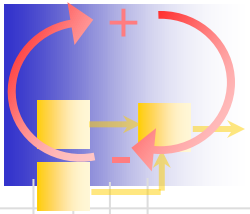
ESD.36 System Project Management



L10: Budgeting and Cost Control

Instructor(s)

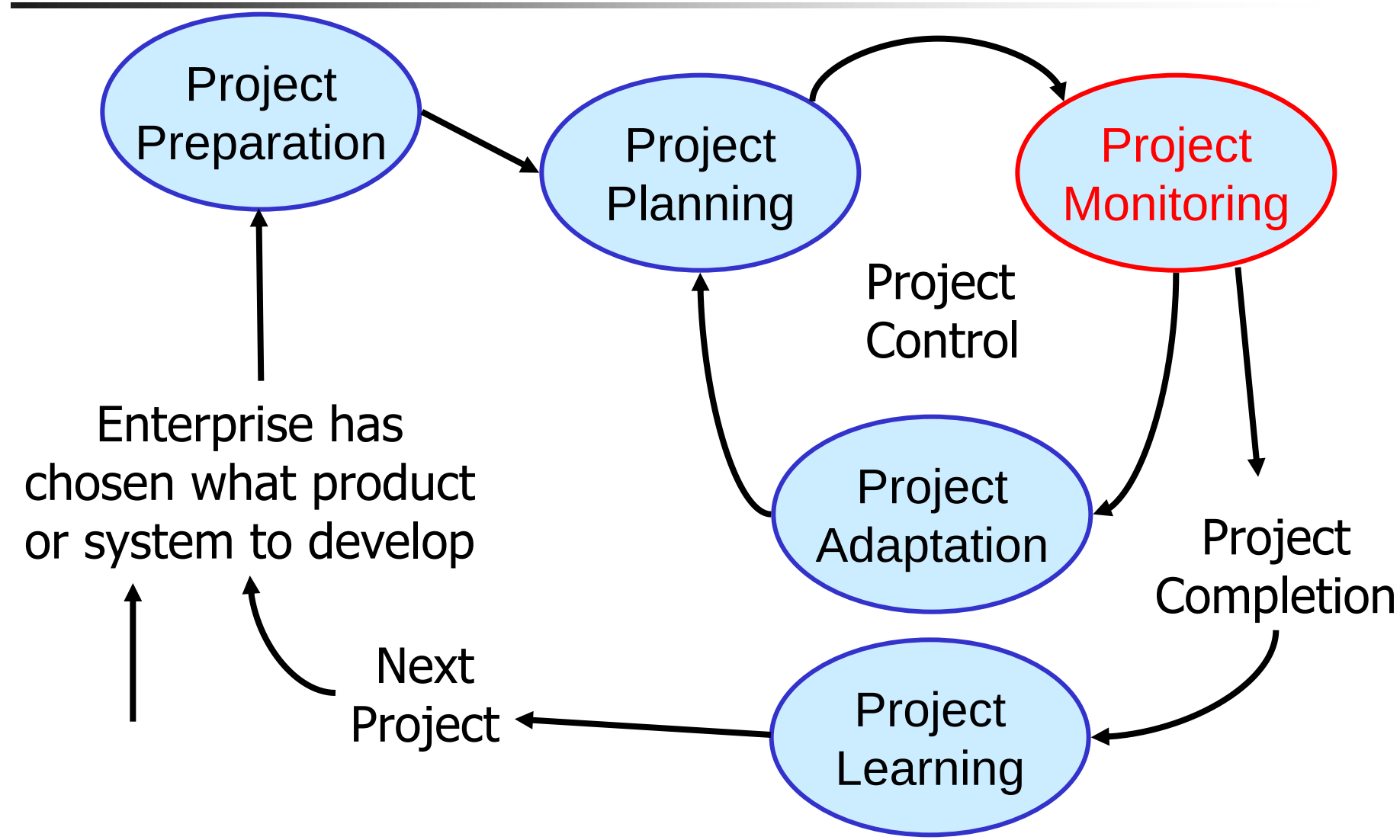
Olivier de Weck

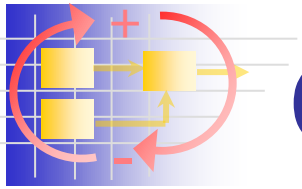
Lecture 10

Oct. 11, 2012

Massachusetts Institute of Technology

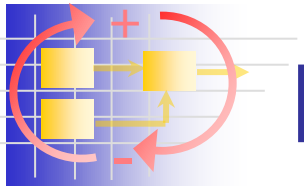
System Project Management
ESD.36 Framework





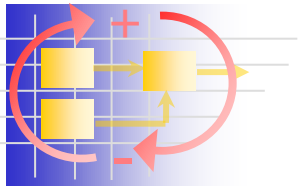
Outline

- Tracking of Resource Consumption and Progress
  - Creating Measurable Plans
  - Schedule, Cost Tracking – "easy"
  - Scope/Progress Tracking – "hard"
  - Risk Tracking - how? (dedicated lecture to risk management)
- Industrial Practice
  - "Earned Value Management" (EVM)
- Role of Metrics in Project Management
  - Process-related metrics
  - Product-related metrics



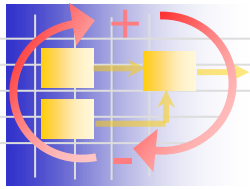
Discussion Point

- What should we track on projects and why should we track it?



Project Tracking Challenges

- CPM/PERT, DSM, SD- our project planning tools are intended to help us establish a credible baseline for planned schedule, project and product cost- tracking should then be easy, right? But…
  - Timely data suited to direct use for project tracking is difficult to access
  - Competing agendas in project resource organizations make the already difficult task of technical progress assessment even harder
  - Fitting the data into the proper context for project assessment requires time and judgment
- The fidelity of tracking can be no better than the corresponding plan- detailed and realistic planning requires significant effort

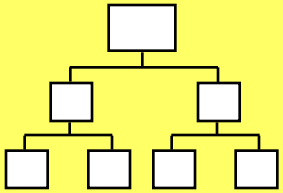


Source Notes

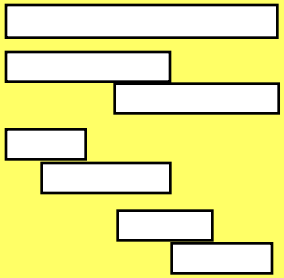
- Many following examples and methods draw upon DOD/aerospace practices
  - Methods originated in industry
  - Initial application found to be resource-intensive
  - DOD applied due to project size and complexity
- Commercial practices are converging with defense (movement in both directions) as IT infrastructure enables data acquisition and analyses
  - Practices are coming full circle
  - Stage-gate processes require tracking metrics
- Tailoring for your organization and project is essential

Creating Measurable Plans

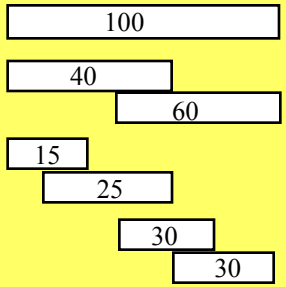
1. DEFINE THE WORK

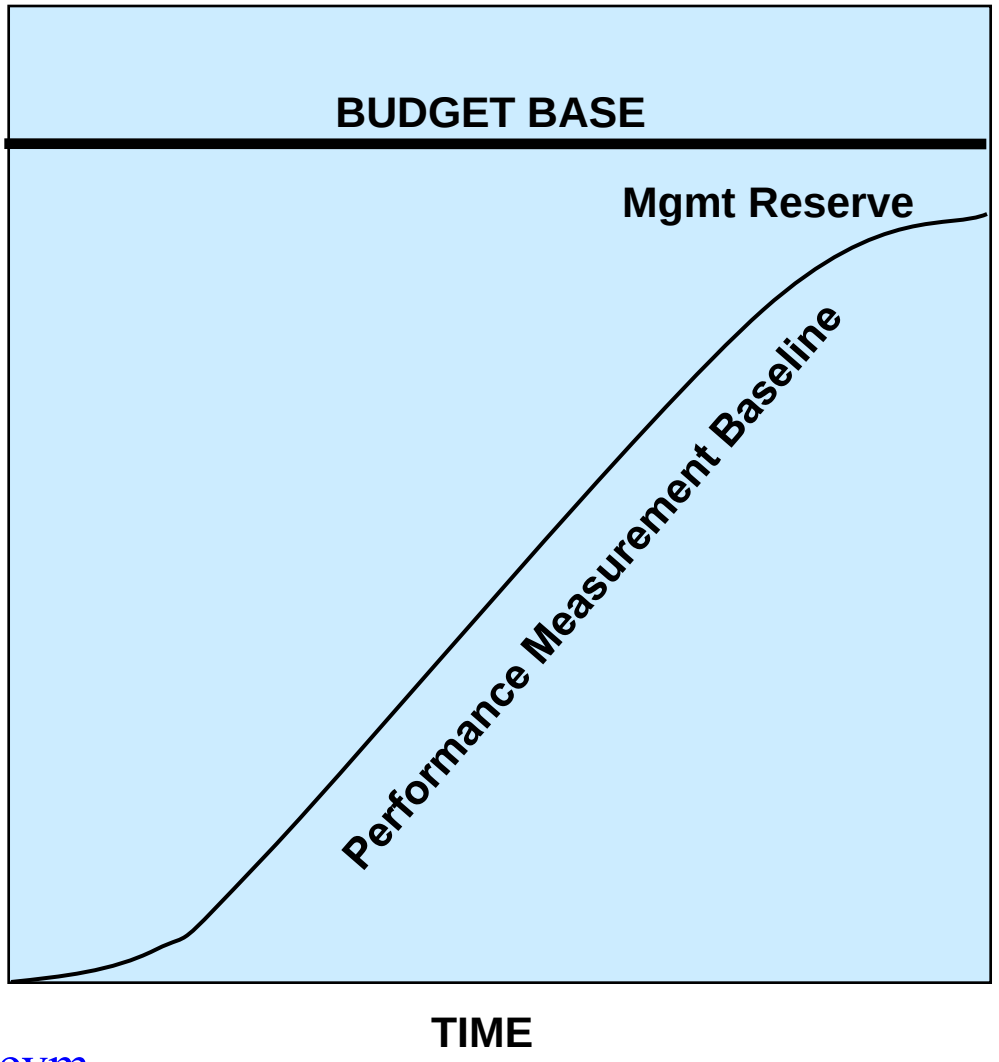


2. SCHEDULE THE WORK



3. ALLOCATE BUDGETS





Source: USAF www.acq.osd.mil/evm

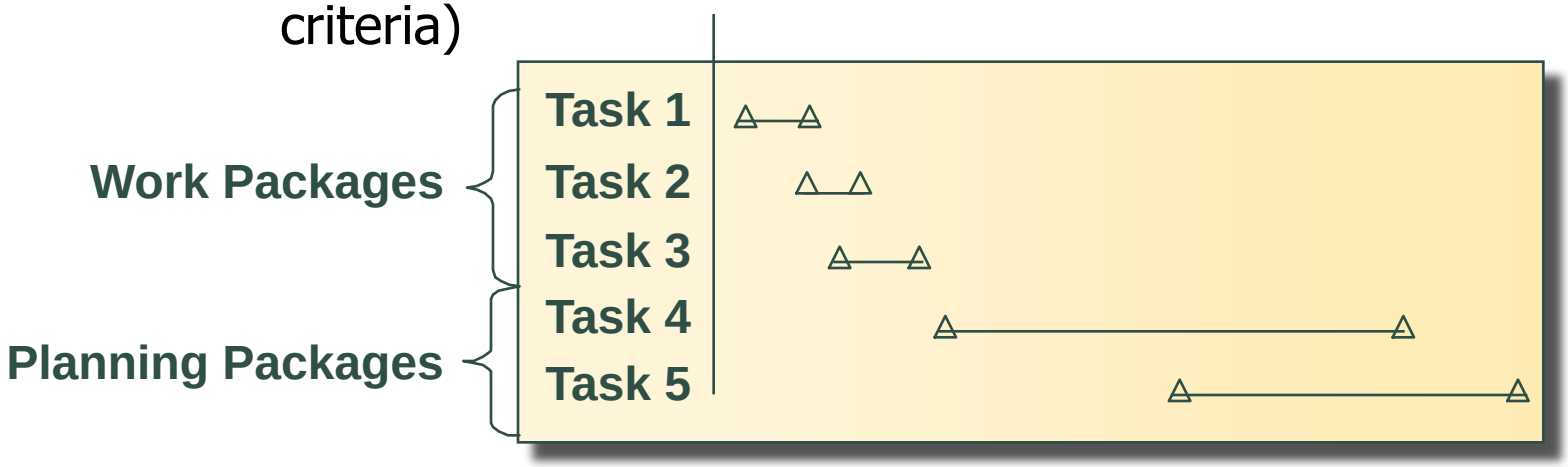
Planning Resolution & Timing

Work Packages

Detailed, short-span tasks, or material items, required to accomplish the objectives, typically in the near term (include costs & completion criteria)

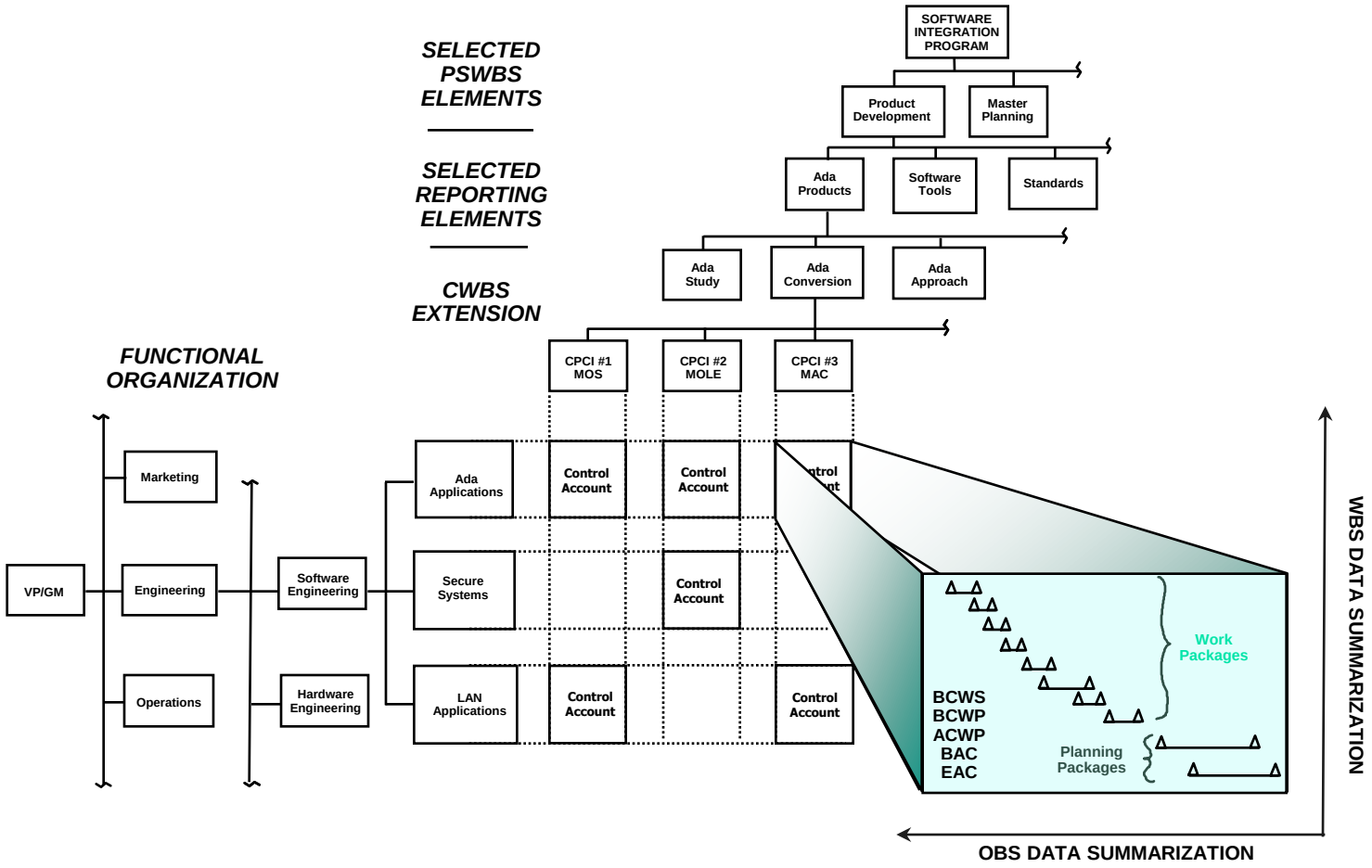
Planning Packages

Future work that has not been detail planned as work packages. They are always scheduled to occur in the future.



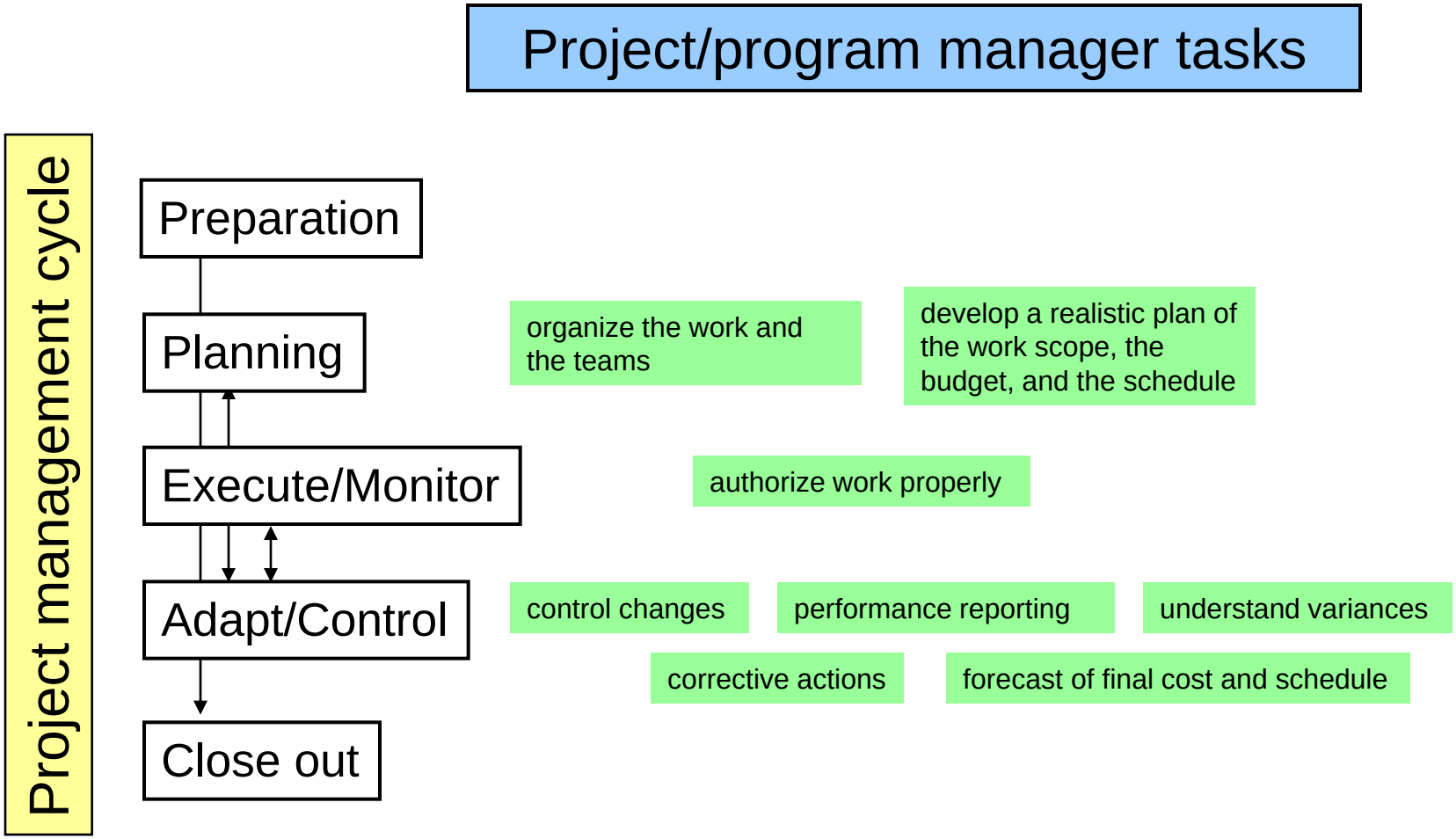
Source: MCG www.acq.osd.mil/evm

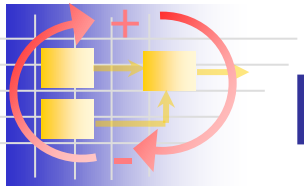
Mapping Work to Resources



Source: public domain; MCG www.acq.osd.mil/evm

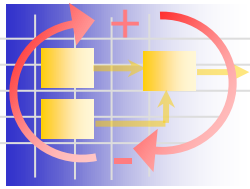
Project Planning & Control Context





Data Sources for Project Tracking

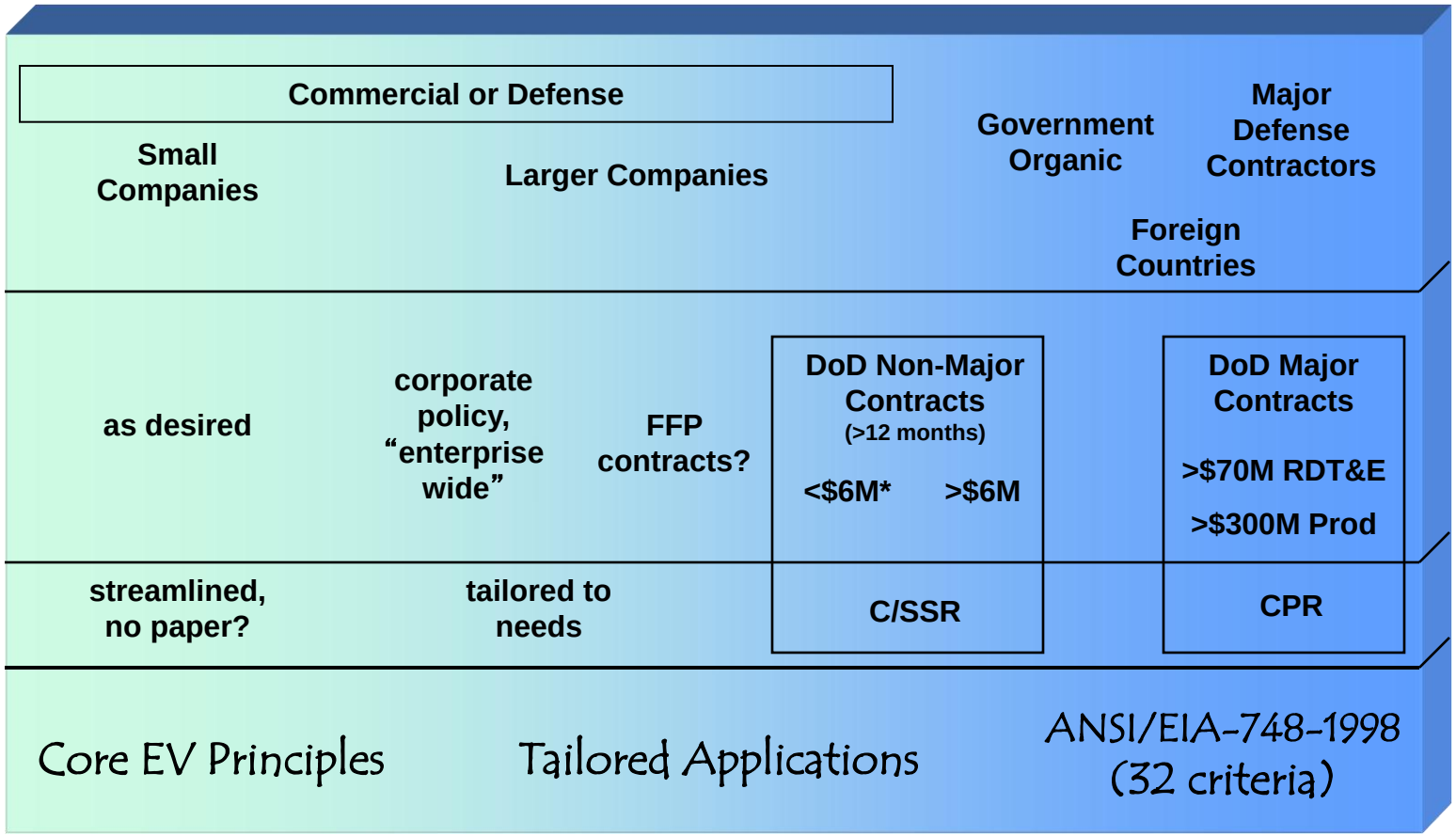
- Project cost is usually tracked in development organization finance system
  - Data should be tracked on a ‘per task, per resource’ basis to be most useful
  - As outsourcing becomes a major strategy, similar costs must be gathered from suppliers
    - Reporting requirements need to be contractually specified
- Work completion is usually measured by milestone, but requires detailed planning and ‘costed’ tasks- this is often the most problematic measurement
  - ‘Percent complete’ measurements are notoriously unreliable
  - Milestone-based reporting is least ambiguous, but requires substantial planning effort

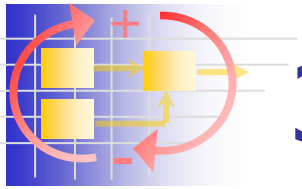


Earned Value Management

- Initially developed in industry (1970s)
- DOD adopted initially as "CSSR", imposed on major contracts
  - CSSR = Cost, Schedule, Status Reporting
- Has converged into current Earned Value Management System (EVMS) in both commercial and DOD use
  - ANSI/EIA-748-1998, Earned Value Management Systems (latest version 748-B 2007)
- If based on reasonable plan, excellent source of risk identification and project control metrics

Implementation Spectrum





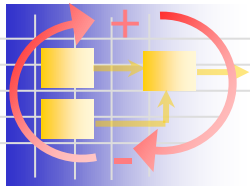
3+2=5 Key Elements

BCWS	Budgeted Cost of Work Scheduled
BCWP	Budgeted Cost of Work Performed
ACWP	Actual Cost of Work Performed
BAC	Budget at Completion
EAC	Estimate at Completion

Planned Value

Earned Value

Actual Cost



Schedule Variance

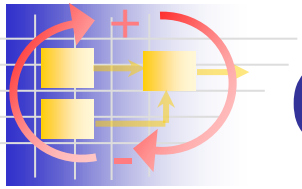
BUDGET BASED

BCWS	of the work I scheduled to have done, how much did I budget for it to cost?
BCWP	of the work I actually performed, how much did I budget for it to cost?

SCHEDULE VARIANCE is the difference between work scheduled and work performed (expressed in terms of budget dollars)

formula: **SV $ = BCWP - BCWS**

example: SV = BCWP - BCWS = $1,000 - $2,000
SV= -$1,000 (negative = behind schedule)



Cost Variance

BC WP

AC WP

PERFORMANCE BASED

of the work I actually performed,
how much did I budget for it to cost?

of the work I actually performed,
how much did it actually cost?

COST VARIANCE is the difference between budgeted cost and actual cost

formula: **CV $ = BCWP - ACWP**

example: CV = BCWP - ACWP = $1,000 - $2,400
CV= -$1,400 (negative = cost overrun)

Variance at Completion (VAC)

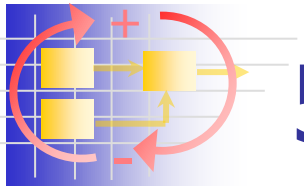
B AC — what the **total** job is supposed to cost

E AC — what the **total** job is expected to cost

VARIANCE AT COMPLETION is the difference between what the total job is supposed to cost and what the total job is now expected to cost.

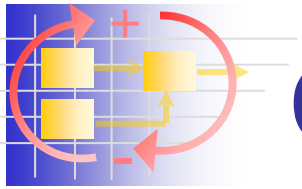
FORMULA: **VAC = BAC - EAC**

Example: VAC = $5,000 - $7,500
VAC = - $2,500 (negative = overrun)



5 Basic Questions/Parameters

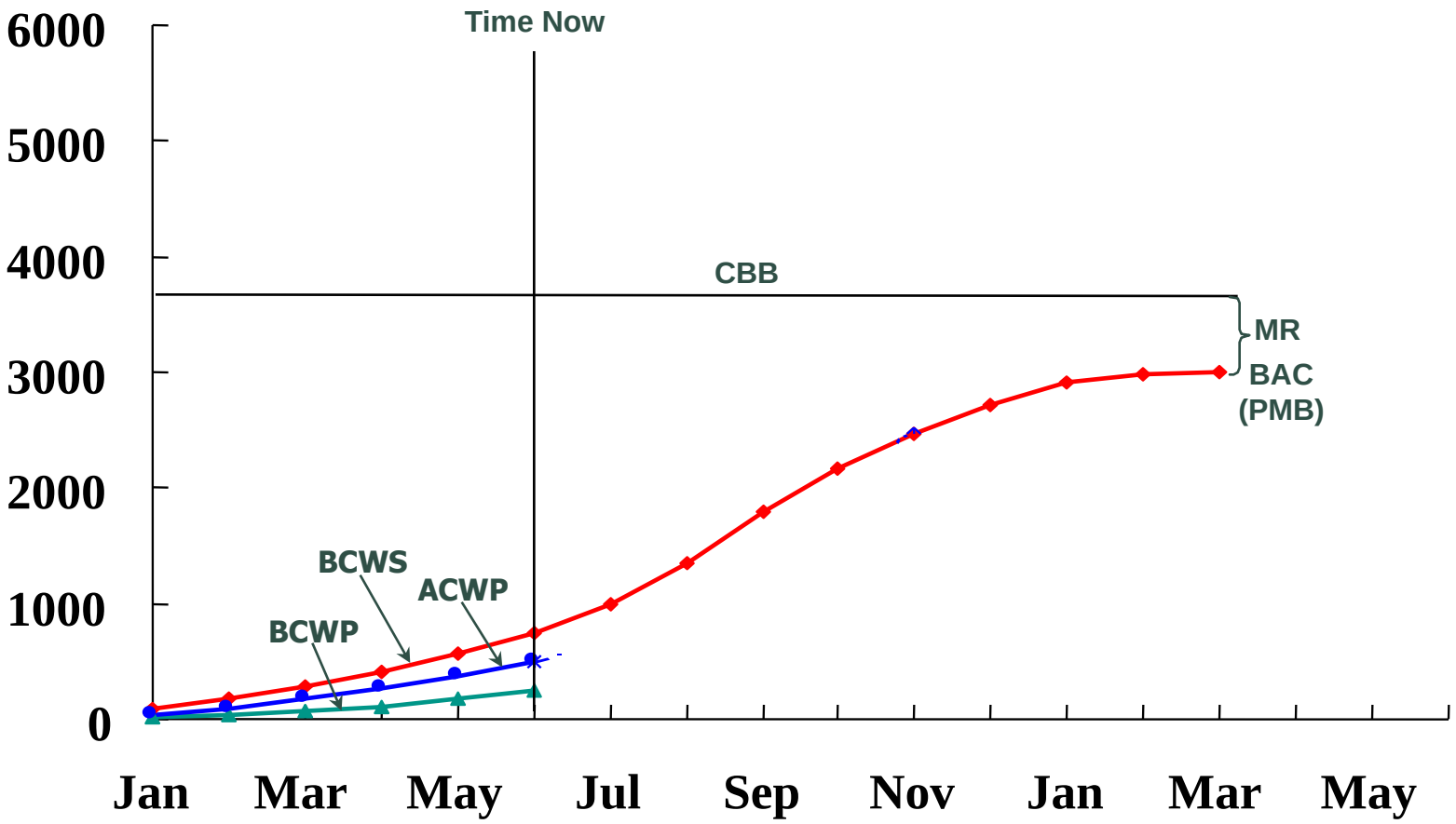
QUESTION	ANSWER	ACRONYM
How much work should be done?	Budgeted Cost for Work Scheduled	BCWS
How much work is done?	Budgeted Cost for Work Performed	BCWP
How much did the is done work cost?	Actual Cost of Work Performed	ACWP
What was the total job supposed to cost?	Budget at Completion	BAC
What do we now expect the total job to cost?	Estimate at Completion	EAC



Concept Question 1

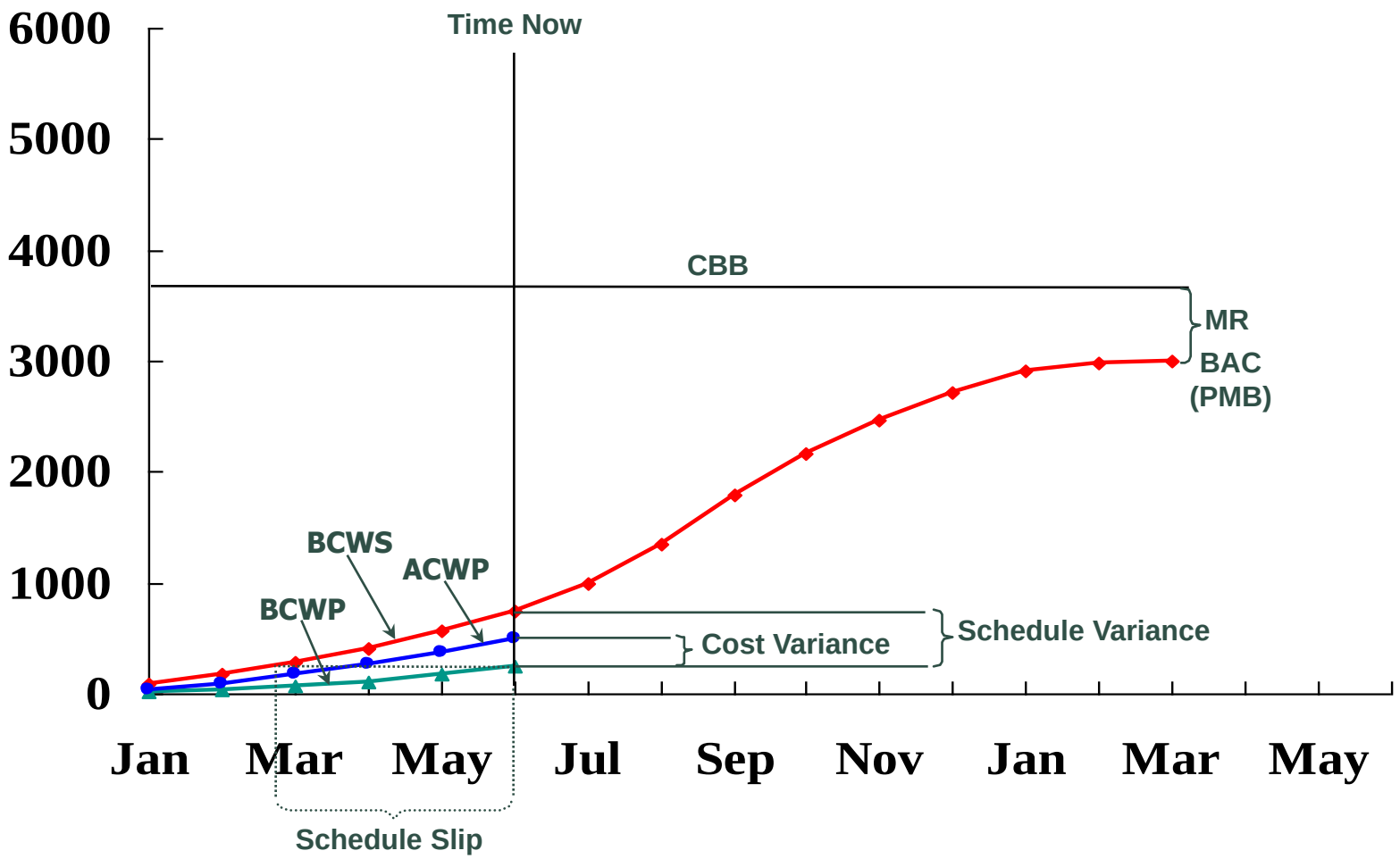
- Which of these 5 quantities is most difficult to track? (and why?)
  - BCWS
  - BCWP
  - ACWP
  - BAC
  - EAC

Earned Value Data Elements



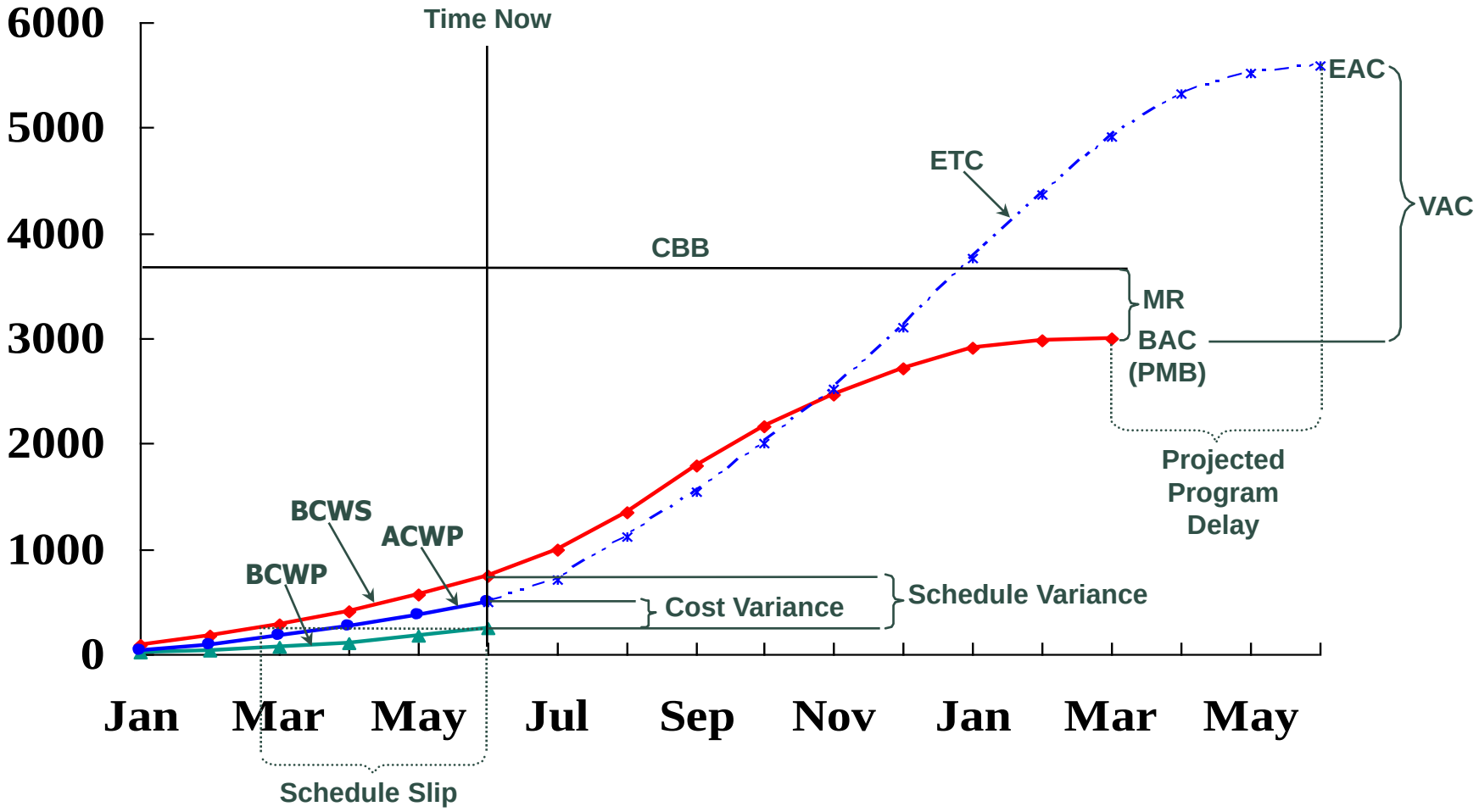
Source: MCG www.acq.osd.mil/evm

EV Data Elements- Variances

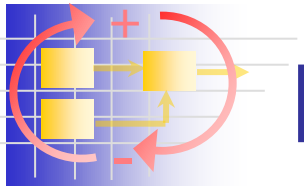


Source: MCG www.acq.osd.mil/evm

EV Data Elements- Projections



Source: MCG www.acq.osd.mil/evm



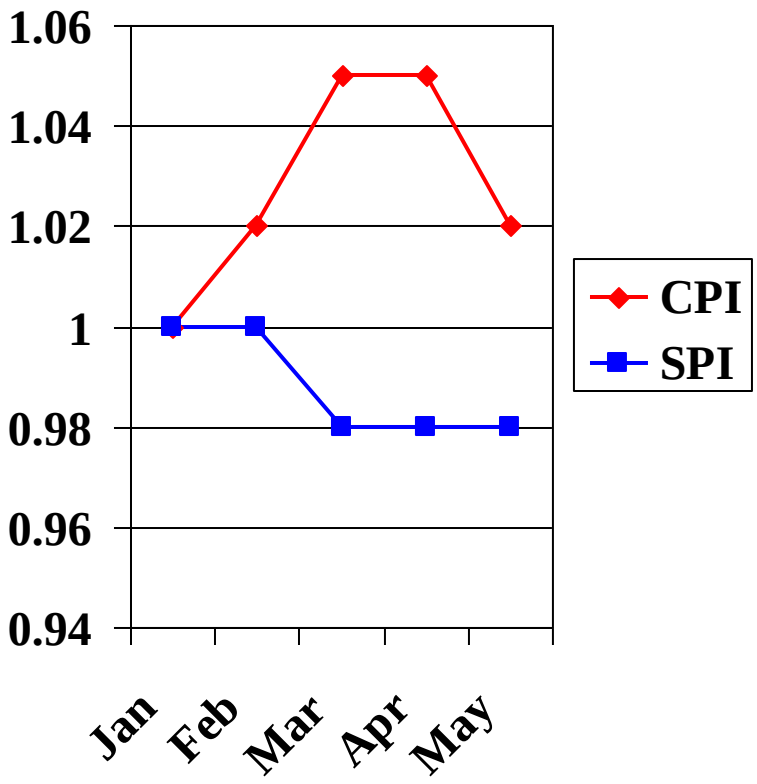
Data Analysis Relationships

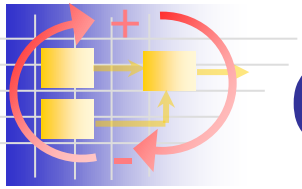
Term	Symbol	Formula	Checklist Actions
Percent Complete	% Done	$\frac{BCWP}{BAC}$	Ratio of work accomplished in terms of the total amount of work to do.
Cost Performance Index or Performance Factor	CPI or PF	$\frac{BCWP}{ACWP}$	Ratio of work accomplished against money spent (Efficiency Rating: Work Done for Resources Expended)
To Complete Performance Index or Verification Factor	TCPI or VF	$\frac{BAC - BCWP}{EAC - ACWP}$	Ratio of work remaining against money remaining (Efficiency which must be achieved to complete the remaining work with the expected remaining money)
Schedule Performance Index	SPI	$\frac{BCWP}{BCWS}$	Ratio of work accomplished against what should have been done (Efficiency Rating: Work done as compared to what should have been done)
Estimate At Completion	EAC	ETC + ACWP	Calculation of the estimate to complete plus the money spent
Estimate To Complete	ETC	$\frac{BAC - BCWP}{CPI}$	Calculation of the budgeted work remaining against the performance factor

Source: MCG www.acq.osd.mil/evm

Risk Indicators

- EVM provides several metrics that can “flag” potential problems (risks) either as trends or thresholds.
- CPI: Good = ≥ 1.0
- SPI: Good = ≥ 1.0





Concept Question 2

- The ACWP of a project is $5.5M, the BCWS is $6.0M and the BCWP is $5M. The SPI and CPI are:
  - SPI=1.2, CPI=0.83
  - SPI=0.91, CPI=1.2
  - SPI=0.83, CPI=0.91
  - SPI=1.2, CPI=0.83
  - SPI=0.91, CPI=1.05

Risk Indicators "corrupted"

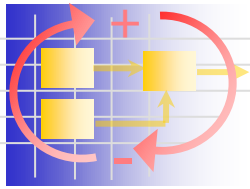
- Email excerpt from one of my NASA sponsored projects:
  - ….they passed on to us new EVM color coding guidelines from the Chief Engineer. We all frantically updated our charts. The failure to communicate was that I did not pass these new guideline to the PI's and COTR's before I left. In my defense, I only got a paper copy of the rules. So it was not straight forward to transfer. **The main change is that being higher then 1.1 on your CPI or SPI is bad and colored that way. So you need to cover that in your comments**. The new standards for CPI/SPI's are:

    0.9 <= CPI/SPI <= 1.1 GREEN
    0.8 <= CPI/SPI < 0.9 YELLOW
    1.1 < CPI/SPI <= 1.2 YELLOW

    CPI/SPI < 0.8 or CPI/SPI > 1.2 RED

    We will use these for the next Monthly reports.

- Question to the class:
  - What message does this send?

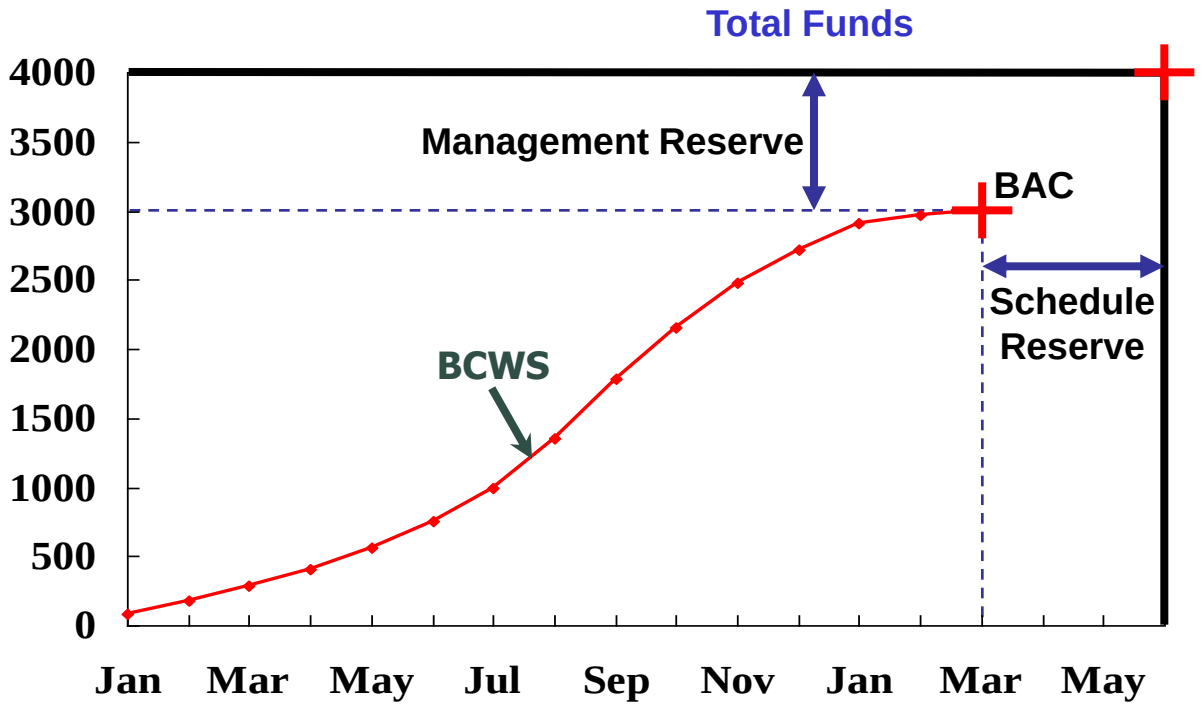


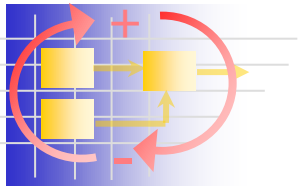
Planning 'Granularity'

- To use EVMS with a reasonable amount of management resources, plan at the appropriate level of detail
- Avoid '% complete' estimation
- Plan work packages with short duration, estimated package cost, and clear deliverable
- Assign 'earned value' at discrete levels, e.g.:
  - Zero value until work package start
  - 50% value while executing
  - Full value when deliverable is complete

Management Reserve

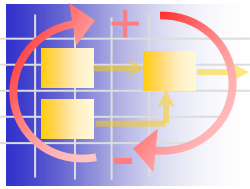
- Calculate total project management reserve required based on
  - statistical modeling
  - past experience





Project Control & Leverage

- Management reserve (cost and schedule) are important project management tools
  - Amounts based on statistical analyses, past experiences typically in the 10-30% range
  - Reserves should be planned and validated with the overall project plan
- The project manager owns management reserve and unallocated budget/schedule
  - Release of Management Reserve should be part of a formal, risk-driven process
  - Requests for reserve allocation should follow a quantitative template

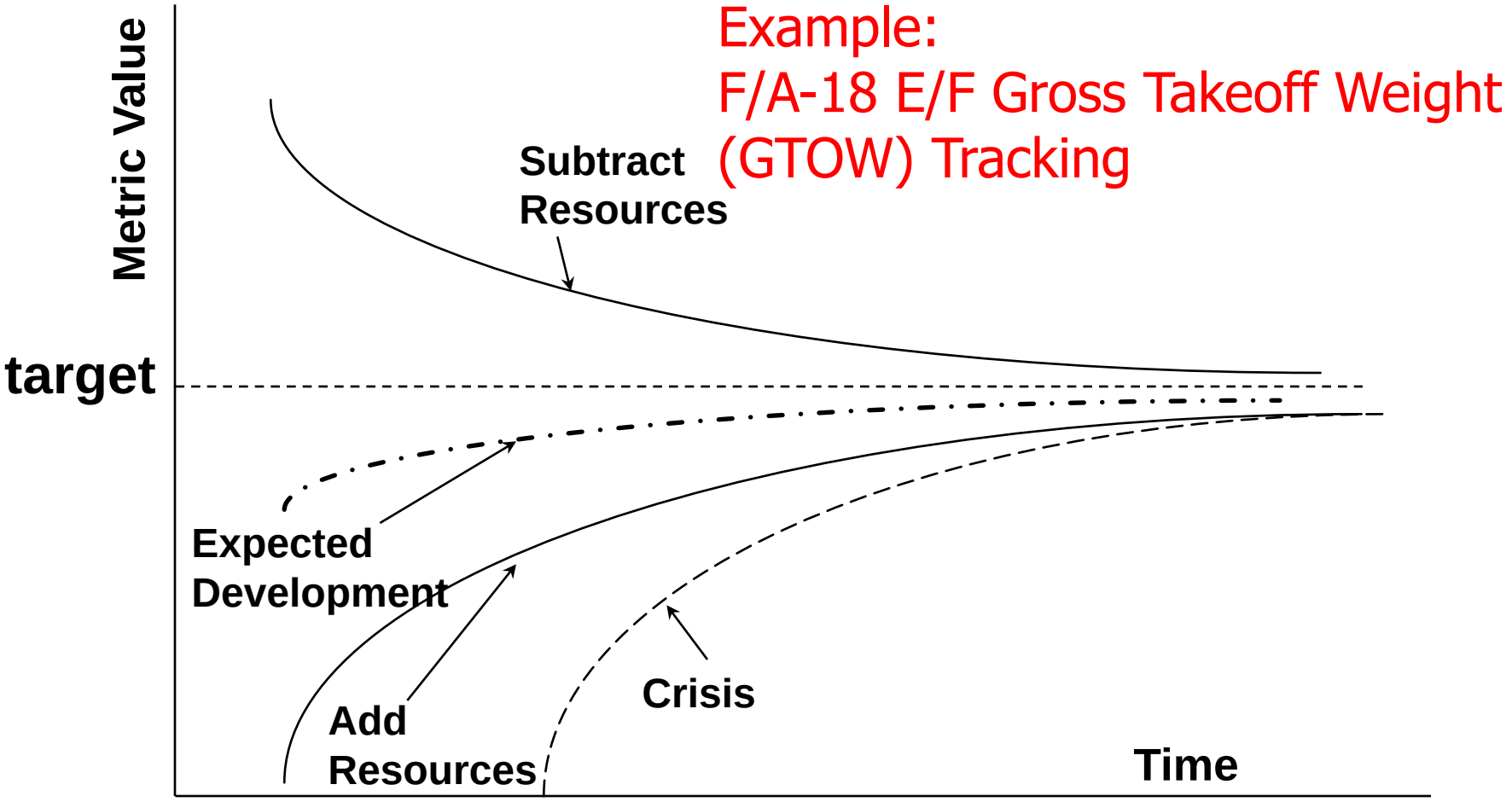


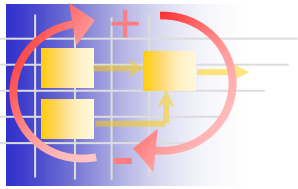
Formulation of Project Metrics

- May be marginal, absolute, probabilistic
  - = X% improvement in _____
  - = X value of _____
  - = X value of _____ with 90% confidence
- Tradition is metric based on benefit/performance (with cost*, schedule and risk assessed later)
- Current practice is metric based on benefit/performance and cost
- "Ideal" would be metrics which include benefit/performance, schedule, cost and risk

*** cost can include liens on resources in addition to $**

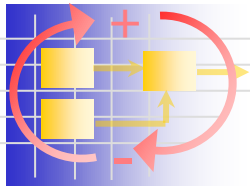
Metric Tracking





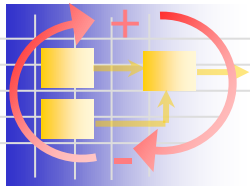
Problems with Metrics

- Identifying real and appropriate metrics is often one of the most difficult parts of engineering system design and projects
  - customer often does not vocalize real metric
  - often have several metrics (must treat independently or combine)
- Metrics don't necessarily add linearly
  - mass does, cost doesn't (can push cost to another element easily)
  - hard to flow metrics down



Earned Value Management 'GOLD CARD'

- Please see https://acc.dau.mil/gc



Summary

- Budgeting and Cost Control
  - Need to monitor Schedule, Cost, Technical Progress vs Budget
  - Risk Identification and Tracking is crucial, but challenging (next week)
  - Formalized methods exist, e.g. EVM, but need to adapt to needs of particular projects
    - Large government project >$1B class
    - commercial product development $10M-100M class
    - small entrepreneurial firm <$10M

ESD.36 System Project Management

Fall 2012